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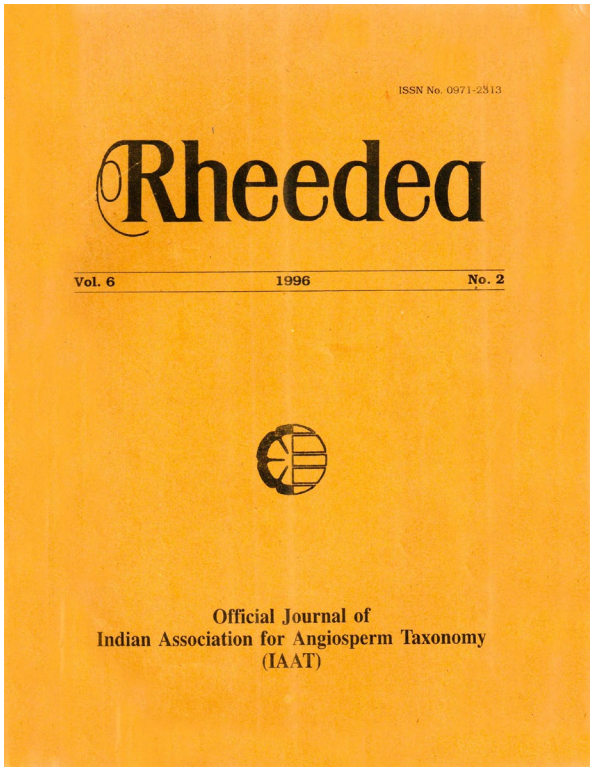

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Cladistics of Cucurbitaceae

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Abstract

A phytochemical study on 45 representative species of Cucurbitaceae is investigated. The chemical data, coupled with the data from anatomy, embryology and morphology of the families usually bracketed in most of the taxonomic treatments purporting the kinship, have been cladistically analysed. It is tentatively held that Bixaceae and Flacourtiaceae constitute the ancestral stock and Cucurbitaceae show early divergence reaching the top slot in the cladogram. It is considered that they are more advanced among the taxa in question. Their unorchestrated attainment, pre-empts any fraternal alliance. Therefore, their elevation to an independent ordinal status, is adduced.

INTRODUCTION

Ever since the publication of Hennig's (1966) book 'Phylogenetic Systematics' there has been a major revolution in the systematic methodology. One of the two methodologies is the Cladistics (the other being the Numerical Taxonomy), with sequence of evolutionary dichotomies, reflecting the divergence, wherein the taxa are ranked on the basis of recency of common descent. There has been an acrimonius, criticism about cladism that it 'steals' the 'name and aura' of taxonomy (Cronquist, 1987) on account of some inherent defects such as failure to recognise the cases of paraphyly, parallelism, convergence, hybridization etc.. Discounting the deficiencies and apprehensions Donoghue and Cantino (1988) and Humphries and Chapill (1988) defended the cladism, as a means to unravel the precise lineage of a taxon.

The Cucurbitaceae received varied taxonomic treatments with regard to their relationships. They are placed in a unifamilial or multifamilial order Cucurbitales according to Engler and Prantl (1936) and Hutchinson (1973) respectively. They are accommodated in Violales with overlapping sets of families in the treatments of Takhtajan (1980), Cronquist (1981), Goldberg (1986) and

Thorne (1992) implying the kinship. In the present communication it is proposed to pinpoint the evolutionary divergence of Cucurbitaceae, through manual cladistic analysis from a band of ten families that are common to most of the phylogenetic systems of classification.

MATERIAL AND METHODS

The phytochemical data with a galaxy of constituents in 45 species, spread over 15 genera and 6 tribes of Cucurbitaceae (Jeffery, 1967, 1980, 1988; Chakravarthy, 1982; noticed in the course of analysis (Gibbs, 1974; Harborne, 1973; Santa Ram, 1982) were squared up and organised into respective major classes of secondary metabolites (Table 1) which have proven and profound chemotaxonomic significance in resolving the relationships at familial levels. The voucher of specimens were deposited in the Department of Botany, Nizam College. The information for all the families in question was culled from the data base of Gornall et al. (1979) and compendium of Gibbs (1974) for chemistry, Johri *et al.* (1991) for embroyology and Cronquist (1981, 1988) for morphology, besides massive compiled data of Sporne (1980).

Of the several methods in vogue, the Wagner's Ground Plan Divergence Method was followed, on account of its simplicity. The polarity of the characters was assessed following the well established dicta of Hutchinson (1973), Takhtajan (1980), Cronquist (1981), Goldberg (1986) and Sporne (1980), and inferences of Bate Smith (1962) and Smith (1976). The selected characters, and their plesiomorphic (-) and apomorphic (+) character-states are shown in Table 2.

OBSERVATIONS

The relative advancement of various families, allegedly related to Cucurbitaceae is based on the total score, as shown in Table 3. The two anatomical synapomorphic character-states namely the vessels with simple performation plates and S-type of sieve tube plastids as denoted by numbers 15 and 16 in the cladogram (Fig. 1) constitute first two concentric semicircles. The first dichotomy in the cladogram is based on the sexuality of the flower (10- and 10+).

Such families as Bixaceae, Cistaceae, Turneraceae and Loasaceae are known for thebisexual flowers. Since this is a primitive feature, the branch leading these families with synapomorphic character states 12 and 13 is continued upto 4 semicircles. At this stage, on account of habital feature a further dichotomy occurs. With the possession of such synapomorphic character states 18,20 and 21, Bixaceae gets delinked signifying as one of the most primitive families with a least total score of 7. Similarly the other families branched out along with Bixaceae get pared off due to a series of dichotomies at successive levels.

On the other hand, the second set of families, which are in possession of unisexuality as the character-state include Datiscaceae, Begoniaceae, Passifloraceae and Caricaceae and get distinguished at level 10, while Flacourtiaceae get branched off much earlier at level 3. The Violaceae with such character-states as the presence of zygomorphic flowers and absence of ellagic acid are held up at lower level. Cucurbitaceae due to a number of apomorphic states denoted by 3, 6,8,9,11,14,18,22 and 24 reach the highest level in the cladogram.

Cladistics of Cucurbitaceae

Table 1. List of taxa studied

Sl.No.	Name of the taxon	Place of Collection	Voucher Specimen Number
		I. Tribe: Benincaseae	
1.	*Benincasa hispida* (Thunb.) Cogn.	Hyderabad, A.P.	11
2.	*Bryonopsis laciniosa* (L.)Naud.	Hyderabad, A.P.	13
3.	*Citrullus colocynthis* (L.)Schrad.	Hyderabad, A.P.	20
4.	*Citrullus vulgaris* (Schrad.) Schrad.	Hyderabad, A.P.	22
5.	*Citrullus vulgaris var. fistulosus* (Stocks.) Chakrav.	Hyderabad, A.P.	43
6.	*Lagenaria siceraria* (Molina) Stand.	Hyderabad, A.P.	12
7.	*Luffa acutangula* (L.) Roxb.	Hyderabad, A.P.	14
8.	*Luffa acutangula* (L.) Roxb.	Baurvelle National Park, Bombay.	44
9.	*Luffa cylindrica* (L.) M.Roem.	Hyderabad, A.P.	15
10.	*Luffa cylindrica* (L.) M.Roem.	Puttaparthi, A.P.	24
11.	*Luffa acutangula* var. *amara* (Roxb.) C.B.Cl.	Deverakonda, A.P.	25
12.	*Coccinia indica* Wight & Arn.	Hyderabad, A.P.	4
13.	*Coccinia indica* Wight & Arn.	Hyderabad, A.P.	5
		II.Tribe: Cucurbiteae	
14.	*Cucurbita moschata* (Duch.ex Lam.) Duch. ex Poir.	Hyderabad, A.P.	18
15.	*Cucurbita maxima* Duch. ex Lam.	Hyderabad, A.P	16
16.	*Cucurbita pepo L.*	Hyderabad, A.P.	17

Sl.No.	Name of the taxon	Place of Collection	Voucher Specimen Number
		III.Tribe: Joliffieae	
17	*Momordica balsmaina* L.	Dharamsala,H.P.	36
18.	*Momordica charantia* L.	Hyderabad, A.P.	6
19.	*Momordica charntia* var. *muricata* (Willd.) Chakrav.	Warangal, A.P.	7 vs
20.	*Momordica diocica* Roxb. ex Willd.	Warangal,A.P.	8 vs
21.	*Momordica involucrata* E.Meyer.	Warangal, A.P.	45 vs
22.	*Momordica tuberosa* Hook .f.	Cuddapah,A.P.	42
23.	*Momordica subangulata* Bl.	Calicut, Kerala	29
		IV. Tribe : Melothrieae	
24.	*Blastania fimbristipula* Kotschy & Peyr.	Hyderabad, A.P.	1
25.	*Cucumis melo* var. *agrestis* Naud.	Hyderabad, A.P.	23
26.	*Cucumis melo* var. *melo* Chakrav.	Bellary, Karnataka	27
27.	*Cucumis* sp.	Mamidipalli, A.P.	9
28.	*Cucumis prophetarum* L.	Calicut, Kerala	28
29.	*Cucumis sativus* L.	Hyderabad, A.P.	34
30.	*Cucumis trigonus* Roxb.	Jadcherla, A.P.	26
31.	*Dicaelospermum ritchiei* Clarke	Baurvelle National Park, Bombay	

Cladistics of Cucurbitaceae

Sl.No.	Name of the taxon	Place of Collection	Voucher Specimen Number
32.	*Melothria heterophylla* (Lour.) Cogn.	Dharamsala, H.P.	32
33.	*Melothria lieosperma* (Wight & Arn.) Cogn.	Madras, Tamil nadu	41
34.	*Melothria mederaspatana* (L.) Cogn.	Warangal, A.P.	2
35.	*Melothria mucronata* (Bl.) Cogn.	Hyderabad, A.P.	3
36.	*Melothria perpusilla* (Bl.) Cogn.	Ooty, Tamil Nadu	39
37.	*Zehneria maysorensis* (Wight & Arn.) Arn.	Calicut, Kerala (Wayanad)	35
	V. Tribe : Trichosantheae		
38.	*Trichosanthes anguina* L.	Hyderabad, A.P.	19
39.	*Trichosanthes bracteata* (Lam.) Voigt	Bhadrachalam, A.P.	30
40.	*Trichosanthes cucumerina* L.	Warangal, A.P.	10 v s
41.	*Trichosanthes cuspidata Lam.*	Zoopark, Hyderabad	40
42.	*Trichosanthes dioica* Roxb.	Calcutta, W.B.	21
43.	*Trichosanthes nervifolia* L.	Calicut, Kerala	31
44.	*Trichosanthes* sp.	Dharamsala, H.P.	37
	VI. Tribe : Sicyoeae		
45.	*Sechium edule* (Jacq.) Sw.	Hyderabad, A.P.	33

Table 2 . Characters and Character-States employed in the cladistic relationships of Cucurbitaceae

Character		Plesiomorphic state (Score -0)	Apomorphic state (Score -1)
Morphological			
01.	Habit	arborescent	Herbaceous
02.	Phyllotaxy	Alternate	Opposite
03.	Stipules	Present	Absent
04.	Leaves	Simple	Compound
05.	Inflorescence	Racemose	Cymose
06.	Corolla	Polypetalous	Gamopetalous
07.	Floral symmetry	Actinomorphic	Zygomorphic
08.	Aestivation	Other than valvate	Valvate
09.	Union of stamens	Free	Connate
10.	Sexuality of flower	Bisexual	Unisexual
11.	Flower in relation to position of ovary	Hypogynous	Epigynous
12.	Fruit	Fleshy	Capsule
13.	Placentation	Other than axile	Axile
14.	Seed	Endospermic	Non-endospermic
Anatomical			
15.	Perforation plate of the vessel	Scalariform	Simple
16.	Sieve-tube plastids	P-type	S-type
Embryological			
17.	Ovular integuments	Bitegmic	Unitegmic
18.	Ripe pollen	2-celled	3-celled
Chemical			
19.	Alkaloids	Absent	Present
20.	Flavonols	Present	Absent
21.	Flavones	Absent	Present
22.	Proanthocyanidins	Present	Absent
23.	Ellagic acid	Present	Absent
24.	Steroids	Absent	Present

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Table 3 . The distribution of character-states in the associates of the Cucurbitaceae

Taxa	Character-states																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total Score
Cucurbitaceae	1		1		1	1		1	1	1	1	1	1	1	1	1		1	1		1	1		1	18
Begoniaceae	1				1		1	1		1	1	1		1	1	1		1	1						11
Bixaceae												1	1		1	1		1		1	1				7
Caricaceae			1	1	1	1			1	1			1		1	1			1						10
Cistaceae	1	1	1		1							1	1		1	1		1			1				10
Datiscaceae			1	1						1		1	1	1	1	1						1	1		10
Flacourtiaceae					1					1		1	1		1	1					1				7
Loasaceae	1	1	1		1			1	1		1	1	1		1	1	1	1				1	1		15
Passifloraceae	1				1					1		1	1		1	1			1		1		1		10
Turneraceae	1		1		1							1	1		1	1			1				1		9
Violaceae	1				1		1			1		1	1		1	1			1		1		1		11

Apomorphic character-states

(1) Herbaceous habit
(2) Opposite leaves
(3) Stipules absent
(4) Compound leaves
(5) Inflorescence
(6) Gamopetalous corolla
(7) Zygomorphic flower
(8) Valvate aestivation
(9) Connate stamens
(10) Unisexual flower
(11) Epigynous ovary
(12) Fruit capsule
(13) Placentation other than axile
(14) Non-endospermic seed
(15) Vessel with simple perforation
(16) Seive tube plastid S-type
(17) Unitegmic ovule
(18) Ripe pollen 3-celled
(19) Alkaloid present
(20) Flavonols absent
(21) Flavones present
(22) Proanthocyanidins absent
(23) Ellagic acid absent
(24) Steroids present

Note: 1. Represents the apomorphic character-state, while blank the plesomorphic state.

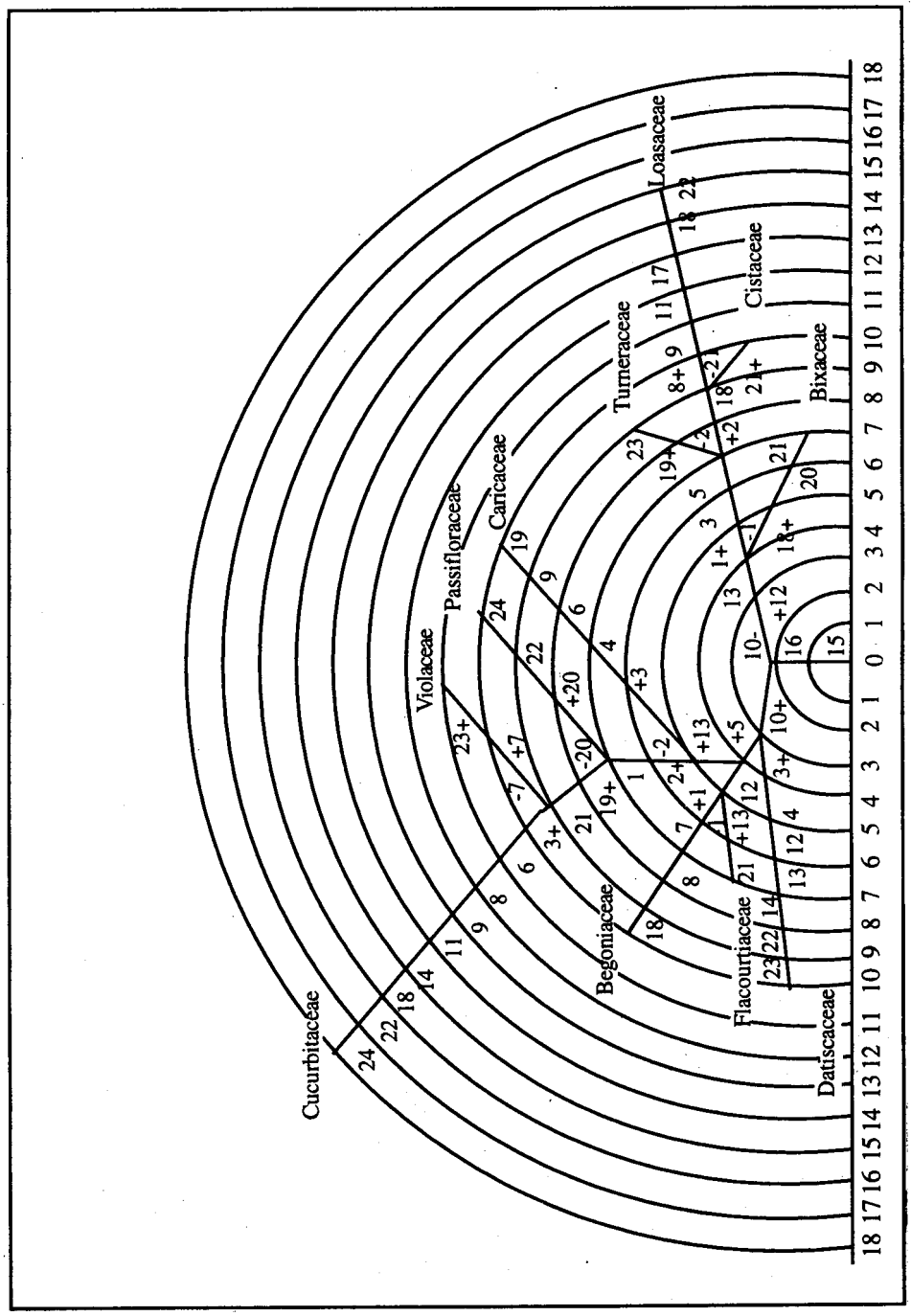

Fig. 1. Cladistic analysis of Cucurbitaceae and allegedly related taxa.

DISCUSSION

From the forgone account it is evident that Flacourtiaceae and Bixaceae form the ancestral stock and Cucurbitaceae attain the highest advancement unaccompanied by any other taxon. This indicates early divergence of the latter through the remaining families. Thus Cucurbitaceae can tentatively interpreted as a family with no fraternal links and it has only filial alliance with the rest, in the order. It also lends support to Englerian unifamilial ordinal status as Cucurbitales rather than sequestrated status (Cronquist, 1981) in Violales or their equivalent.

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Literature cited

Bate-Smith, E.C.1962. The phenolic constituents of plants and their taxonomic significance. I. Dictotyledons. *J. Linn. Soc. (Bot.)* 58:95-174.

Chakravarthy, H.L.1982. Cucurbitaceae. *Fascicles of Flora of India,* 11. B.S.I., Howrah.

Cronquist, A.1981. *An integrated system and classification of flowering plants.* Columbia Univ. Press, New York.

Cronquist, A. 1987. A Botanical Critique of cladism. *Bot.Rev.* 53:1-52.

Cronquist, A. 1988. *The evolution and classification of flowering plants.* Columbia Univ. Press, New York.

Donoghue M.J & P.D. Cantino. 1988. Paraphyly ancestry and the goals of taxonomy. A botanical defense of cladism. *Bot. Rev.*54:107-128.

Engler, A. & K.Prantl. 1936. *Die Naturlichen Pflazen familien.* Leipzig, Germany.

Gibbs, R.D. 1974. *Chemotaxonomy of flowering plants.* 1-IV. McGill. Queens Univ. Press, London.

Goldberg, A. 1986. *Classification, Evolution and Phylogeny of the families of Dicotyledons.* Smithsonian Institution, Washington.

Gornall, R.J., B.A. Bohm & R.Dahlgren. 1979. The distribution of flavanoids in the angiosperms. *Bot.Notiser* 132:1-30.

Harborne, J.B.1973. *Phylogenetic Systematics* (Eng.Transl., D.D.Davis and R. Sangerl). Urbana.

Hutchinson, J.1973. *The families of flowering plants.* Clarendon Press. London.

Humphries, C.J. & Chapill. 1988. Systematics as science- Response to Cronquist. *Bot.Rev.* 54:129-144.

Jeffrey, C. 1967. Cucurbitaceae. *In:* Emilne - Redhead & R.M.Rolhill (Eds.), *Flora of Tropical Coast Africa.* Crown Agents, London.

Jeffrey, C.1980. A review of the Cucurbitaceae. *Bot.J. Linn.Soc.* 81:233-247.

Jeffrey, C. 1988. The Cucurbitaceae of the Indian subcontinent. *Kew Bull.*34:789-809.

Johri, B.M., J.B.Ambergaokar, & P.S. Srivastava. 1991. Comparative embryology of angiosperms I & II. Springer - Verlag, Berlin.

Santaram, A. 1983. A Chemotaxonomic study of some species of Coffea, Cocoa, Thea. 27:183-190.

Smith, P.M. 1979. *The Chemotaxonomy of Plants.* Edward Arnold Ltd., London.

Sporne, K.R. 1980. A reinvestigation of character correlation among dicotylendons. *New Phytol.* 419-449.

Takhtajan, A. 1980. Outline of the classification of flowering plants (Magnoliophyta). *Bot.Rev.* 46:225-359.

Thorne, R.F. 1992. Classification and geography of the flowering plants. *Bot.Rev.*58:225-348.