CLADISTIC ANALYSIS OF FAMILIES WITHIN THE CARYOPHYLLALES

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Cladistics is a method by which the organisms are ranked entirely on the basis of recency of common descent, that is, on the basis of sequence of dichotomies in the inferred phylogeny. It aims at decreasing the amount of subjectivity and intuition. Cladistics, in strict sense, does not allow the existence of polyphyletic groups or an existing taxon to be ancestral to any other existing taxon. The cases of parallelism, convergence, divergence and hybridisation cannot be represented in a cladistic treatment. The polarity of characters as well as the selection of out-groups are mostly left to the judgement of the taxonomist, thus increasing the subjectivity. Of the many cladograms theoretically possible, the one which is most parsimonious is selected preferably by a computer. Cronquist (1987), while thoroughly criticising the cladism, calls for a restraint on the indiscriminate usage of the method in deducing phylogeny. He suggests exercising a rational consideration in the selection of characters and advises to prepare the cladogram manually on the basis of Wagner's groundplan-divergence method (Wagner, 1980).

In the present study 14 families, belonging to the Caryophyllales and the related taxa, have been subjected to

a cladistic treatment using characters taken from morphology and chemistry. Though Wagner's groundplan-divergence method is followed largely, a number of logical modifications are done to produce a more parsimonious tree.

Eighteen characters, taken from morphology and chemistry, have been used for the construction of a cladogram. Of the 18 apomorphic characters selected, 11 were from morphology and the rest from chemistry. Polarity of the morphological characters was assessed following Cronquist (1968), Hutchinson (1948) and Takhtajan (1980); whereas for the chemical characters, the known biosynthetic pathways and correlation studies were used. The selected characters and their plesiomorphic and apomorphic status are presented in the table 20 . The distribution of these characters in the families studies is represented in the table 21 . An advanced (apomorphic) character was given a score-I, while the primitive (plesiomorphic) character was given the score-0.

Wagners 'bulls eye' chart, consisting of a number of concentric semicircles having a common base point, was prepared in which each semicircle represented a single evolutionary state. These semicircles were given number 1,2,3 etc. The total number of apomorphic characters corresponded to the total number of semicircles. The score

of the taxon gave the extent of advancement that taxon attained and the corresponding semicircle in which it is to be placed. For e.g. if the taxon A had a total score of 17, then it was considered highly advanced and placed on the 17th semicircle.

The hypothetical ancestor, having all the plesiomorphic characters, formed the groundplan. The construction of cladogram strictly followed the pattern of the formation of dichotomous keys of identification found in a flora. The length of a branch represented the total number of common characters of that group. Branching occurred at the point where some members of this group acquired additional advanced characters. From this node two branches diverged, one with the acquired characters and the other without them. Further branching occurred with the acquisition of more characters. In the case of closely allied taxa; one taxon say B, was derived from a close relative A, if B possessed all the characters of A, in addition to its own acquired characters. But if B did not contain all the characters of A, both A and B were considered two separate branches of the same evolutionary line. A most advanced taxon occupied the farthest semicircle and that taxon with least advanced characters occupied the lowest semiricle.

Explanation of some of the characters used

8. Wind polination (Anemophily)

Wind polination in gymnosperms is a primitive character whereas in angiosperm it is considered a derived condition associated with the reduction of perianth.

9. Flavones

Flavones are always associated with the advanced group of angiosperms.

10. Glycoflavones

Glycoflavones represent a primitive situation in angiosperms, but when compared to the presence of more primitive flavonols, the presence of glycoflavone is an advanced feature.

11. Proanthocyanidins

Proanthocyanidins form another feature associated with woody nature. Their absence is therefore advanced.

13. Presence of Quinones

Presence of quinones is normally correlated with other advanced characters, so it is also considered as an advanced character.

14. Tannins

Tannins are found associated with primitive woody plants,

and hence considered as a primitive character. The loss of tannins in plants is a relatively advanced feature.

16. Presence of perisperm

Presence of massive endosperm is a primitive character, whereas presence of perisperm as chief nutritive tissue of the embryo is an advanced character.

17. Flavonols

Flavonols as the main phenolic pigment occur in large amounts in primitive woody angiosperm. The rarity of these compounds represent processes leading to the elimination of these compounds.

18. Pantoporate type of pollen

It is generally accepted that the uniaperturate and tricolpate pollen grains are primitive and other type of pollens are derived from it, hence the pantoporate pollen is considered advanced.

The cladogram showing the relationships of the Caryophyllalean families and the Polygonaceae is presented in Fig. 5

TABLE - 20. Showing the characters and their apomorphic and Plesiomorphic status

Sl. No.	Character	Plesiomorphic Score-0	Apomorphic Score-1
1.	Placentation	Parietal	Basal
2.	Habit	Woody	Herbaceous
3.	Arrangement of leaves	Alternate	Opposite
4.	Sex of the flower	Bisexual	Unisexual
5.	Nature of carpels	Apocarpous	Syncarpous
6.	Number of stamens	Unlimited	Limited
7.	Number of ovules	Unlimited	Limited
8.	Nature of pollination	Entomophilous	Anemophilous
9.	Flavones	Absent	Present
10.	Glyflavones	Absent	Present
11.	Proanthocyanidins	Present	Absent
12.	Betalains	Absent	Present
13.	Quinones	Absent	Present
14.	Tannins	Present	Absent
15.	p-type plastids	Absent	Present
16.	Nature of nutritive tissue of the embryo	Endosperm	Perisperm
17.	Flavonols	Abundance	Rarity
18.	Pollen	Tricolpate	Pantoporate

TABLE - 21. Showing the distribution of various characters in the families studied.

FAMILIES	1 BASAL Placentation	2 Herbaceous habit	3 Opposite leaves	4 Unisexual flowers	5 Syncarpous gynoecium	6 Limited number of stamens	7 Limited number of ovules	8 Anemophilous	9 Flavones	10 Glycoflavones	11 Absence of pro-anthocyanidins	12 Presence of Betalains	13 Rarity of flavonols	14 Presence of Quinones	15 Absence of Tannins	16 Presence of Periderm	17 P-type plastids	18 Pantoporate pollen	Total Score
AMARANTHACEAE	+	+	-	-	+	+	+	+	+	+	+	+	+	-	+	+	+	+	15
CHENOPODIACEAE	+	+	-	-	+	+	+	+	-	+	+	+	-	-	+	+	+	+	14
CACTACEAE	-	-	-	-	+	-	-	-	-	-	-	+	-	-	+	+	+	-	5
AIZOACEAE	-	+	+	-	+	-	-	-	-	-	-	+	-	-	+	+	+	-	7
PHYTOLACCACEAE	+	+	+	-	-	+	+	+	-	+	+	+	+	-	+	+	+	+	12
NYCTAGINACEAE	+	-	+	-	+	+	+	-	-	-	+	+	+	-	+	+	+	+	12
GISEKIACEAE	+	+	+	-	-	+	+	+	-	-	+	+	-	-	+	+	+	+	12
PETIVERIACEAE	+	+	+	-	+	+	+	+	-	-	+	+	-	-	+	+	+	+	13
ILLECEBRACEAE	+	+	+	-	+	+	+	+	-	-	+	-	-	-	+	+	+	+	12
BASELLACEAE	+	+	+	-	+	+	+	-	+	+	+	+	-	-	+	+	+	+	14
CARYOPHYLLACEAE	-	+	+	-	+	+	+	+	+	+	+	-	+	-	+	+	+	+	14
MOLLUGINACEAE	-	+	+	-	+	+	+	+	+	+	+	-	+	-	+	+	+	+	14
PORTULACACEAE	+	+	+	-	+	+	-	-	-	-	+	+	+	-	+	+	+	+	11
POLYGONACEAE	+	+	-	-	+	+	+	+	-	-	+	-	-	+	-	-	-	-	9

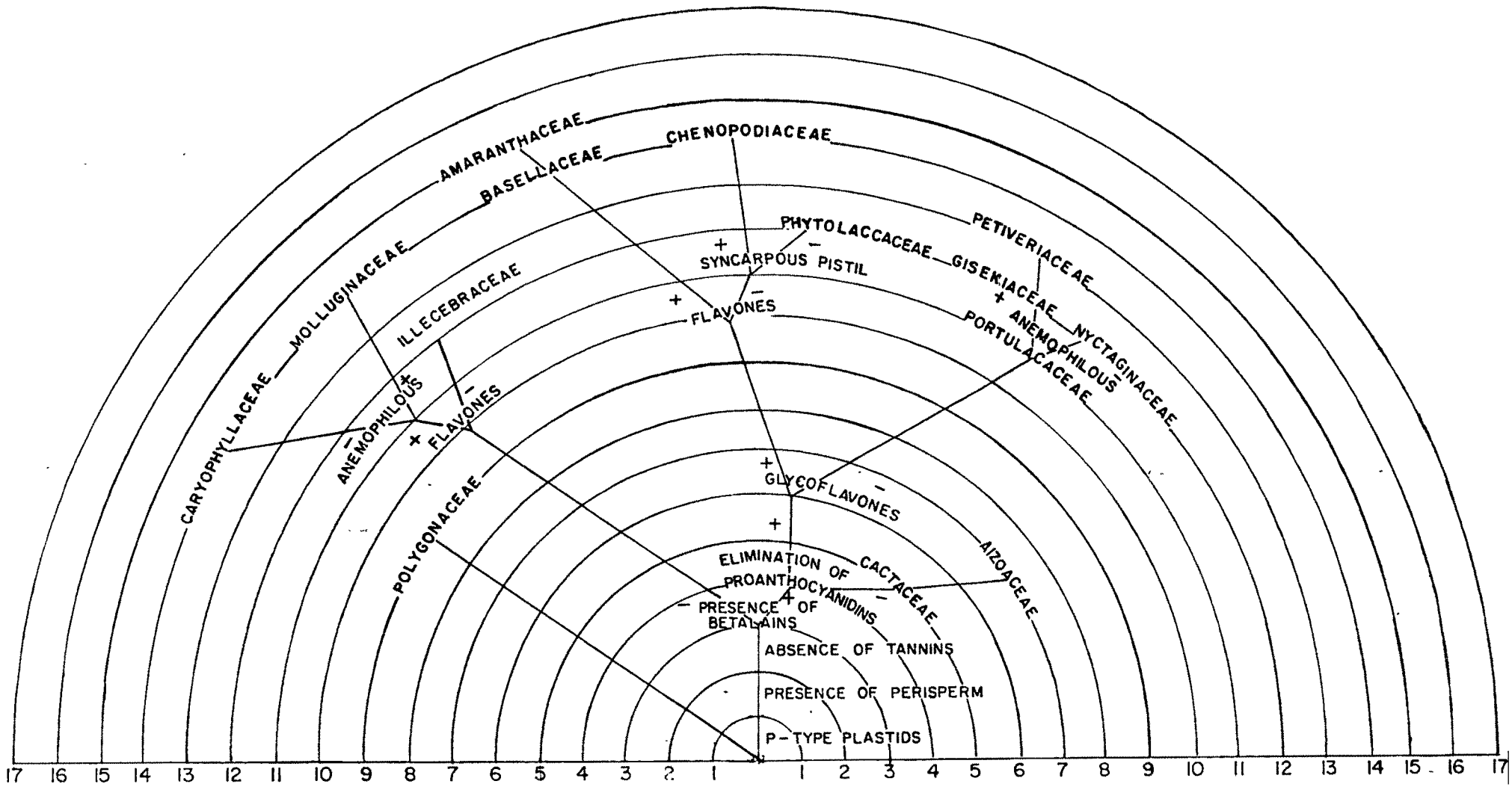

FIG. 5 A CLADOGRAM SHOWING RELATIONSHIP OF THE CARYOPHYLLALES (Cronquist, 1981) AND POLYGONACEAE.

From the Cladogram it is evident that the Polygonaceae diverged from the rest of the families at the base itself. All other families evolve together by developing P-type plastids, perisperm and eliminating the quinones. The apomorphic characters of the Polygonaceae elevate this family to the level 9.

A dichotomy occurrs in the Caryophyllalean families at level 3; one branch, containing the Caryophyllaceae, Molluginaceae and Illecebraceae, diverges in their inability to synthesise betalains from the rest of the families which develops betalains.

The betalain-containing group forks at the level four. The plants acquiring pantoporate type of pollen, limited number of stamens and the elimination of proanthocyanidins proceed as one branch away from the other branch containing Aizoaceae and Cactaceae. The Cactaceae remains at the level five. The Aizoaceae possess all the apomorphic characters of the Cactaceae, in addition to their own acquired characters. So Aizoaceae which reach the level 7 is derived from the Cactaceae.

The group which acquired the pantoporate type of pollen, limited number of stamens and elimination of proanthocyanidins reaches the level 6 where further

branching occurs. The Portulacaceae, Nyctaginaceae, Petiveriaceae, and Gisekiaceae form the first branch which is unable to synthesise glycoflavones, and Amaranthaceae, Phytolaccaceae, and Chenopodiaceae form the second branch which synthesises glycoflavones. Of the families of the first branch, the Portulaccaceae is the most primitive member of this group having a score of 11. From this family two lines of evolution i.e. the Nyctaginaceae on one hand and the Petiveriaceae through Gisekiaceae on the other hand emerges. The former line (Nyctaginaceae) retain the entomorphilous nature and the latter resorted to anemophily.

In the glycoflavone containing group dichotomy occurrs at the level 10. The Amaranthaceae and Basellaceae having flavones, form the first branch and the Chenopodiaceae and Phytolaccaceae without flavones form the second branch. Since the Amaranthaceae have all the characters of the Basellaceae, they are derived from the latter family. The Chenopodiaceae and Phytolaccaceae forked at the level 11.

In the branch representing the anthocyanin group, forking takes place at the level 10. The Illecebraceae diverge from the branch containing the Molluginaceae and Caryophyllaceae, due to their inability to synthesise flavones. The Molluginaceae and Caryophyllaceae which elaborate flavones diverged at the level 11. From the

Cladistic analysis it is evident that the Amaranthaceae are the most advanced family and the Cactaceae are the most primitive family.