Foliar architecture of Passiflorales occurring at Visakhapatnam

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This article discribes the foliar architecture including the gross morphology and venation patterns in 14 species of Passiflorales occurring at Visakhapatnam, India. The venation patterns recorded are pinnately pancraspedo-brochidodromous, craspedodromous, palmatous actino-brochidodromous, actinodromous and campylo-actinodromous types. The term campylo-actindromous type is newly introduced. The foliar architecture is found to be of taxonomic importance and a key for identification of these species is provided.

Key-words- Foliar architecture, Passiflorales, Taxonomy.

INTRODUCTION

IN Angiosperms, the foliar architecture has been considered as a good taxonomic character especially when used with other characters. (Lee 1948; Hickey 1973, 1979; Hickey & Wolfe 1975; Foster, 1950; Varghese 1966; Melville 1963, 1976; Kundu 1974; Sehgal & Paliwal 1975; Singh *et al.* 1976; Mohan & Inamdar 1982; Rao *et al.*, 1983; Spicer 1986; Anna Mani & Prabhakar 1991a, 1991b; Anna Mani 1993; Ferzana Jabeen *et al.* 1991). The present investigation is a part dealing with the identification of Visakhapatnam flora based on the foliar architecture.

MATERIAL AND METHODS

Mature leaves of 14 species belonging to Passiflorales *viz.*, *Benincasa hispida* (Thunb.) Cogn., *Citrullus colocynthis* (L.) Schrad. *Coccinea grandis* (L.). Voigt., *Cucurbita maxima* Duch., *Cucumis sativus* L., *Lagenaria leucantha* (Duch.) Rusby., *Luffa acutangula* (L.) Rob., *L. cylindrica* (L.) Roem., *Momordica charantia* L., *Mukia maderaspatana* (L.) Roem., *Trichosanthes anguina* L. and *T. tricuspidata* Lour. (Cucurbitaceae), *Turnera ulmifolia* L. (Turneraceae), *Passiflora foetida* L. (Passifloraceae) available at Visakhapatnam (Venkateswarlu *et al.*, 1972) have been collected and preserved in Carnoy's fixative (Johansen, 1940). Ten leaves of each species collected from five different plants were cleared following the usual techniques (Dilcher 1974). The terms used are after Hickey (1973, 1979), Melville (1976), Prabhakar and Ramayya (1982), Anna Mani and Prabhakar, (1991a, 1991b, 1992) and Ferzana Jabeen *et al.* (1991). To accommodate the new venation patterns encountered, the term campylo-actinodromous (one or more primary veins or their branches originating at, or close to a single point and running in strongly developed, recurved arches before diverging towards margin) is introduced.

OBSERVATIONS AND DISCUSSION

The leaves are simple, alternate, symmetrical. They are elliptic in *Turnera ulmifolia*, cordatus-lobed in *Cucurbita maxima*, *Benincasa hispida*, *Lagenaria leucantha* and *Cucumis sativus*, cordatus-angularis in *Coccinea grandis*, *Luffa acutangula* and *L. cylindrica*, cordate in *Mukia maderaspatana*, palmatifid, cordate-trilobed in *Passiflora foetida* and *Trichosanthes anguina*, pedatus in *Trichosanthes tricuspidata*, *Citrullus colocynthis* and *Momordica charantia*. The margin is crenulate in five taxa, crenate in *Mukia*, lobed in *Citrullus*, entire in *Passiflora*, crenulate to lobed in *Momordica* and *Trichosanthes tricuspidata*, erosus in *Benincasa* and *Lagenaria*, serrulate in *Cucurbita* and biserratus in *Turnera*. The apex is acute in *Passiflora*, *Lagenaria*, *Luffa cylindrica*, *Turnera*, *Trichosanthes tricuspidata* and *Benincasa*, retuse in *Cucumis*, acute mucronate in *Luffa acutangula*, obtuse in *Citrullus* and obtuse mucronate in five other taxa. Leaf base is cordate in all except in *Turnera* and *Citrullus* where it is acute and obtuse respectively (Table 1).

The general venation pattern is planiusculus (veins distributed in one plane in the mesophyll; c.f. Prabhakar & Ramayya 1982), palmatous actino-brochidodromous

in *Passiflora, Coccinea* and *Luffa acutangula* (Figs. 1B, 3B); actinodromous in *Cucurbita, Cucumis, Lagenaria, Luffa cylindrica, Momordica, Mukia* and *Trichosanthes tricuspidata* (Fig. 3A); campylo-actinodromous in *Benincasa* (Fig. 2A) and *Trichosanthes anguina*, while pinnately planiusculus pancraspedo-brochidodromous (secondary veins branching within the margin, one of the branches terminating at the margin, the other joining the superadjacent secondary veins throughout the leaf; Synonym: semicraspeodromous of Hickey, 1973) in

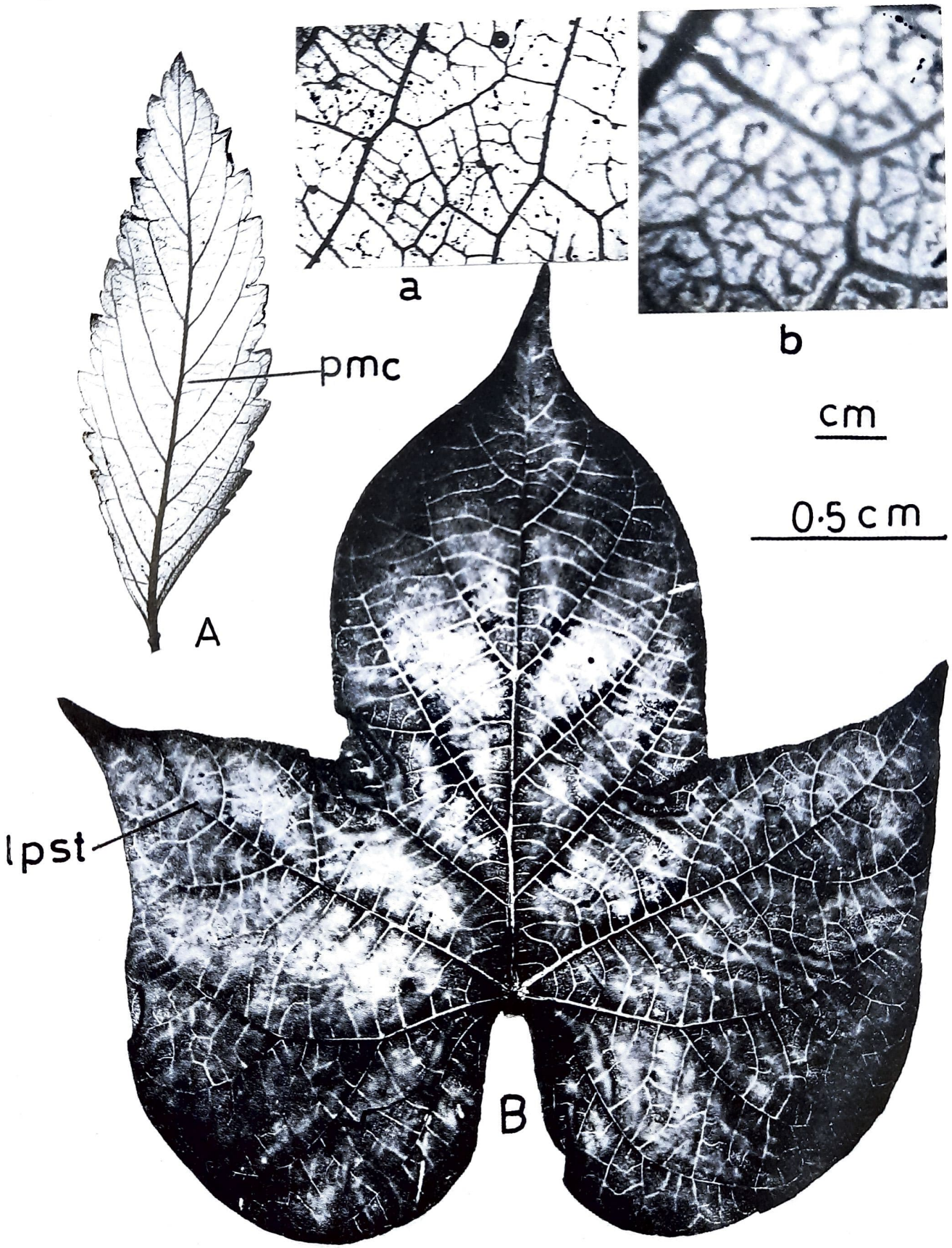

Figure 1 A, B. Leaves showing venation patterns, a,b. enlarged portion from middle of the leaf showing areoles and veinlets; A,a. pancraspedo-brochidodromous in *Turnera ulmifolia*; B,b. Actino-brochidodromous in *Passiflora foetida* (lpst-lateral primaries straight; Pmc-primary vein curved).

Table 1. Macromorphology of leaf

Name of the taxa	Leaf ramification	Apex	Base	Margin	Venation type	Lateral primaries		
						Number	Course	Angle of divergence
Turnera ulmifolia	S	A	A	BS	PCB	-	-	-
Passiflora foetida	PAF	A	C	EN	AB	4	UC	AM-R
Benincasa hispida	S	A	C	ER	CA	2	RET	AW
Citrullus colocynthis	PAF	OB	OB	LO	CRA	-	-	-
Coccinia grandis	S	OBM	C	CRE	AB	4	STR	AM-R
Cucurbita maxima	S	OBM	C	SER	AC	2	STR	AW
Cucumis sativus	S	RE	C	CRE	AC	4	STR	AM-R
Lagenaria leucantha	S	A	C	ER	AC	2	STR	AM
Luffa acutangula	S	AMU	C	CRE	AB	2	STR	AM-R
L. cylindrica	S	A	C	CRE	AC	6	STR	AM-OB
Momordica charantia	PAF	OBM	C	CRE-LO	AC	2	STR	AW
Mukia maderaspatana	S	OBM	C	CR	AC	2	STR	AW
Trichosanthes anguina	PAF	OBM	C	CRE	CA	2	RET	AW
Trichosanthes tricuspidata	PAF	A	C	CRE-LO	AC	2	STR	AW

A-acute; AB-actino-brochidodromous; AC- actinodromous; AM-acute moderate; AMU- acute mucronate; AW - acute wide; BS- biserratus; C-cordate; CA-campylo-actinodromous; CR- crenate; CRA-craspedodromous; CRE-crenulate; EN-entire; ER-erosus; LO-lobate; OB-obtuse; OBM-obtuse mucronate; PAF-palmatifid; PCB- pancraspedo-brochidodromous; R- right angle; RE-retuse; RET- retroflexed; S-simple; SER-serrulate; STR-straight; UC- uniformly curved; - absent.

Turnera (Fig. 1A) and craspedodromous in *Citrullus* (Fig. 2A; Table 1). The thickness of the primaries are stout in 12 taxa but in *Citrullus* and *Mukia* it is moderate. The course of the median primaries are usually straight in all but curved in *Turnera* and *Citrullus* (Figs. 1A, 2B). The lateral primaries vary from two to six (Fig. 2A; Table 1). The angle of divergence of the lateral primaries are acute moderate to right angle in *Passiflora, Coccinea, Cucumis* and *Luffa acutangula* (Figs. 1B, 3B), acute moderate to obtuse angle in *Luffa cylindrica* (Table 1), acute wide in *Benincasa, Cucurbita, Momordica, Mukia* and *Trichosanthes anguina* (Fig. 2A) and acute moderate in *Lagenaria* and *Trichosanthes tricuspidata* (Table 1). The lateral primaries are uniformly curved in *Passiflora* (Fig. 1B), recurved in *Benincasa* and *Trichosanthes anguina* (Fig. 2A) and straight in rest of the nine species (Table 1). The lateral primaries are simple in *Passiflora* (Fig. 1B) but branched in others.

Table 2. Characters of secondary veins

Name of the taxa	Secondaries of Midvein/Lateral veins			Course	Behaviour of loop forming branches
	Number	Position	Angle of Divergence		
Turnera ulmifolia	20/-	OP-AL/-	AN-AM/	UC-AC	A
Passiflora foetida	14/6	AL-OP/ALOP	AM/AMR	UC-AC	R-O
Benincasa hispida	6-12/6-8	AL/AL	AM/AM	UC-AC	O
Citrullus colocynthis	10/-	OP/-	R-AW/-	STR	-
Coccinia grandis	8/4	OP-AL/ALSO	AM-AW/AW	UC-AC	R-O
Cucurbita maxima	8/8	OP-AL/AL	AM/AM	STR	-
Cucumis sativus	6/4	AL-OP/AL	AM/AM	STR	-
Lagenaria leucantha	6/4-6	SO-AL/ALOP	AM-AW/AM	STR	-
Luffa acutangula	8/6	OP-AL/OPAL	AM-AM/AW	UC-AC	R-O
L. cylindrica	6/6	OP/OP-AL	AM-AW/AM	UC-AC	R-O
Momordica charantia	8/8	AL-SO/OPAP	AM-AW/AM-AW	UC-AC	R-O
Mukia maderaspatana	6/4	SO-AL/ALOP	AM-AW/AW	UC-AC	R-O
Trichosanthes anguina	8/6	OP-SO/AL	AM-R/AM-R	UC-AC	O
Trichosanthes tricuspidata	16/16	OP-SO/ALOP	R-AW/AM-R	UC-AC	O

AC - abruptly curved; AL - alternate; ALOP - basally alternate to apically opposite; ALSO - alternate to subopposite; AM - acute moderate; AMR - acute moderate to right angle; AN - acute narrow; AW - acute wide; O - obtuse angle; OPAL - opposite to alternate; R - right angle; STR - straight; UC - uniformly curved; - absent.

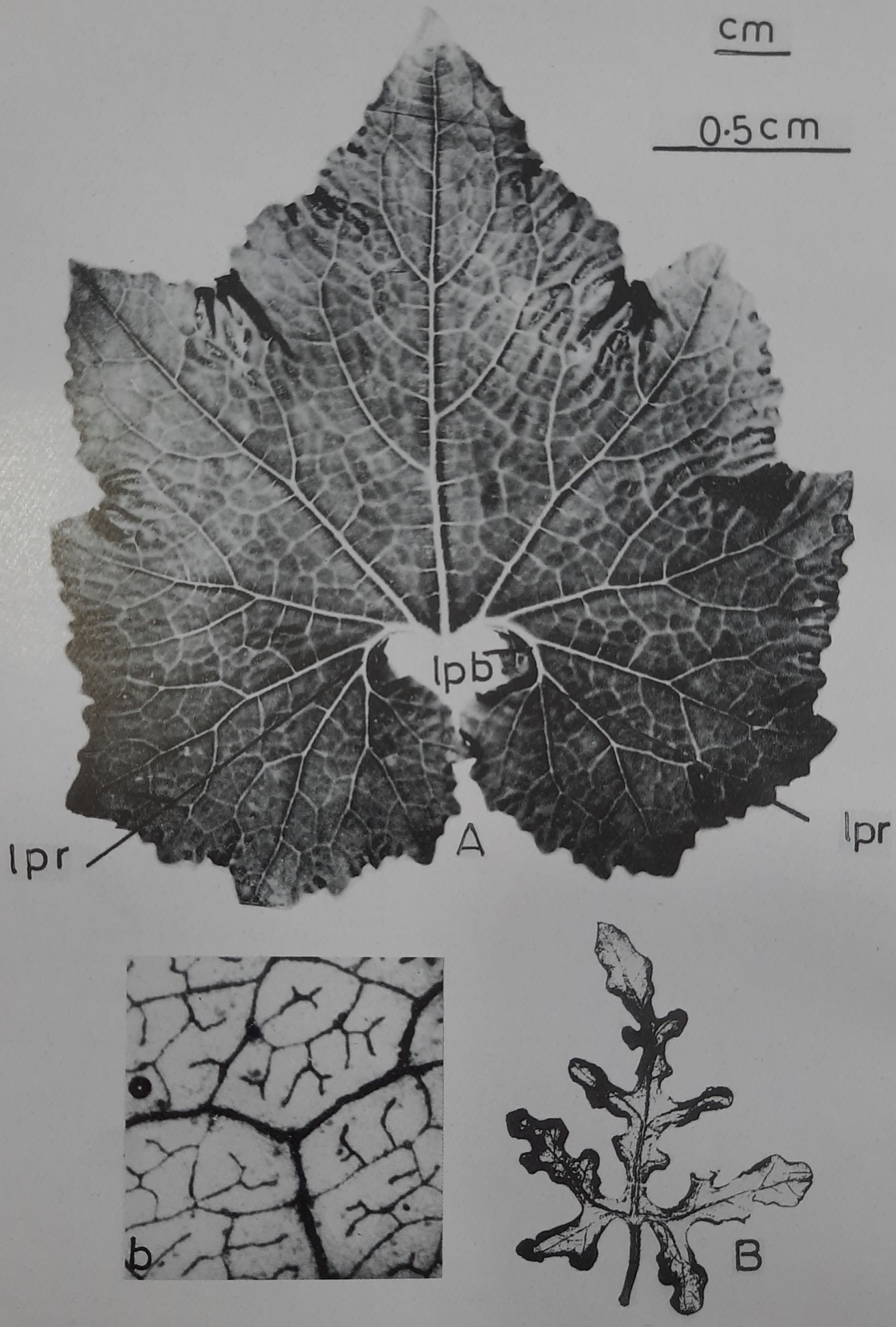

Figure 2A,B. Leaves showing venation patterns, a,b. enlarged portion middle of the leaf showing areoles and veinlets; A. campylo-actinodromous in *Benincasa hispida*; B,b. Craspedodromous in *Citrullus colocynthis* (lpb-lateral primaries branched; lpr: lateral primary recurved).

Table 3. Characters of tertiary veins and areoles

Name of the taxa	Course	Relationship to midvein	Areoles		Veinlets	
			Shape	Frequency/Sq. cm.	Branching	Course
Turnera ulmifolia	SI-RET	PC	Q	80	1B/S	C/STR
Passiflora foetida	CO-STR	POO	Q	120	1B/S	C/STR
Benincasa hispida	CS-RET	POO	Q	160	2B	STR
Citrullus colocynthis	RE	-	Q	60	3B	STR
Coccinia grandis	Z	POO	Q	75	1B/S	C/STR
Cucurbita maxima	RE	-	Q	140	2B	STR
Cucumis sativus	Z	POO	P	135	1B	C
Lagenaria leucantha	CS-STR	POO	Q	150	S	C
Luffa acutangula	CO-RET	POO	P	175	1B	STR
L. cylindrica	CO-Z	POO	P	175	1B	STR
Momordica charantia	CO-Z	POO	P	180	1B	STR
Mukia maderaspatana	CO-Z	POO	Q	380	1B	STR
Trichosanthes anguina	CO-RET	POO	Q	155	1B	STR
Trichosanthes tricuspidata	RE		Q	85	1B	STR

B- branched; C-curved; CO-convex; CS-convexly sinuate; P-pentagonal; PC- perpendicular constant; POO- perpendicular but oblique outward; Q-quadrangular; RE-reticulate; RET- retroflexed; S-simple; SI- sinuate; STR straight; Z- zig zag; - absent.

The number of secondaries produced by the midvein vary from three to ten pairs (Fig. 1A; Table 2) and on the lateral primaries they vary from two to eight pairs (Table 2) but in *Passiflora* the basal lateral primaries produce secondaries only on exmedial side (Fig. 1B). The secondaries are basally alternate to apically opposite in *Passiflora* and *Cucumis* (Fig. 1B) but basally opposite to apically alternate in *Turnera, Coccinea, Cucurbita* and *Luffa acutangula* (Fig. 1A, 3B; Table 2), and basally alternate to apically subopposite in *Momordica*, opposite to subopposite in *Trichosanthes* (Table 2), subopposite to alternate in *Lagenaria* and *Mukia* (Table 2), alternate throughout in *Benincasa* (Fig. 2A), opposite in *Citrullus* and *Luffa cylindrica*, but on the lateral primaries the secondaries are basally alternate to apically opposite in *Lagenaria, Mukia* and *Trichosanthes tricuspidata* (Fig. 3A; Table 2), opposite to alternate in *Luffa* and *Momordica* (Table 2) and alternate in *Cucurbita, Cucumis* and *Trichosanthes anguina*. The angle of divergence of the secondaries on median primary varies from acute moderate to acute wide in *Coccinea, Lagenaria, Luffa cylindrica, Momordica* and *Mukia* (Fig. 3B; Table 2), acute moderate to right angle in *Trichosanthes anguina*; right angle to acute wide in *Trichosanthes tricuspidata* and *Citrullus* (Figs 2B, 3A), acute narrow to acute moderate in *Turnera* (Fig. 1A) and it is nearly uniform being acute moderate in *Passiflora, Benincasa, Cucurbita, Cucumis* and *Luffa acutangula* (Figs 1B, 2A; Table 2). The angle of divergence of secondaries on the lateral primaries vary from acute moderate to right angle in *Passiflora* and *Trichosanthes* (Figs 1B, 3A), acute wide in *Coccinea* and *Mukia* (Fig. 3B), acute moderate in *Benincasa, Cucurbita, Cucumis, Lagenaria* and *Luffa cylndrica* (Fig. 2A), acute moderate to acute wide in *Luffa acutangula* and *Momordica* (Table 2). They are relatively thick in 11 and moderately thick in *Citrullus, Luffa acutangula* and *Trichosanthes tricuspidata* (Figs 2B, 3A; Table 2). The course of the secondaries are uniformly curved but abruptly curved at margin in *Benincasa, Coccinea, Lagenaria* and *Luffa* (Figs 2A, 3B; Table 2), uniformly curved to abruptly curved at margin in *Turnera, Mukia, Momordica* and *Trichosanthes tricuspidata* (Figs 1A, 3A; Table 2) but straight in *Citrullus, Cucurbita, Cucumis, Lagenaria* and *Trichosanthes anguina* (Table 2). However, in *Trichosanthes tricuspidata* (Fig. 3A) some of the secondaries are terminating in the margin while others are forming loops. The secondaries are branched in *Turnera, Citrullus, Lagenaria, Momordica* and *Mukia* (Figs. 1A, 2B). All or few of the secondaries are forming loops throughout in ten species (Table 2). The loop forming branches of secondary veins join the superadjacent secondaries usually at right angle to obtuse angle in six species (Figs 1B, 3B; Table 2), obtuse angle in *Trichosanthes* and *Benincasa* (Figs. 2A, 3A) and acute angle in *Turnera* (Fig. 1A). The loop forming branches are enclosed by arches of 3 and 4° veins in ten species. Two intersecondary veins are present in *Citrullus*, four in *Coccinea, Luffa cylindrica, Momordica* and upto 10 in *Trichosanthes anguina* (Fig. 3B) and are of simple type.

Tertiaries are predominantly percurrent, alternate to opposite throughout the lamina in 11 species (but reticulate in leaf apex of *Benincasa, Lagenaria* and *Luffa*; Fig. 2A) while reticulate throughout in *Citrullus, Cucurbita* and *Trichosanthes tricuspidata* (Fig. 3A). The percur-

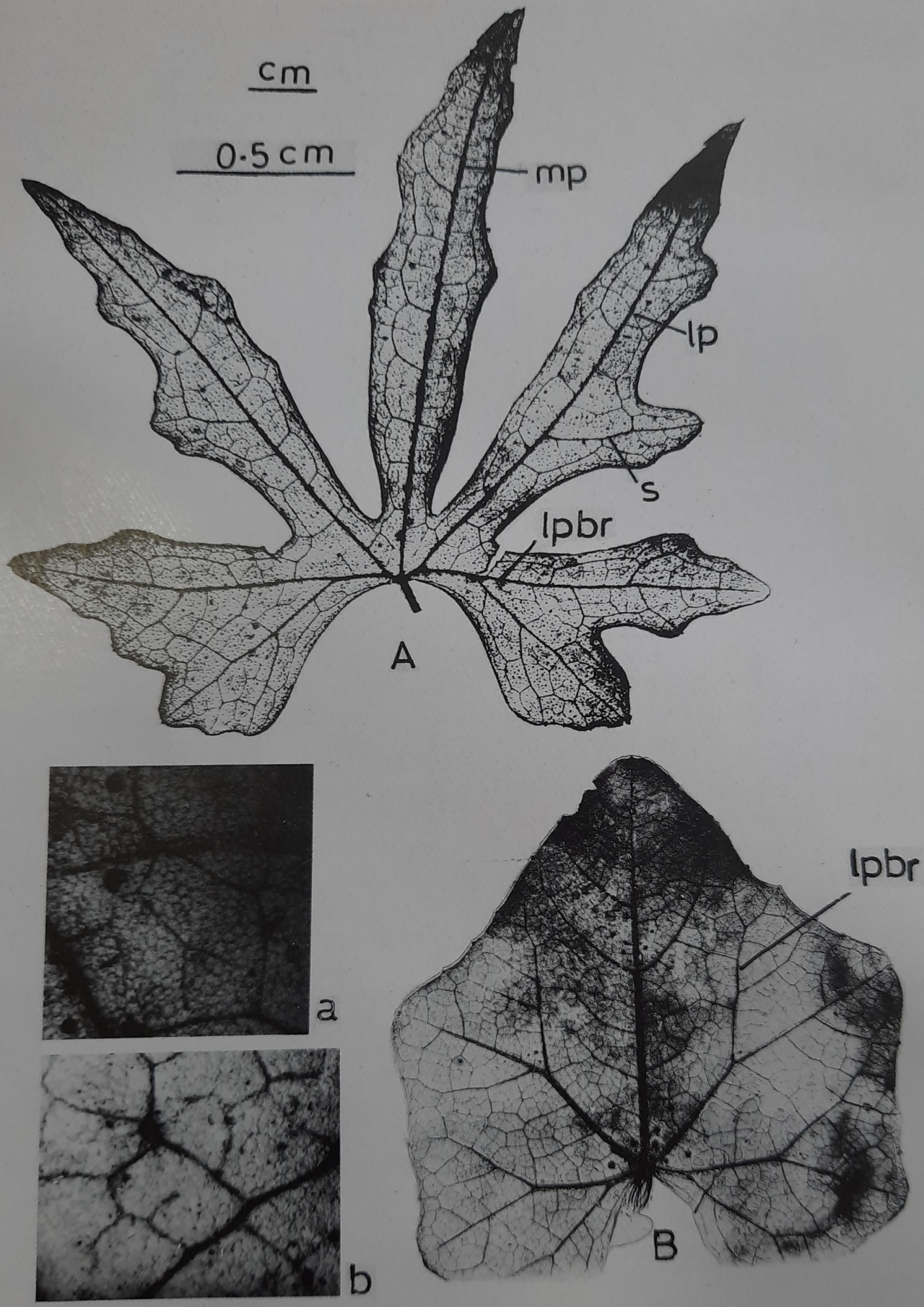

Figure 3A,B. Leaves showing venation patterns, a,b. enlarged portion from middle of the leaf showing areoles and veinlets; Aa. Actinodromous in *Trichosanthes tricuspidata;* B,b. Actino-brochidodromous in *Coccinea grandis* (lp-lateral primary; lpbr-lateral primaries branched; mp-median primary; S-secondary vein).

rent tertiaries are predominantly simple, convex to straight in *Passiflora* (Fig. 1B), convexly zigzag in *Momordica* and *Mukia* but branched, convexly sinuate to straight in *Lagenaria*, convexly zigzag in *Luffa cylindrica*, convexly retroflexed in *Luffa acutangula* and *Trichosanthes anguina*, zigzag in *Coccinea* and *Cucumis*, convexly sinuate to retroflexed in *Benincasa* and sinuate to retroflexed in *Turnera* (Figs 1A, 2A; Table 3). The angle of origin of tertiaries are predominantly acute angle: acute angle (AA) to right angle: right angle (RR) (Figs. 2A, 3A), except in *Turnera* (Fig. 1A), where they are right angle: right angle (RR) to acute angle: right angle (AR) but in *Passiflora* (Fig. 1B) and *Momordica* it is acute angle: right angle (AR) to acute angle: acute angle (AA). The relationship of tertiaries to midvein is perpendicular but oblique outward in ten species and perpendicular constant in *Turnera* (Fig. 1A; Table 3).

The next finer order 4° veins are distinct in *Trichosanthes anguina* 6° veins are in *Cucurbita* and 5° veins in rest of the species (Figs 1AB, 2AB, 3AB). The higher order of veins are predominantly orthogonal in all except in *Citrullus* and *Trichosanthes tricuspidata* where they are random reticulate (Figs 2B, 3A). The marginal ultimate venation is looped in all except *Mukia* where it is incomplete.

The development of the areoles are imperfect and the arrangement is random in all. The shape of the areoles vary from pentagonal to quadrangular (Figs 1ab, 2ab, 3ab; Table 3) and are large (60-85/cm^2) in *Citrullus, Coccinea, Turnera* and *Trichosanthes tricuspidata* (Figs 1a, 2b, 3ab), medium (120-380/cm^2) in ten other taxa (Figs 1b, 2a; Table 3). The number of veinlets/areole is one in 11 species and one to two in *Turnera, Passiflora* and *Coccinea* (Figs 1a, b, 3b) and the frequency of areoles/cm^2 vary from 60-380 (Table 3.) The veinlets are simple, curved in *Lagenaria*, once branched to simple, curved to straight in *Turnera, Passiflora* and *Coccinea* (Figs 1a, b, 3b; Table 3), once branched, straight in *Luffa, Momordica, Mukia* and *Trichosanthes* (Fig. 3a) but curved in *Cucumis*, twice branched, straight in *Benincasa* and *Cucurbita* and thrice branched, straight in *Citrullus* (Fig. 3b; Table 3).

All the above characters are found to be of taxonomic value and based on the above a key for identification of the Passiflorales occurring at Visakhapatnam is provided below:

Key for identification of the taxa:

1. Leaves with pinnate venation
   2 Venation pancraspedo-brochidodromous type ...*Turnera ulmifolia*
   2. Venation craspedodromous type ...*Citrullus colocynthis*
1. Leaves with palmate venation
   3. Venation campylo-actinodromous type
      4. Leaves simple, margin erosus ...*Benincasa hispida*
      4. Leaves palmatifid, margin crenulate ...*Trichosanthes anguina*
3. Venation palmatous actino-brochidodromous or actinodromous type
   5. Venation palmatous actino-brochidodromous type
      6. Number of lateral primaries two ..*Luffa acutangula*
      6. Number of lateral primaries four
         7. Leaves palmatifid, cordate-trilobed, lateral primaries not branched ...*Passiflora foetida*
         7. Leaves simple, cordatus-angularis, lateral primaries branched ...*Coccinea grandis*
5. Venation palmatous actinodromous type
   8. Leaves pedatus
      9. Tertiaries percurrent ...*Momordica charantia*
      9. Tertiaries reticulate ...*Trichosanthes tricuspidata*
8. Leaves cordate
   10. Secondary veins looped ...*Luffa cylindrica*
   10. Secondary veins terminating at margin
      11. Number of lateral primaries four ...*Cucumis sativus*
      11. Number of lateral primaries two
      12. Tertiaries reticulate, leaf margin serrulate ...*Cucurbita maxima*
      12. Tertiaries percurrent, leaf margin crenulate
         13. Veinlets simple curved, marginal ultimate venation looped ...*Lagenaria leucantha*
         13. Veinlets once branched, straight, marginal ultimate venation incomplete ...*Mukia maderaspatana*

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