CHEMOSYSTEMATICS OF THE PHYTOLACCACEAE

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INTRODUCTION

The Phytolaccaceae, a loosely knit family of 18 genera and 125 species (Cronquist, 1981), are widely distributed in tropical and subtropical regions especially of the new world. Some members of this family such as Phytolacca, Rivina, Agdestis, Ercilla and Petiveria are ornamentals of repute. Young shoots of Phytolacca americana are used as edible 'greens' or pot herbs.

Members of this family vary in habit from herbs (sometimes climbing) to shrubs and even small and medium sized trees. Leaves are simple, entire; arranged alternately. Inflorescences most commonly are axillary or leaf-opposed racemes, sometimes spikes or open cymes. Flowers are regular, small, perfect (sometimes unisexual) and hypogynous. Sepals mostly 4-5, distinct or connate below. Petals are absent except in Stegnosperma. Stamens 4-many, in two alternating cycles and twice as many as the sepals, when numerous originating in centrifugal sequence. Filaments distinct or basally connate. Anthers tetrasporangiate and dithecal opening by longitudinal slits. Gynoecium consists of one (Rivina) or, more often, 2-many carpels. Carpels are distinct or more or less connate to form a

compound pistil with distinct styles and as many locules as carpels (in Stegnosperma the partition is ephemeral). Ovules are solitary in each locule or in each simple pistil, campylotropous, bitegmic, crassinucellar and basal. Fruits are various; berry, drupe, schizocarp, urticle or achene.

TAXONOMY

The Phytolaccaceae have been divided into three tribes viz. the Rivineae (9), Euphytolaccae (4), and Gyrostemoneae (4) (Bentham and Hooker, 1865). The tribe Rivineae possess 4 tepals, one style (or even absent), unicarpellate, unilocular ovary and one seeded fruit. The Euphytolaccae contain members with 5 tepals, 5-10 styles, ovary of 5 or more nearly free carpels which are sometimes united at the base and a 5-seeded black berry. The tribe Gyrostemoneae is characterized by more or less lobed or truncate tepals which are persistent in fruit, 6- or more stamens in one or more series around or on a flat central disk, superior ovary with 2 or more carpels connate around a central column, free styles and solitary ovule in each carpel attached to the inner angle. Stegnosperma and Agdestis were not assigned to any of the above tribes and were considered genera anomali. Lawrence (1951) recognized 5 tribes viz. the Stegnospermae, Agdesteae, Rivineae, Barbeyieae and Euphytolaccae in this family. Thorne (1968) divided the Phytolaccaceae into 4 subfamilies,

viz. the Phytolaccoideae, Stegnospermatoideae, Microteoideae and Achatocarpoideae. Hutchinson (1973) regrouped the members belonging to these taxa into five families, the Phytolaccaceae sensu stricto, Barbeuiaceae, Gyrostemonaceae, Agdestidaceae and Petiveriaceae. Cronquist (1981), is of the opinion that all these families should be accommodated in the Phytolaccaceae under the appropriate subcategory.

Gisekia (with 5 species), a genus of controversial systematic position, had originally been included in the tribe Gisekieae in the Phytolaccaceae (Moquin-Tandon, 1849; Heimerl, 1889). Cronquist (1981) also agreed to the placement of Gisekia in Phytolaccaceae. Muller (1908), Pax and Hoffmann (1934) and Ehrendorfer (1976) assigned this genus to the Aizoaceae. Hutchinson (1934), Eckardt (1964) and Takhtajan (1966) included this genus in Molluginaceae because of the similarities in habit, inflorescence and in pollen and ovule morphology. Apart from that Gisekia have parity with the Molluginaceae in P-type sieve element plastids (Mabry et al., 1976) and in many embryological features (Raghavan and Sreenivasan, 1940). Nakai (1942) even created an unigeneric family Gisekiaceae. After the discovery of betalains in Gisekia, Mabry et al. (1976) also supported a separate family status for this genus.

A controversy of similar nature exists regarding

the placement of Sphenoclea, a genus normally assigned to the Campanulaceae. This taxon was shifted to the Phytolaccaceae by Airy shaw (1948) due to presence of dense spikes and some superficial morphological similarities. Hutchinson (1969) retained the genus in the Campanulaceae because of the characters like sympetalous flowers, semi-inferior bilocular ovary containing many ovules and circumscissile capsule which are not seen in the Phytolaccaceae. Some of the characters such as circumscissile dehiscence of fruits and the dense spike of Sphenoclea are not found in other Campanulaceae members. These features prompted Cronquist (1981) to raise this genus to a monogeneric family, the Sphenocleaceae, closer to the Campanulaceae.

EARLIER CHEMICAL WORK

The known chemical data of various taxa within the Phytolaccaceae (Table 7) include flavonoids like flavonols and glycoflavones (Richardson, 1978), triterpenoid and related compounds like Phytolaccagenin, A, Acinolic acid A, Acinolic acid B, Jaligonic Acid, 20-β-carbomethoxyoleanolic acid, Dimethylphytolaccagenin and Phytodecanol. Alkaloids reported in this family are Cadonocarpine and N-methyl Codonocarpine (Doskotch, et al. 1974).

In the present work, 5 plants belonging to the two tribes, the Rivinoae and Euphytolaccae have been screened

TABLE 7 SOME OF THE EARLIER CHEMICAL WORKS IN THE PHYTOLACCACEAE

Sl.No.	Name of the plants	Organ	Name of the compounds	Reference
			STEROIDS	
1	Phytolacca americans	-	Jaligonic acid, Phytolaccagenin, Olean-12-en-28-oic and olean-12-en 28,30 dioc acid. r-Spinasterol β Stigmasterol their D.glucoside and their acylated (6' palmityl) glycoside	Woo,Worn.S (1974)
2	Phytolacca acinosa		3β-acetoxy-30β-methyloleanate-12 en-28 β-oic acid 3β-23γ-diacetoxy-28 -methyloleanate -12-en-3D βoicacid 2β-3β-23γ triacetoxy-28 β-methyl Oleanate-12-en 30 β-oic acid	Razdan et al (1983)
3	Phytolacca acinosa	14-en-2	14-en-3γ,30 β-diol-3-acetate 3γ acetyltarazen 14-en-28 β oic acid	Razdan et al (1982)
4	Phytolacca esculenta		Jaligonic acid, 2β, 3β, 23-trihydroxy-Olean-12 ene 28,30 dioic acid	Woo Wonsick(1973)
5	Phytolacca rivinoides		20β-Carbomethoxy-oleanolica acid	Gonealez et al (1972)
6	Phytolacca acinosa	Berries	3β-acetoxy 30β-methyl oleanate-12-en-28 β-oic acid. 3β, 23-γ-diacetoxy -28 β-methyl oleanate 12-en 30β-oic acid and 2β, 3β, 23 triacetoxy-28 β-methyl oleanate 12 en. 30β-oic-acid	Razdan et al (1983)
7	Phytolacca americana	Berries	Dimethyl phytolaccagenin 3β-23-dihydroxy olean-12-ene-28 30 dioc acid	Johnson et al (1974)

(Contd...)

TABLE 7 (Contd.)

Sl.No.	Name of the plants	Organ	Name of the compounds	Reference
8	Phytolacca acinosa	Berries	Phytodaccanol acid, epiacetyl oleuricolic acid (Sitosterol)	Razdan (1982)
9	Phytolacca dodecandra	Fruit	Oleanoglycotoxin - A 3(2,4,dio (β-D-glucopyranosyl) - β-D-glucopyranosyl olean-12-ene β 28-oic acid	Parkhurst et al. (1973)
			ALKALOIDS	
10	Codonocarpus anstralis		Codonocarpine and N-Methyl-codonocarpine	Dokotch et al. (1974)

for various chemical markers.

MATERIALS AND METHODS

Screening was done with plant materials collected from different localities of Gujarat, Kashmir and Kerala.

Standard procedures were followed for the extraction, isolation and identification of various chemical markers (ref. chapter 2) Petiveria alliaceae was analysed for their sulphur compounds and the chromatographic pattern was compared with that of garlic (Allium sativum). The procedure followed for the analysis of sulphides is as follows: Leaf powder of Petiveria alliaceae was extracted with methanol. The methanol extract was then concentrated, HCl was added to this concentrate and allowed to dry. To this dry residue, solvent ether was added and spotted on TLC plates along with garlic extract as reference. The solvent-system used was, Toluene : ethylformate : formic acid (5:4:1). The developed plate was then placed in an iodine chamber for detecting sulphur compounds which appeared as brown spots.

RESULTS

The distribution of flavonoids, phenolic acids, alkaloids, saponins and steroids from the leaves of 5 members of Phytolaccaceae is presented in the Table. 8

TABLE - 8 . DISTRIBUTION OF PHENOLIC ACIDS, SAPONINS, STEROIDS, ALKALOIDS AND FLAVONOIDS IN THE FAMILY PHYTOLACCACEAE*

Sl.No.	Name of the plants	1	2	3	4	5	6	7	8	9	10
	PHYTOLACACEAE										
	TRIBE - RIVINEAE										
1.	Petiveria alliaceae Linn.	+		+			+	+		+	+
2.	Rivina humilis Linn.	+	+	+	+		+	+			
	TRIBE - EUPHYTOLACEAE										
3.	Phytolacca acinosa Roxb.	+	+	+			+	+	+		
4.	P. latbenia Buch-Ham.	+		+		+	+	+	+		

1. Vanillic, 2. Syringic, 3. p-OH Benzoic, 4. Gentisic, 5. Chlorogenic,
6. Saponins, 7. Steroids, 8. Alkaloids, 9. 3'-OMe Quercetin,
10. 3',4'-DiOMe quercetin.

* After Bentham and Hooker (1880).

Except flavonols no other flavonoid was obtained from this family. Petiveria alliaceae was the only member which contained flavonols-3'-OMe quercetin and 3',4'-di-OMe quercetin.

Five phenolic acids have been identified in this family, of which vanillic, and p-OH benzoic acid were very common. Gentisic acid was confined to Rivina and Chlorogenic acid to Phytolacca latibenia.

Saponins and steroids were present in all the members screened. Alkaloids were present in Phytolacca acinosa and P. latibena (Euphytolaccae). None contained tannins, proanthocyanidins, iridoids or quinones. Three sulphur containing compounds were detected in Petiveria alliaceae of which two were similar to those of garlic.

DISCUSSION

Petiveria alliaceae is quite distinct from all other members screened in containing flavonols. It also has a rare distinction of possessing sulphides which are otherwise not reported from this family. These features in conjunction with the morphological uniqueness of Petiveria in having dry and elongated fruit with 4 reflexed, sharp, apical, prickles; densely pubescent ovary, and stigma with hairs, recommend a separate identity to this taxon, and supports the family status assigned to it.

TABLE 9 INTERRELATIONSHIP OF *Gisekia* WITH THE PHYTOLACCACEAE, MOLLUGINACEAE AND AIZOACEAE

Characters	*Gisekia*	Aizoaceae	Molluginaceae	Phytolaccaceae
1) Branching of vascular bundles at the node	Monopodial	Sympodial	Sympodial	Sympodial
2) Photosynthetic pathway	C_4 Pathway	CAM Pathway	C_4 Pathway	C_3 Pathway
3) Sieve element plastids	P-type plastids with protein crystaloids P:gC.rbF	S-type plastids with globular protein crystaloids P: gF.rbF	S-type plastids with globular protein crystaloids P: gC.rbF	S-type plastids with globular protein crystaloids P:gC.rbF
4) Inflorescence	Dichasium, Pleiochasium	Cymose inflorescence	Dichasium, Pleiochasium	Racemose, Spike, Panicle
5) Nature of Pistil	Apocarpous, each carpel with one basal ovule	Syncarpous, 2-5 or more carpels united to form a compound ovary, each carpel with one to numerous ovules in basal, apical or parietal placentation	Syncarpous-each carpel with many axile ovules	Apocarpous, each carpel with one basal ovule
6) Betalains	Present	Present	replaced by Anthocyanins	Present
7) Flavonoids	Flavonols	Flavonols	Flavones and glycoflavones	Flavonols

The features of similarity/dissimilarity of Giseckia with all the three families, the Phytolaccaceae, Aizoaceae, and Molluginaceae, with which it was associated at one time or another, are presented in Table - 9 . In containing betalains and flavonols (Richardson, 1981) it resembles the Aizoaceae and Phytolaccaceae. The apocarpous pistil with each carpel containing one basal ovule is another feature similar to the Phytolaccaceae. It possesses similar P-type sieve element plastids subgroups P.gC.rbF (Behnke, 1976) which is also present both in Molluginaceae and Phytolaccaceae.

In spite of these similarities, Giseckia finds an odd place in all these three families. It differs from the Phytolaccaceae in inflorescence structure, C_4 photosynthetic pathway and in certain nodal anatomical features (Sharma, 1968). In the fine structure of sieve-element plastids, structure of inflorescence, nature of gynoecium and in nodal anatomy, Giseckia is dissimilar to all the members of Aizoaceae. The Molluginaceae do not contain flavonols, betalains and apocarpous pistil and monopodial branching of vascular connection at nodes (Sharma, 1968) which are the characteristic features of Giseckia.

Since it is apparent that the inclusion of Giseckia in any of the families mentioned above will create marked hetrogeneity in otherwise homogeneous families, the best

possible solution is to keep it separate as a unigeneric family as practised by Nakai (1942). The presence of flavonols and betalains keep this family, the Gisekiaceae closer to the Aizoaceae and Phytolaccaceae than to the Molluginaceae. The interrelationships of the Gisekiaé (the Gisekiaceae) with the other families mentioned above are represented in Fig. 2.

Rarity or near absence of flavonoids in the Phytolaccaceae Sensu lato is the main argument against the inclusion of flavonol-rich Sphenoclea (Daniel and Sabnis, unpublished) in this family. Moreover, Sphenoclea does not possess betalains, the pigments unique to Caryophyllales. Embryological and anatomical studies (Subramanyan, 1950) also do not favour such a merger.

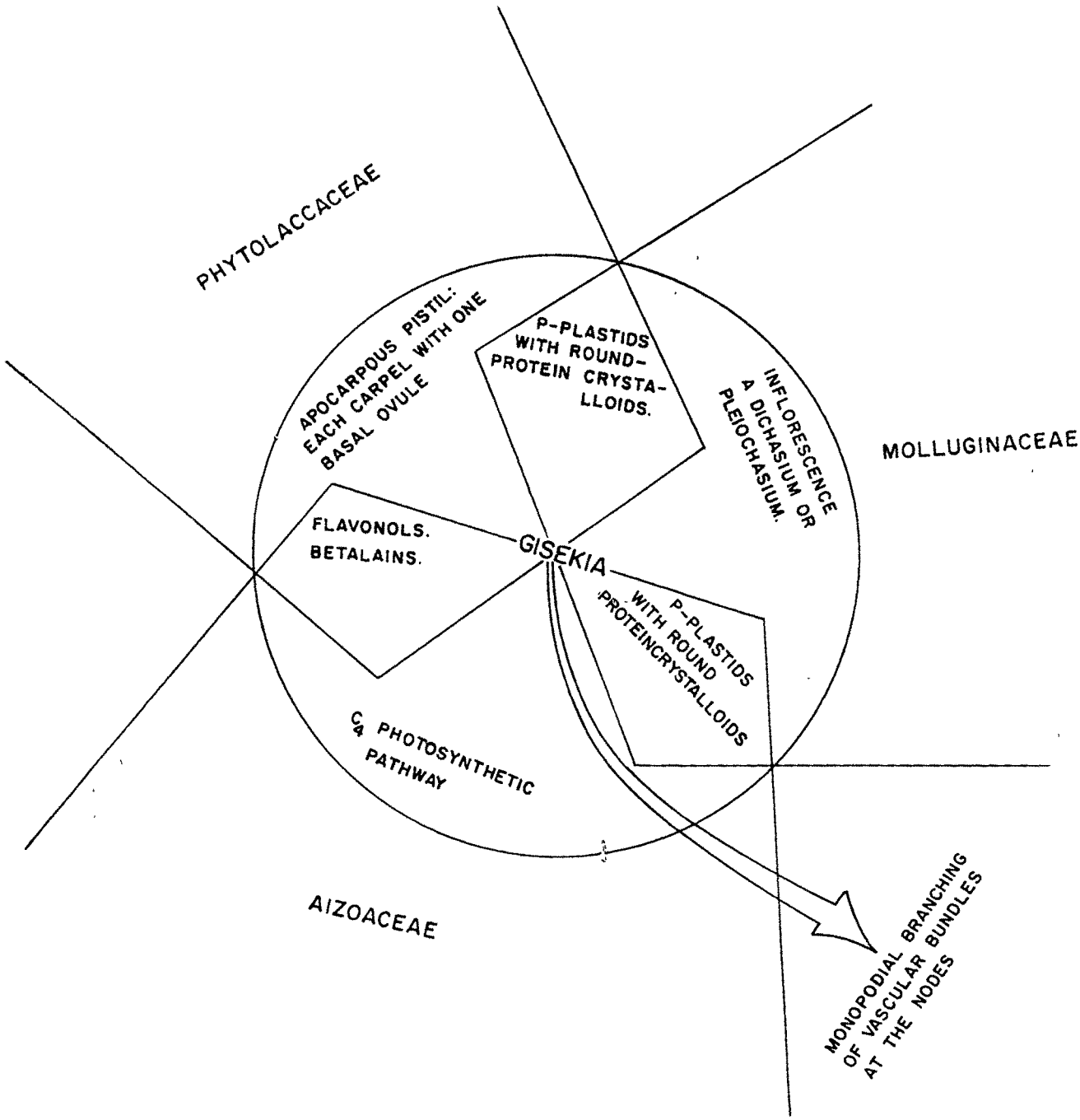

FIG. 2 INTERRELATIONSHIPS OF GISEKIA