5. Family BURSERACEAE

The Burseraceae, a family of resinous trees consisting of 16-20 genera, are widely distributed in tropics and subtropics and are best represented in tropical America. Only seven genera belonging to **Boswellia**, **Bursera**, **Canarium**, **Commiphora**, **Filicium**, **Protium** and **Garuga** are found in India.

The family characteristically shows alternate compound leaves usually crowded at the tips of the branches; tri-or pentacarpellary mostly unisexual flowers, calyx connate at the base, stamens twice or as many as petals, a prominent intrastaminal disk, ovary with two epitropous ovules in each locule and a drupe with a single fertile and two minute sterile locules. The epidermal cell wall of anther shows papillate projections similar to that of the Meliaceae (Narayana, 1958). The pollen grains are tricolporate, striate or striate-reticulate having aspidate and tectate type of exine (Palacio-Chavez, et al, 1987). The ovules in the Burseraceae are anatropous, hemianatropous or campylotropous, crassinucellate, bitegmic with ventral raphe and the micropyle upward and outward directed. The embryo sac is Polygonum type.

The unisexual flowers present in the family is considered have been derived from a bisexual flower (**Garuga**) and this is evidenced by the remnants of gynoecium in male flower and stamens in female flower. The floral parts tend to unite and resultantly, as in **Garuga**, a cup like structure is formed. In **Canarium** a reduction in antipetalous stamens is observed.

Similar to the closely allied Anacardiaceae, the Burseraceae show schizolysigenous cavities in the phloem. But it differs from the former in having septate fibers, intercellular secretory cavities,distinct growth rings and in the ability to accumulate silica (Metcalfe and Chalk, 1983).

Classification :

The Burseraceae are placed in the Rutales (Dahlgren et al., 1981; Gibbs, 1974; Hutchinson, 1973; Rendle, 1950; Takhtajan, 1980; Thorne 1981), in the Geraniales (Engler, 1931; Bessey, 1915; Bentham and Hooker, 1862) or in the Sapindales (Cronquist, 1981). In all these treatments they are always kept in close association with the Meliaceae, Rutaceae, Simaroubaceae and sometimes with the Anacardiaceae. The affinities existing between the Burseraceae and Anacardiaceae have already been dealt with in the previous chapter.

Engler (1931), divided the family into 3 tribes, Protieae, Boswellieae (Bursereae) and Canarieae; based on the characters of their fruits. The Protieae (**Garuga** and **Protium**) have separate endocarpous pyrenes and pericarp and mesocarp fleshy or dry. The Boswellieae (**Boswellia**, **Bursera**, **Commiphora**) have connate endocarpous pyrenes, pericarp and mesocarp dry and dehiscent while the Canarieae (**Canarium**) have pyrenes formed by the complete fusion of endocarp and mesocarp.

The taxonomic position of certain genera and species included within is debated often. Gamble (1957) included **Protium caudatum** W. & A. under **Commiphora** (**Commiphora caudata** (W. & A.) Engl.) and **Bursera serrata** Colebr. in the genus **Protium** (**P. serratum** Engl.). The position of **Filicium decipiens** also remains controversial. Though it was placed in the Burseraceae (Hooker, 1875), it is now accepted that the genus is closer to the Sapindaceae. Hutchinson (1973) differentiates **Bursera** and **Commiphora** on the basis of aestivation of corolla **i.e.** imbricate in **Bursera** and valvate in **Commiphora** while Hooker (1875) cites the receptacle character, flat in **Bursera** and cup-shaped in **Commiphora**. Because of these apparently flimsy differences by which these genera are separated, Willd (1965) considered these two as cogenera. In a similar way

Brandis (1906) pointed out that the only character by which **Protium** differed from **Commiphora** is in the nature of inflorescence; paniculate in **Protium** and spikate in **Commiphora**. There appears to be a great generic inflation because of descriptions based on the insufficient material. This clearly indicate that the generic delimitations within the family are not strongly defined and thus the taxa belonging to this famly seem to be closely related to each other.

Economic importance :

The Burseraceae are well-known from the ancient times for their aromatic oleoresins present in the bark (Tucker, 1986). The most important resins are 'elemi', 'frankin cense' and 'myrrh', Elemi is obtained from the species of **Canarium**. This finds use in perfumary and medicine. The black dammar, the non-aromatic resin from **Canarium strictum** is mainly used for preparing varnishes, bottling waxes, lighting torches and as a substitute for burgundy pitch plaster. Frankincense is the resin of **Boswellia** which is chiefly used as incense and for ointment preparation. This oleoresin is a good substitute for turpentine. The rosin is suitable for varnishes and as a mounting medium. Myrrh is the resin obtained from **Commiphora**, which is highly rated for its medicinal properties. It is used in the treatment of rheumatism and obesity. Myrrh also shows antiinflammatory and hypocholestremic activity. It is considered as a tonic and antiseptic. **Bursera** produces 'linaloe' oil which is used in a similar way. The wood obtained from this family being susceptible to fungus and insect attacks, is mainly used for planking, packing cases and boxes and for temporary construction work. The wood of **Canarium euphyllum** is used in the match industry.

Previous Chemical Reports :

The available chemcial data on the family Burseraceae pertain to the resins obtained from its members. The family is a rich storehouse of terpenoids. The volatile oil fraction of the resin consists chiefly of monoterpenes and sesquiterpenes. The monocyclic monoterpenes such as limonene and α--phellandrene (Bandaranayake, 1980) are widespread and bicyclic monoterpenes, thujane, pinene and camphene, (Pernett, 1972) are located only from. **Boswellia**. **Canarium** and **Commiphora** are good accumulators of sesquiterpenes (Hinge et al., 1965; Wahg et al., 1964; Brieskorn and Noble, 1982; Maradufu, 1982). δ-Cadinene, caryophyllene and canarone are reported from **Canarium** while β-bisabolene, ar-curcumene and furosesquiterpenes are isolated from **Commiphora**. The sole lactonoid sesquiterpene - commiferin - reported from the family is found in **Commiphora myrrha**. Diterpenes have been located in only two genera **Boswellia** and **Commiphora** of which the compounds of the former genus are incensols and of the latter genus are cembrene and its derivatives. A wide range of triterpenes also occur as constituents of resins. Elemolic acid, isomasticodienonic acid, sapelin A and sapelin B are the tetracyclic triterpenes of euphane/tirucallane type isolated from the family. Pentacyclic triterpenes occuring in the family fall into 3 series, lupane, ursane and oleanane. The members of the lupane series commonly found are lupeol (**Boswellia** anmd **Bursera**), lupeonone (**Commiphora**) and cannaric acid (**Canarium**). β-Amyrin from **Bursera** and **Canarium**; α-boswellic acid from **Boswellia** and commic acid from **Commiphora** are the few triterpenes belonging to the oleanane series and α-amyrin from **Bursera**, **Commiphora** and **Canarium**, commic acid from **Boswellia** and **Commiphora** are the ursane type of triterpenes located in the family (Ekong and Okogun, 1969; Strappaghetti et al., 1982).

Coumarins such as coumarin lignoid propacin and 5-methylcoumarin are reported from **Protium apocum** (Joshi and Hegde, 1979) while lignans of 2,3-dibenzylbutyrolactones, 4-aryltetrahydro - and 4-aryl dihydronaphthalenes are identified from the genus **Bursera** (Bianchi et.al., 1968; 1969; Cole and Wledhopf, 1978).

Flavonoid chemistry of the family is poorly known. The few flavonoids reported are biflavone - amentoflavone - from leaves of **Garuga** and **Canarium** (Ansari et al., 1978; Geiger and Quinn, 1988) and flavonols such as quercetin and kaempferol (Pernett, 1972; Kakarni, 1982) from **Protium** and **Commiphora**.

A detailed treatise on the terpenoid chemistry of the Burseraceae is available elsewhere (Pernett, 1972; Khalid, 1983).

In this chapter chemotaxonomic and cladistic studies on nine members of the Burseraceae are presented.

Materials and Methods :

The leaf material of the plants screened were collected from various regions of India. The plants available in Gujarat are **Bursera delpechiana**, **Canarium strictum**, **Filicium decipiens** (Waghai) **Commiphora wightii** (Kutch) and **Bursera citronella** (Baroda). **Protium serratum** is procured from Botanical Garden, BSI, Howrah and P. **caudatum** and **Canarium commune** from the forests of Srinagar and Guntur (A.P.) respectively.

The procedures followed for the isolation and identification of the phytochemicals and for cladistic analysis are explained in the previous chapters. A number of characters selected for the cladistic analysis of the Anacardiaceae are adopted here also. The additional characters utilised in the analysis of the Burseraceae are the following :

Tables - 5.2 gives the plesio - and apomorphic status of 36 characters selected. Tables 5.3 and 5.4 show the distribution of these characters in 9 taxa and the manhathan distances respectively.

Character 12 : Ovules : Two integuments = 0; One integument = 1.

In Gymnosperms the ovules are invariably unitegmic. But in Angiosperms, where the ovules are bitegmic, unitegmic condition may arise by the elimination of one primordium or by the fusion of two separate primordia (Maheswari, 1964). Since the unitegminal condition is a derived state in Angiosperms, it is considered apomorphic.

Character 13 : Nucellar beak present = 0, Nucellar beak absent = 1.

According to Eames (1961) the nucellus tends to disintegrate in the advanced taxa. Massive nucellus (crassinucellate) is present in most of the primitive dicots. In sympetalous dicots the nucellus remains as a single layer (tenuinucellate). Therefore the presence of a massive nucellar beak is considered as a plesiomorphic charater.

Characters 14, 15 : Presence of obturator = 0, Absence of obturator = 1.
Presence of hypostase = 0; Absence of hypostase=1.

In coding these characters the views of Gulati and Mathur (1977) are followed. The presence of the obturator and hypostase are considered as primitive features.

Character 17 : Pyrenes with endocarp = 0, Pyrenes with endocarp and mesocarp = 1.

Table - 5.2

The Characters Used for the Cladistics of the Burseraceae.

Sr. No.	Characters	Plesiomorphic Score = 0	Apomorphic Score = 1
1.	Petiole	Simple	Winged
2.	Inflorescence	Many-flowered	Few-flowered
3.	"	Bisexual	Polygamous
4.	Sex of the plant	Monoecious	Dioecious
5.	Flowers	Pentamerous	Tetramerous
6.	Aestivation	Imbricate	Valvate
7.	No. of stamens	Ten	Less than ten
8.	Nature of stamens	Free	Connate
9.	Disk	Extrastaminal	Intrastaminal
10.	Carpels	Pentacarpellary	Tetra/tricarpellary
11.	Gynoecium	Free	Sunken
12.	No. of integuments	Two	One
13.	Nucellar beak	Present	Absent
14.	Obturator	Present	Absent
15.	Hypostase	Present	Absent
16.	Ovules	Anatropous	Hemianatropous
17.	Pyrenes	With endocarp	With endo-and mesocarp.
18.	Fruit	Without receptacle	With receptacle
19.	"	Dehiscent	Indehiscent
20.	Myricetin	Present	Absent
21.	Flavone	Absent	Present
22.	Biflavones	Present	Absent
23.	Proanthocyanidins	Present	Absent
24.	Syringic acid	Present	Absent
25.	Tannins	Present	Absent

Table : 5.2 (Contd.)

Sr. No.	Characters	Plesiomorphic Score = 0	Apomorphic Score = 1
26.	Gallic acid	Present	Absent
27.	Monoterpenes	Absent	Absent
28.	Bicyclic monoterpenes	Absent	Present
29.	Sesquiterpenes	Absent	Present
30.	Diterpenes	Absent	Present
31.	Triterpenes	Absent	Present
32.	Lupeol	Present	Absent
33.	Cannaric acid	Absent	Present
34.	α- Amyrin	Present	Absent
35.	Boswellic/Commic acid	Absent	Present
36.	Steroids	Absent	Present.

Table : 5.3 the Distribution of the Characters Among 10 Members of the Burseraceae

	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	332	33	34	35	36	AD(I) Value
Bos. ser.	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	0	1	0	0	0	1	0	0	0	1	1	1	1	1	1	0	0	1	1	0	18
Bur. gla.	1	1	1	1	0	1	0	0	1	1	0	1	1	1	1	1	0	1	1	1	0	0	0	0		1	1	0	0	0	1	0	0	0	0	0	17
Bur. del.	0	1	1	1	0	1	0	0	1	1		1	1	1	1	1	0	1	1	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	16
Can. com.	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	1	0	1	1	1	0	0	0	18
Can. str.	0	1	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	0	1	0	0	0	0	1	0	1	0	1	1	1	0	0	0	22
Com. wig.	0	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	1	1	26
Gar. pin.	0	1	0	0	0	1	0	1	1	0	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	0	14
Fil. dec.	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	1	0	1	0	0	10
Pro. cau.	0	1	0	0	1	1	1	0	1	1	0	1	1	1	1	1	0	0	1	1	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	17
Pro. ser.	0	1	1	0	1	1	1	0	1	0	0	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	0	16

Table : 5.4 Manhattan Distances Betsween Pairs of OTUs. of the Burseraceae

	Bos. ser.	Bur. gla.	Bur. del.	Can. com.	Can. str.	Com. wig.	Gar. pin.	Fil. dec.	Pro. cau.	Pro. ser.
Bos. ser.	-	13	12	14	16	16	14	20	15	16
Bur. gla.	-	-	1	15	14	15	11	17	10	9
Bur.del.	-	-	-	14	14	14	10	18	9	8
Can.com.	-	-	-	-	4	18	10	20	11	10
Can. str.	-	-	-	-	-	16	10	20	11	10
Com. wig.	-	-	-	-	-	-	18	22	13	14
Gar. pin.	-	-	-	-	-	-	-	16	7	6
Fil. dec.	-	-	-	-	-	-	-	-	11	14
Pro. cau.	-	-	-	-	-	-	-	-	-	3
Pro. ser.	-	-	-	-	-	-	-	-	-	-

The seeds of the advanced families (Poaceae and Asteraceae) are protected by the pericarp which is presistant or fused with the seedcoat. This indicates that the contribution of pericarp as a hard covering around the seed is a derived trait. So the pyrenes with only endocarp is considered primitive when compared with the pyrenes in which the mesocarp also is fused with the endocarp.

Character 18 : Fruit without receptacle = 0, Fruit with receptacle = 1.

Any contribution from the receptacle to the fruit formation is advantageous to the plant. In some of the Burseraceae the receptacle of the fruit forms a central fistulose structure which form wings between the pyrenes. As a result the seeds are dispersed in a more efficient way. Therefore the fruit with a persistant receptacle is considered advanced.

Characters 27,29,30 :

Absence of monoterpenes = 0, Presence of monoterpenes = 1.
Absence of sesquiterpenes = 0, Presence of sesquiterpenes = 1.
Absence of diterpenes = 0, Presence of diterpenes = 1.

The polarity of these characters is determined by the outgroup comparison.. These terpenes were less frequent or absent from the sister groups such as the Anacardiaceae, Simaroubaceae and Meliaceae. Therefore the presence of these terpenes in Burseraceae form apomorphic states.

Character 28 : Absences of bicyclic monoterpenes = 0, Presence of bicyclic monoterpenes = 1.

Bicyclic monoterpenes are formed by the cyclisation of the monocyclic monoterpenes. Since bicyclic compounds represent a derived state their presence is given a score = 1.

Caharacters 31, 32 :

Presence of lupeol' = 0; Absence of lupeol = 1.
Absence of cannaric acid = 0, Presence of cannaric acid = 1.

The plesiomorphic and apomorphic states of these two characters are established following Khalid (1983). Lupeol is widespread in **Bursera** sp. This compound on further oxidation gives rise to a 3,4-secotriterpene, cannaric acid. The plants with lupeol has fewer enzymes and are simpler. Therefore the presence of lupeol is considered primitive while that of cannaric acid is an advanced feature.

Character 34, 35 :

Presence of α-amyrin = 0, Absence of α-amyrin = 1.
Absence of boswellic acid/commicacid = 0, Presence of boswellic acid/commic acid = 1.

Boswellic acid and commic acid are also formed late in the biosynthetic pathway indicating their presence to be an advanced feature while the -amyrin occurs at the earlier stages and therefore is a primitive character.

Character 36 : Absence of guggulsterols = 0; Presence of guggulsterols = 1.

Guggulsterols in **Commiphora** are derived from the ubiquitous phytosterols. Since these are derived compounds, the occurence of them is given an apomorphic status. The outgroup comparision also resulted in the same conclusions.

Results :

The distribution of various flavonoids, phenolic acids, saponins and tannins in nine members of the Burseraceae is presented in Table5.1. Flavonols formed the dominant phenolic pigments in the family in that all the plants screened contained them. The flavonols encountered are kaempferol, quercetin, myricetin and their methoxylated derivatives. Quercetin and their methoxylated derivatives occuring in all the plants screened formed the most abundant flavonols. 3'-OMe Quercetin, 3', 4'-diOMe quercetin, & 3,3',4'-triOMe quercetin are the various quercetin derivatives identified. 3'-OMe Quercetin and 3', 4'-diOMe quercetin showed 70% incidence while the 3,3',4'-triOMe quercetin showed 20% incidence occuring only in the genus **Canarium**. Kaempferol is located in two genera, **Protium** and **Bursera**. **Gaurga**, **Boswellia** and **Canarium** possessed myricetin. Biflavones such as agathisflavone are also quite frequent having been located in seven members. Both **Boswellia** and **Commiphora** are devoid of them. The latter genus is distinct in containing the flavone, acacetin, confined to it. Except **Commiphora**, all the plants screened produced proanthocyanidins in their leaves. The proanthocyanidins are chiefly of cyanidin type. Of the nine phenolic acids located, seven were benzoic acids and two were cinnamic acids. p-Hydroxybenzoic acid and vanillic acid are the most common compounds. Cinnamic acids were less common. Gallic acid was found in **Garuga**, **Boswellia** and **Canarium**. Tannins occur throughout the family in large amounts. Saponins were locatd in **Filicium** only.

Discussion :

The most striking feature of the family is the production of biflavones in seven members of the family. These biflavones are seen in only one other family Anacardiaceae

Table : 5.1 **The Distribution of Various Flavonoids, Phenolic Acids, Tannins & Saponins in 10 Members of the Family Burseraceae.**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
TRIBE PROTIEAE																					
1. **Garuga pinnata** Roxb.		+			+		+		+	+	+		+	+	+	+	+	+	+	+	
2. **Protium caudatum** W.&A.		+	+		+		+			+	+		+			+				+	
3. **P serratum** Engl.		+	+		+	+	+			+	+		+	+		+				+	
TRIBE BOSWELLIEAE																					
4. **Boswellia serrata** Roxb.						+	+		+	+				+		+	+			+	
5. **Bursera glabrifoliola** Engl.		+	+			+	+			+	+		+	+		+		+	+	+	
6. **B. delpechiana** Poiss.		+	+	+	+					+	+		+	+						+	
7. **Commiphora wightii** Bandari	+					+					+	+	+								
TRIBE CANARIEAE																					
8. **Canarium commune**		+			+	+		+	+	+	+		+	+			+	+	+	+	
9. **C. strictum** Roxb.		+				+		+		+	+		+	+			+	+	+	+	
10. **Filicium decipiens** Thw.							+			+	+		+		+					+	+

1. Acacetin 2. Biflavones 3. Kaempferol 4. 4'-OMe Kaempferol 5. Quercetin 6. 3'-OMe Quercetin 7. 3', 4'-DiOMe Queretin 8. 3,3',4'-TriOMe Quercetin 9. Myricetin 10. Proanthocyanidins 11. p-Hydroxybenzoic acid 12. Protocatechuic acid 13. Vanillic acid 14. Syringic acid 15. Melilotic acid 16. Gentisic acid 17. Gallic acid 18. **cis** p-Coumaric acid 19. **trans**. p-Coumaric acid 20. Tannins 21. Saponins.

within the Rutales and this feature brings both these families together. This is further supported by the occurence of similar type of flavonols, proanthocyanidins, tannins and morphological characters.

Though **Filicium decipiens** Thw. has some similarities to the members of the Burseraceae in the flavonoid chemistry, it does not contain biflavones and di-/triterpenes prevalent in the family. It contains saponins, a feature common with the family Sapindaceae to which the genus is often referred to. Therefore the shifting of **Filicium** to Sapindaceae seems to be more appropriate (see also the discussion on the Sapindaceae).

With the exclusion of **Filicium**, the Burseraceae appear a chemically homogeneous taxon characterised by biflavones, flavonols, proanthocyanidins and tannins. Terpenes such as monoterpenes and triterpenes with different oxidation pattern also occur throughout the family. The homogeneity of the family is to such an extent that the 3 tribes are difficult to be distinguished from each other on the chemical characters.

Eventhough the 3 tribes are chemically not very distinct certain taxonomic trends can be observed. The tribe Canarieae contains trimethoxy-quercetin, gallic acid and cinnamic acids such as **cis** and **trans** p-coumaric acids. The two tribes Protieae and Boswellieae are similar in containing kaempferol, 3',4'-di OMe quercetin and similar type of pentacyclic triterpenes. The characters shared by the tribe Canarieae and Boswellieae are the presence of 3'-OMe quercetin and similar type of triterpenes such as α -amyrin (ursane series) and β-amyrin (oleanane series).

The genus **Commiphora** is distinct from other taxa of the family in containing some of the advanced characters such as the presence of flavones and absence of proanthocyanidins and tannins. The absence of primitive characters and the presence of advanced characters such as flavones, sesquiterpene lactone, commiferin, and highly oxidised triterpenes such as commic acid keep this genus as the most advanced taxon of the family.

Protium caudatum is strikingly different from the species of **Commiphora** (**C. wightii**) with which it is some times grouped. P. **caudatum** contains kaempferol, quercetin and proanthocyanidins while **Commiphora** contains flavones and 3'-OMe quercetin. Incidentally P. **serratum**, another species of **Protium** screened, contains the same chemical compounds present in the former plant. Infact the two species of **Protium** are indistinguishable and therefore the placement of P. **caudatum** along with P. **serratum** is valid. In containing biflavones and similar flavonols, the two genera **Protium** and **Bursera** are chemically not distinct. So **Protium serratum** can be placed either in **Protium** or in **Bursera** (**B. serrata**).

The predominance of primitive chemical characters such as biflavones, myricetin, proanthocyanidins and tannins keep the Burseraceae at a lower level in evolutionary hierarchy. The production of flavones and methoxylated flavonols by a few members evidently indicates the possibility of deriving the advanced families of this order i.e. the Rutaceae, Simaroubaceae, (possessing flavones) and Meliaceae (containing highly methoxylated flavonols) from the Burseraceae. This view was discussed in detail by Khalid (1983) who opines that "the strong ability for oxidative modification of a number of terpenes may reflect the early states of the limonoids of the Rutaceae and Meliaceae and quassinoids of Simaroubaceae". The primitiveness of the family is evident in the wood structure also (Metcalfe and Chalk, 1950).

CLADISTIC ANALYSIS :

The Wagner tree superimposed on the Wagner 'Bull eye' chart is presented in Fig. 5.1 and the dendrogram in Fig. 5.2. The tree forks near the base at the level 4 and the first branch terminates in **Filicium** at level 10. The second branching is from HTU2 at level 9 where the bifurcation produces two major branches, A and B. The branch A consists of three OTUs belonging to **Garuga** and **Protium**. From this branch **Garuga** separates at the node HTU3 and the other branch bears the two species of **Protium**. **Protium caudatum** is the most advanced member of this group reaching the level 16. The branch B holds six plants belonging to the genrea **Boswellia**, **Bursera**, **Canarium** and **Commiphora**. From this branch, **Bursera**, **Commiphora** and **Boswellia** get deviated sequentially from the node HTU6, HTU4 and HTU7 respecitvely. This branch terminates in **Canarium** (two species). **Commiphora wightii** with AD(I) value 26 is the most advanced taxon of this branch and also of the family and **Filicium decipiens** with AD(I) value 10 is the most primitive taxon in the family.

Discussion :

From the cladogram it is clearly evident that except **Filicium decipiens**, all the taxa of the family are closely related to each other. The separation of **Filicium** at the base of the family tree indicates that it is a stranger within the Burseraceae. The magnitude of differences in morphological (extrastaminal lobed disk and solitary pendulous ovules in each locule), embryological (presence of obturator, nucellar beak and hypostase) and chemical characters (absence of wide range of terpenes, biflavones and presence of saponins) is so large emphasising the great dissimmilarity of **Filicium** with any member of the Burseraceae. Therefore, the shifting of this taxon to the Sapindaceae, the nearby family to which **Filicium** shares a number of characters (see the discussion

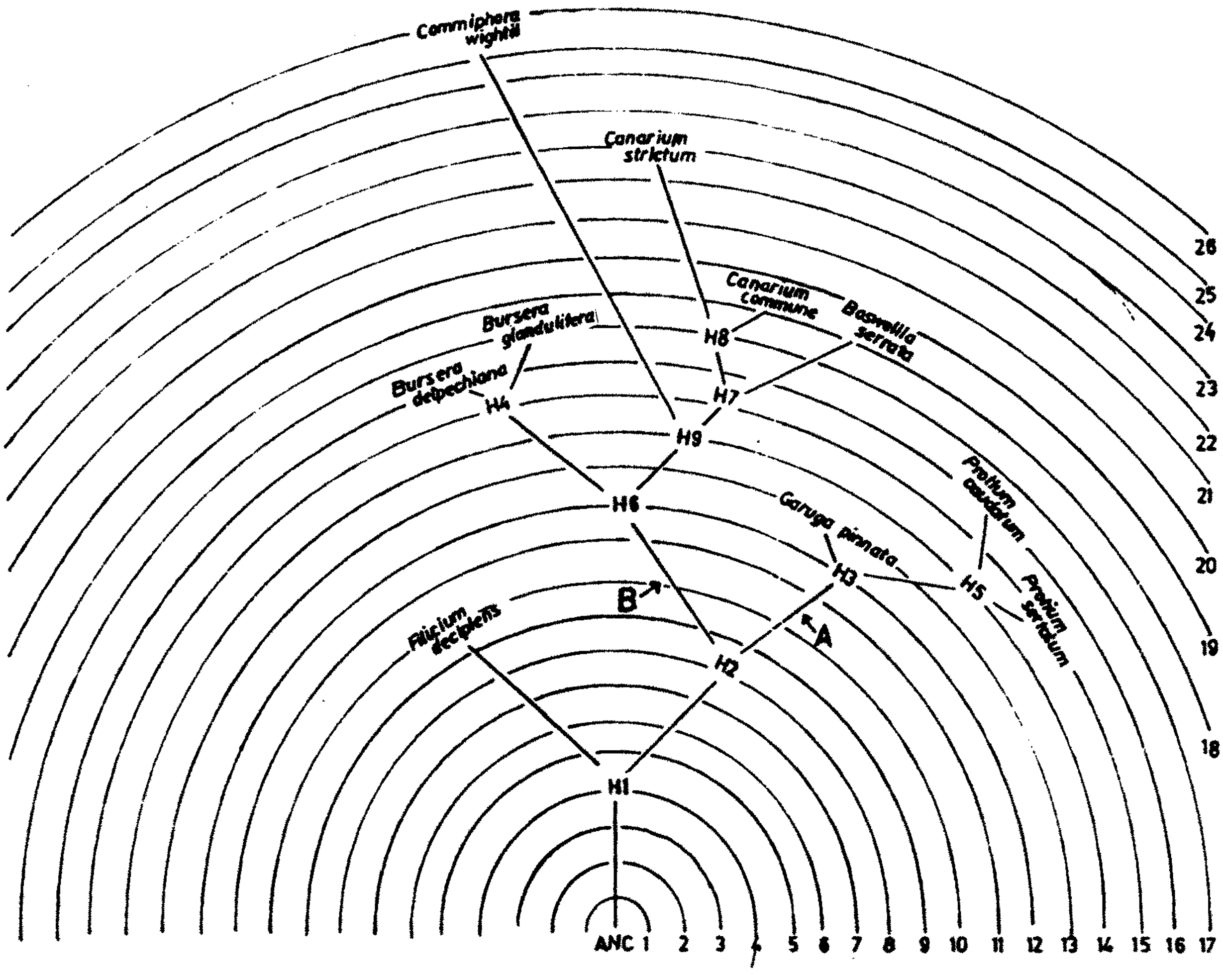

Fig. 5.1 Cladogram depicting the phylogenetic relationships within the Burseraceae

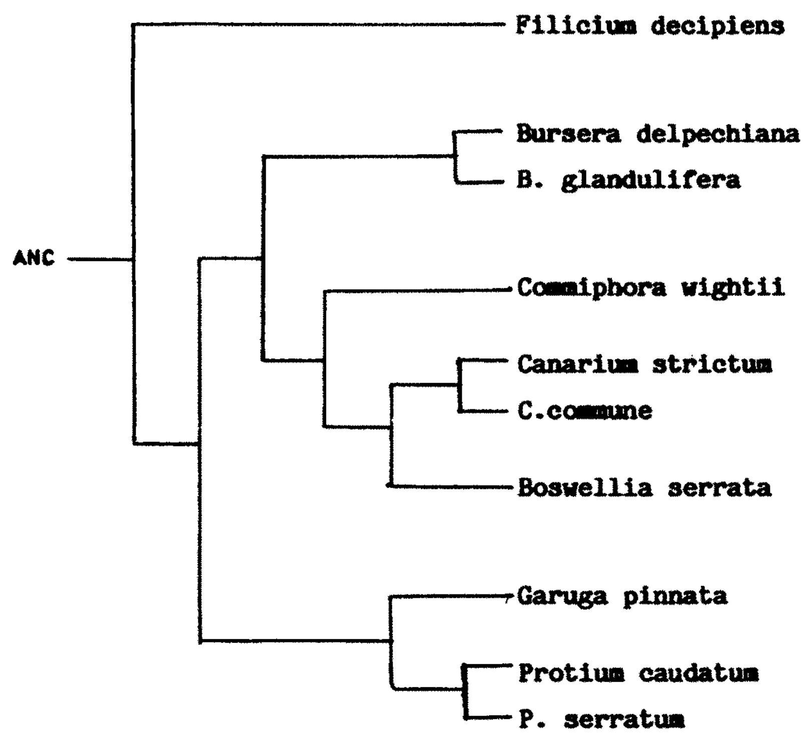

Fig. 5.2 Dendrogram of some members of the family Burseraceae

in Sapindaceae) is highly logical and proper.

Unlike the observations from the chemical characters, the branching pattern, more or less, agrees with that of Engler's division of the family. The branch A corresponds to the tribe Protieae while the branch B includes plants of both the Boswellieae and Canarieae. The genus **Commiphora** has equal minimal distances from **Bursera**, **Boswellia** and **Canarium**. This indicates that **Commiphora** enjoys same amount of affinity with all the 3 genera. So the merger of these two tribes is in order and this group may be given the name of the larger tribe the Boswellieae.

The present analysis positions **Protium caudatum** next to **Protium serratum** indicating the overall similarities these two species enjoy. This means that the former species is more at home in the genus **Protium** rather than in **Commiphora**. In the same way the distance shown by **Protium serratum** with species of **Bursera** in the cladogram reflects its dissimilarities with the latter genus and therefore the shifting of latter genus **Protium serratum** to **Bursera** as B. **serrata** is taxonomically unsound.

The need for optimisation and the low values obtained during the calculation of minimum distances indicate the close relationship enjoyed by the members of the Burseraceae. Thus this family evidently is a very natural taxon where the members evolved certain special characters such as resin ducts, biflavones and the ability to synthesise a wide range of terpenes. These conclusions are in line with the results from the chemical analysis.