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Morpho-anatomical Study on Certain Taxa of Myrtaceae

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Abstract: The macro- and micromorphological characters of five selected species of Myrtaceae was examined representing five genera, two tribes and two sub-families to see if it could throw light on the general morpho-anatomical features. A general description of macro- and micro morphological characters of vegetative and floral parts is given using LM and SEM and the importance of them for the identification and distinctness between taxa is assessed by means of statistical analysis utilizing criteria from morphology and anatomy of stem, petiole, lamina, flower and seeds. The floral anatomical criteria provide data which support the appendicular nature of the inferior ovary in all the species under investigation. The dendrogram produced from the cluster analysis of all combined characters indicates that there is high degree of homoplasy amongst both morphology and anatomy of the studied taxa of tribe Myrteae with the *Eucalyptus camaldulensis* from tribe Leptospermeae.

Key words: Myrtaceae, morphology, anatomy, SEM, numerical analysis

INTRODUCTION

Family Myrtaceae is spread over 80 genera and 3000 species. Cronquist[1] and Willis[2] regard 100 genera and 3000 species. The plants are distributed in tropical and sub-tropical regions with centers of distribution in Australia and America. The family plays a significant role in characterizing the vegetation of Brazilian floras. The genus *Eugenia* L., with 14 species being the most numerous representative in the ecosystem of Rio de Janeiro[3]. Barroso *et al.*[4] pointed out that the American species of Myrtaceae are very similar morphologically and their identification being therefore difficult.

Myrtaceae attract the attention of many authors to do with it, some of the recent literature in this subject are the work of Andrew *et al.*[5], McDonald *et al.*[6], Michael *et al.*[7], Pound *et al.*[8], Rachel *et al.*[9] and Stephen and David [10].

Myrtaceae includes trees or shrubs bearing essential oils. Helophytic to xerophytic. Heterophyllous sometimes markedly so, e.g. *Eucalyptus* spp. or not heterophyllous. There are gland dotted aromatic edgewise to the stem and leaves commonly in *Callistemon* and *Eucalyptus*[11].

Among studies in comparative anatomy, Bailey and Howard[12] studied the wood characteristics and their potential to separate groups within the family and to define lines of phylogenetic specialization. Howard[13], Johansen[14] and Khatijah *et al.*[15] when commenting on the taxonomic significance of the anatomical characteristics, asserted that they sometimes show affinity between species.

Cuticular and epidermal studies on Myrtaceae have been carried out by many workers as characters to separate up to the level of genera and species[16-26].

The nature of the inferior ovary has always received a great attention on telling evolutionary pathways; and all the floral phenomena that of the inferior ovary has doubtless been extensively discussed. Since the nineteenth century two theories about its nature have received strong support and, simply presented, these are the appendicular theory[27] and the axial theory[28,29].

Not easy as above either theory can be accepted since the whole situation is further complicated by the so-called hypanthium[10]. Eames[29] stated that the inferior ovary had developed in two morphologically different ways, by adnation of the floral appendages and by hollowing the axis tip. In monocots, however, the case is not as easy as in dicots. This is because, as Stebbins[30] states, epigyny in monocots is derived by routes which differ from those of the dicots.

More recently, SEM and embryological development in certain taxa are helping considerably in solving some of the taxonomic problems[31-35].

The ultimate goal of the present study is threefold: (1) to gain further insight into morpho-anatomy of selected taxa of Myrtaceae by using LM and SEM, (2) to further our understanding of floral anatomy in general and specifically the nature of the inferior ovary and (3) to clarify the interrelationships among the present members of Myrtaceae.

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MATERIALS AND METHODS

The five investigated taxa, the sources of collection and classification cited after Willis[2] are listed in Table (1). These selected taxa represent the famous ornamental and cultivated myrtaceous plants in Egypt. The voucher specimens are kept at the Herbarium of Botany Department, Faculty of Science, Ain Shams University. The identification of the studied taxa was done according to Bailey[36].

Macromorphological characters were studied from the fresh specimens as well as relevant literature[37, 2, 38].

The anatomical investigation was achieved through transverse sections of stem, petiole and lamina by a hand microtome at 15-20 μm and stained with safranine and light green. Also, stomata and epidermal cells were examined in epidermal peels stained with toludine blue. In addition to some microphotographs of some specific structures.

For floral anatomy, the flower buds were fixed in F.A.A. and then stored in alcohol[39]. These buds were dehydrated and embedded in paraffin wax of melting point 56-58°. Transverse sections were cut from pedicel upward at 10-18 ìm thick on a Rotary microtome and double stained with crystalviolet-erythrosine[40]. These sections were examined under light microscope. In addition to some microphotographs of some specific structures.

For SEM examination, the seeds were cleaned and washed carefully then mounted on brass stubs and coated with gold palladium in sputter coating unit. The scanning was carried out by a Joel JSM 100 SEM at accelerating voltage 15 Kv. The terminology used here to describe the seed surface sculpture was adopted after Stearn[41], Barthlott [20]and Munson .[42]The comparative evaluation were made at 600, 1500 and 2000 magnification according to the seed size.

The taxa under investigation were collected from Botanic Garden, Department of Botany, Faculty of Science, Ain Shams University, Abassia, Cairo, Egypt.

For the data analysis, the data obtained from the total number of the recorded characters in each taxon were subjected to the numerical analysis. The presence or absence of each of all characters was treated as a binary character in a data matrix. For computation the SPSS, version 10 was used. SPSS (Statistical Package for the Social Science), version 10 is a data management and analysis product. It can perform a variety of data analysis and presentation functions, including statistical analysis and graphical presentation of data.

The OTU's (Operational Taxonomic Units), produced from the analysis of present characters of the taxa under investigation and resulted in a dendrogram that was compared with the current taxonomic treatments of Myrtaceae.

Table 1: Collected data and their classification after Willis[2]

Sub-family	Tribe	Genus	Species
Leptospermoideae	Chamaelaucieae	_	_
	Leptospermeae	*Callistemon*	*citrinus* Staf.
		Eucalyptus	*camaldulensis* Dehnhardit
		Melaleuca	*leucadendra* L.
Myrtoideae	Myrteae	*Eugenia*	*uniflora* L.
		Psidium	*guajava* L.
	Myrcieae	_	_

RESULTS AND DISCUSSION

The morphological and anatomical characters of the vegetative and floral organs of the studied taxa provide 312 indicative characters illustrated in Table 2 using LM and SEM.

By comparing the present data with the former results of Willis[2], it was observed that the macro-morphological characters of the vegetative and floral organs are more or less consistent among the studied species of tribe Myrteae and Leptospermeae Table 2 (specimens 01, 02 and 04) for more details. The characters of *Eugenia uniflora* and *Psidium guajava* provide data to support the inclusion of them in one series and *Callistemon citrinus*, *Eucalyptus camaldulensis* and *Melaleuca leucadendra* in another series. The morphological features of the seed surface sculpture as revealed by SEM show no clear boundaries between the species of the same tribe except minor variations in the aspect of the anticlinal and periclinal walls (Table 2 and Plate II). The former results supported by the dendrogram produced from the cluster analysis of 152 macromorphological characters of vegetative and floral organs (Fig. 1) in which the species have highest taxonomic distance of 25. The dendrogram shows two series, Series I includes *Eugenia uniflora* and *Psidium guajava* while series II includes *Callistemon citrinus, Eucalyptus camaldulensis, Melaleuca leucadendra*. This is in accordance with Willis classification (Table 1).

The stem anatomical characters of the species under investigation recorded in Table 2 show great homogeneity amongst *Callistemon citrinus, Eucalyptus camaldulensis, Melaleuca leucadendra* and *Eugenia uniflora* (Plate I). These observations was supported by the phenogram produced from the cluster analysis of 54 microanatomical characters (Fig. 2) in which the studied species show highest average of taxonomic distance of 25. Two series are recorded one with *Psidium guajava* and the second with the remaning studied taxa.

Johansen[39] when commenting on the taxonomic significance of anatomical characteristics asserted that they sometimes show affinity between species and define

Table 2: Macro- and micromorphological criteria of the selected studied taxa of Myrtaceae. 01: *Callistemon citrinus*; 02: *Eucalyptus camaldulensis*; 03: *Eugenia uniflora*; 04: *Melaleuca leucadendra*; 05: *Psidium guajava*; 0: Absent; 1: Present

				01	02	03	04	05
I- Macromorphological criteria								
General characters	Habit		Tree	0	1	0	0	0
			Tree-Shrub	0	0	0	1	0
			Shrub	1	0	1	0	1
	Height		More than 10 meters	0	1	0	1	0
			Less than 10 meters	1	0	1	0	1
	Trunk		One main trunk	0	1	0	1	0
			One or more	1	0	0	0	0
			One main branched diffusely at base	0	0	1	0	1
	Young twigs		Slightly downy	0	0	0	0	1
			Glabrous	0	1	1	1	0
			Brown scaly, downy	1	0	0	0	0
	Flowering time		February-March	0	1	1	0	0
			March	0	0	0	1	0
			April-May	1	0	0	0	1
			One time/ year	1	0	0	1	0
			Two or more times/year	0	1	1	0	1
Leaf characters	Phyllotaxis		Alternate	1	1	0	1	0
			Opposite	0	0	1	0	0
			Alternate-opposite	0	0	0	0	1
	Petiole	Length	1 - 1.2 cm long	0	0	0	0	1
			1.2 – 2 cm	0	1	0	0	0
			1 – 1.5 cm	0	0	1	0	0
		Adaxile surface	Concave	0	0	1	0	1
			Terete-flat	0	1	0	0	0
		Texture	Glabrous	0	1	1	0	0
			Slightly downy	0	0	0	0	1
		Base	Rounded	0	1	1	0	1
		Margin	Entire	0	0	1	0	1
			Slightly wavy-entire	0	1	0	0	0
	Lamina	Base	Wedge-shaped	1	0	0	0	0
			More or less rounded	0	0	1	0	1
			Rounded	0	1	0	0	0
			More or less tapered	0	0	0	1	0
		Margin	Entire	0	1	1	1	0
			Slightly wavy	1	0	0	0	0
			Entire – slightly wavy	0	0	0	0	1
		Apex	Acute-spiny	1	0	0	0	0
			Acute	0	1	0	1	0
			Acuminate	0	0	1	0	0
			Rounded -acute	0	0	0	0	1
		Size	4-6cm Length X 3-5 mm width	1	0	0	0	0
			6-8 cm X 3-4 cm	0	0	1	0	0
			17-25 cm X 2-4 cm	0	1	0	0	0
			2-3 cm X 2-3 mm	0	0	0	1	0
			10-12 cm X 5-7 cm	0	0	0	0	1
		Texture	Dark brown pigmented	1	0	0	0	0
			Glabrous	0	0	1	1	0
			Slightly downy	0	0	0	0	1
			Dark brown pigments-glabrous	0	1	0	0	0
		Colour	Dark grayish above & below	1	0	0	0	0
			Lustrous green above	0	1	1	1	0
			Dark green, red, lustrous green above	0	0	0	0	1
		Stiffness	Stiff	1	0	0	0	0
			More tender	0	0	1	0	0
			Stiff to more tender	0	1	0	1	1
		Appearance	Coracious (leathery)	1	1	0	1	1
			Herbaceous	0	0	1	0	0
		Shape	Linear-lanceolate,long ovate,elliptic	1	0	0	1	0
			Ovate	0	0	1	0	0
			Lanceolate	0	1	0	0	0
			Broad ovate	0	0	0	0	1
		Venation	Reticulate unicostate	0	1	1	0	1
			Reticulate multicostate	1	0	0	1	0

Table 2: Continue

Floral macrocharacters	Inflorescence	Type	Flower solitary or Heads or spikes	0	0	1	0	0
			Umbel, Heads or spikes 0	1	0	0	1	
			Heads or spikes	1	0	0	1	0
		Insertion	Apical	1	0	0	0	0
			Axillary	0	1	1	0	1
			Apical-axillary	0	0	0	1	0
		Colour	Green, brown-red	1	0	0	0	0
			Green-white	0	1	1	1	1
	Flower	Size	±Small	0	0	1	1	0
			± Medium & ± large	1	0	0	0	0
			±Large	0	0	0	0	1
			± Small & ± medium	0	1	0	0	0
		Perianth	Tetramerous	0	0	1	0	0
			Pentamerous	1	1	0	1	0
			Tetramerous - pentamerous	0	0	0	0	1
		Type / position	Epigynous	1	0	1	1	1
		of ovary	Perigynous/ epigynous	0	1	0	0	0
		Symmetry	Symmetric	1	1	1	1	1
		Regularity	Regular	1	1	1	1	1
		Sex	Bisexual	1	1	1	1	1
		Shape	Pear shaped-brush	1	1	0	1	1
			Ballon like-brush	0	0	1	0	0
	Pedicel	length	Short	0	0	0	0	1
			Long	0	1	1	0	0
		Thickness	Thin	0	0	1	0	0
			Thick	0	1	0	0	1
	Calyx	Colour	Green	1	0	1	0	1
			Dark green	0	1	0	1	0
		No. of units	Four	1	0	1	0	0
			Five	0	0	0	1	0
			Four- five	0	0	0	0	1
			Ill-defined	1	1	0	0	0
		Union of sepals	Polysepalous	0	0	1	1	1
			Gamosepalous	1	1	0	0	0
	Corolla	Colour	Pink or red	0	0	0	0	0
			Green	0	1	0	0	0
			White	0	0	1	1	1
		No. of petals	Four	1	0	1	0	0
			Five	0	0	0	1	0
			Four- five	0	0	0	0	1
			Ill-defined	0	1	0	0	0
		Union of petals	Polypetalous	1	0	1	1	1
			Gamopetalous	0	1	0	0	0
	Androecium	No. of stamens	Numerous (infinity)	1	1	1	1	1
		Union	Polystamenous	1	1	1	1	1
		Length	Long	1	0	0	0	0
			More / less long	0	1	1	1	1
		Fixation	Basifixed	0	0	1	0	1
			Dorsifixed	1	1	0	1	0
		Anther	Dithecous	1	1	1	1	1
	Gynoecium	Ovary	Inferior	1	0	1	1	1
			Seminferior	0	1	0	0	0
		No. carpels	Two	0	0	1	0	0
			Three	1	0	0	1	0
			Four	0	1	0	0	0
			Four-five	0	0	0	0	1
		Union	Syncarpous	1	1	1	1	1
		Placentation	Axile	1	1	1	1	1
		No.ovules	Numerous/carpel	1	1	1	1	1
		Style position	Terminal	1	1	1	1	1
		Style number	One, single	1	1	1	1	1
		Stigma	One capitate	0	1	1	0	1
			One flat	1	0	0	1	0
	Fruit	Type	Capsule	1	1	0	1	0
			Berry	0	0	1	0	1
		Shape	Cup-shaped	1	0	0	0	0
			Ball or spherical	0	0	1	0	0
			Pear-shaped	0	1	0	1	1

Table 2: Continue

		Colour	Pale brown	0	0	1	0	0
			White-straw yellow	0	0	0	0	1
			Brown - Pale brown	1	1	0	1	0
		Size	Small	0	0	0	1	0
			Small- medium	0	1	0	0	0
			Medium	0	0	0	0	0
			Medium- large	1	0	1	0	1
			Large	0	0	0	0	0
		Seed shape	Ribbon-like	1	0	0	0	0
			± Compressed ovate	0	0	1	0	1
			Ribbon-threads-like	0	1	0	1	0
		Seed colour	Brown	1	1	1	1	0
			White/straw yellow	0	0	0	0	1
		Seed size	Very small	0	1	0	1	0
			Medium	1	0	0	0	1
			Medium-large	0	0	1	0	0
		Sculpture	Sulcate-foveate	1	0	0	0	0
			Reticulate-foveate	0	0	1	0	0
			Alveolate-glebulate	0	0	0	1	0
			Alveolate-foveate	0	1	0	0	0
			Reticulate,favulariate	0	0	0	0	1
II- Micro-morphological criteria								
Stem microanatomy	Stem in outline		±Terete	1	1	1	1	0
			Rectangular- terete	0	0	0	0	1
	Epidermal cells	Type	Radially elongated	1	1	1	1	0
			Radially- tangentially	0	0	0	0	1
		Thickness	Thin	1	1	1	1	1
	Cuticle	Thickness	Thin	1	1	1	1	1
	Trichomes	Type	E-glandular, unicellular	1	1	1	1	1
	Oil cavity	No.	Few-numerous	1	1	1	1	1
		Walls	Thin	1	1	1	1	1
		Shape	Spherical	1	1	1	1	1
		Colour	Transparent	1	1	1	1	1
	Druses	No.	Few-numerous	0	0	0	0	1
		Location	Cortex & pith	0	0	0	0	1
	Stone cells	No.	Few	1	0	1	0	1
		Location	Cortex & pith	0	0	0	0	1
			Pith	1	0	1	0	0
	Cortex	No. of tissues	One	0	0	0	1	0
			Two	0	1	1	0	1
			Three	1	0	0	0	0
		Type	Parenchyma	0	0	0	1	0
			Collenchyma.+ parenchyma	0	1	0	0	0
			Parenchyma + fiber patchs	0	0	0	0	1
			Parenchyma, collenchyma, fibers	1	0	1	0	0
		Shape of parenchy.	Polyhedral	1	1	1	0	0
			Flattened/elongated	0	0	0	1	1
	Periderm	Presence	Present	1	1	1	1	1
		Location	Sub-epidermal / cortical	1	1	1	1	1
	Secondary	Aspect	Continuous siphonostele	1	1	1	1	1
	vascular cylinder	Secondary phloem	Consitituents Sieve tube,	0	1	0	0	1
			companion cells, par.	1	0	1	1	0
			Sieve tube, companion cells, par., fibers					
		Aspect, fascicular	Continuous	1	1	1	0	1
		& inter-fascicular	Discontinuous	0	0	0	1	0
		Rays	Homogenous	1	1	0	1	1
			Heterogenous	0	0	1	0	0
		No. of rays rows	Uniseriate	1	1	0	1	1
			Uni-biseriate	0	0	1	0	0
	Secondary xylem	Aspect	Continuous	1	1	1	1	1
		Homogeneity	Homogenous, fascicular & inter-fascicular	1	1	1	1	1
		Consitituents	Vessels, fibers, parenchyma	1	1	1	1	1
		Xylem vessels	Ring porous	1	1	1	1	1
		Ray homogenity	Homogenous	1	1	0	1	1
			Heterogenous	0	0	1	0	0
		Rays raws	Uniseriate	1	1	0	1	1

Table 2: Continue

			Uni-biseriate	0	0	1	0	0
		Rays wall	Primary & secondary	1	1	1	1	1
		Rays size	Narrow	0	1	1	1	0
			Wide	1	0	0	0	1
	Pith	No. of tissues	One	0	0	1	1	1
			Two	1	1	0	0	0
		Type	Parenchyma	0	0	1	1	1
			Parenchyma & fibers	1	1	0	0	0
		Shape of parenchyma	Polyhedral- angular	1	1	1	1	0
			Angular	0	0	0	0	1
		Wall of parenchyma	Thin walled-lignified	1	1	1	1	1
Petiole microanatomy	Shape in outline		Rounded-terete	0	1	0	0	0
			Kidney-shaped	0	0	0	0	1
			Half a circle	0	0	1	0	0
	Epidermis	Type	Radially	0	1	1	0	1
		Thickness	Thin	0	1	1	0	1
	Cuticle	Thickness	Thin	0	1	1	0	1
	Oil cavity	No.	Few-various	0	1	1	0	1
		Location	Outermost cortex	0	1	1	0	1
		Colour	Transparent	0	1	1	0	1
		Walls	Thin	0	1	1	0	1
	Druses	No.	Few-numerous	0	1	1	0	1
		Location	Ground tissue	0	1	1	0	1
	Ground tissue	No. of tissue	Two	0	0	1	0	1
			Three	0	1	0	0	0
		Types	Parenchyma & collenchyma	0	0	1	0	1
			Par., coll., fibers	0	1	0	0	0
		Walls of parenchym.	Thin- lignified	0	1	1	0	1
	Stone cells	No.	Few	0	0	0	0	1
		Location	Ground parench.	0	0	1	0	1
	Vascular cylinder	Aspect	Shallow crescenti	0	0	1	0	0
			Crescenti form	0	0	0	0	1
			Strongly recurved arc-shaped	0	1	0	0	0
	Sec.phloem		Sieve tube cells, companion cells, parenchyma	0	1	1	0	1
		Sec.xylem.	Vessels, fibers, parenchyma	0	1	1	0	1
		Vessels	Ring porous	0	1	1	0	1
		Rays homogenity	Homogenous	0	1	1	0	1
		Ray type	Uniseriate	0	1	1	0	1
		Ray walls	Thin-thick	0	1	1	0	1
		Sheath	Lignified parenchyma+ fibers	0	1	1	0	1
Lamina microanatomy	Outline	Ribbon-like		1	0	0	1	0
		± incurved		0	1	1	0	0
		Strongly incurved		0	0	0	0	1
	Epidermis	Type	Uniseriate	1	1	1	1	0
			Multiseriate	0	0	0	0	1
		Shape	Radially	1	1	1	1	0
			Rad-tangentially	0	0	0	0	1
		Thickness	Thin	1	1	1	1	1
	Cuticle	Thickness	Thin	1	1	1	1	1
	Stomata	Level	Superfacial	1	1	1	1	1
		Type	Anomocytic	1	0	0	1	1
			Anomo-anisocytic	0	1	0	0	0
			Anomo-paracytic	0	0	1	0	0
		Location	Abaxially	0	0	1	0	1
			Ab- Adaxially	1	1	0	1	0
	Trichome	Type	E-glandular, unicellular	0	0	0	0	1
	Oil cavity	No.	Few-various	1	1	1	1	1
		Location	Mesophyll	0	1	1	0	1
			Mesophyll-mid-vein	1	0	0	1	0
		Colour	Transparent	1	1	0	1	1
			Transparent-black-brown	0	0	1	0	0
		Walls	Thin	1	1	1	1	1
	Druses	No.	Few-numerous	1	1	1	1	1
		Location	Mesophyll & mid-vein	1	1	1	1	1
	Mesophyll	Type or aspect	Dorsiventral	0	0	1	0	1
			Isobilateral	1	1	0	1	0
		Palisade rows	2 at adaxil epidermis	0	0	1	0	0
			3-4 at adaxil	0	0	0	0	1

Table 2: Continue

			2 ad- & abaxil	1	0	0	1	0
			2-3 ad- & abaxil	0	1	0	0	0
		Continuation of	Continuous ad- & ab-	0	0	0	1	0
		palisade at midvein	Discontinuous ad-& ab-	0	1	0	0	0
			Discont. Adaxilly	0	0	1	0	1
			Cont. adaxilly only	1	0	0	0	0
	Vascular supply	Aspect at mid-vein	Dissected	1	0	0	1	0
			Continuous	0	1	1	0	1
		No. of Vascular	1 Median +2 lateral	1	0	0	0	0
		bundles of dissected	1 Median + 6 lateral	0	0	0	1	0
		vascular supply						
		Aspect of	Shallow crescenti	0	0	1	0	0
		continuous vascular	U-shaped	0	0	0	0	1
		supply	Crescenti form + 2-3	0	1	0	0	0
			inverted vascular bundles					
		Vascular sheath	Totally fibers	1	0	0	1	0
			Fibers + lignified parenchyma	0	1	1	0	1
Floral micro anatomy	Pedicel	Vasculature	Continuous siphonostele	1	1	1	1	1
	Receptacle	No. of initial	8	0	0	1	0	0
		protrusions	10	1	1	0	1	1
	Calyx vasculature	Initial traces	4	0	0	1	0	0
			5	1	1	0	1	1
		Final bundles	4 Median + numerous lateral	0	0	1	0	0
			5 Median + numerous lateral	1	1	0	1	1
	Corolla	Initial traces	4	0	0	1	0	0
	vasculature		5	1	1	0	1	1
		Final bundles	4 Median + numerous lateral	0	0	1	0	0
			5 Median + numerous lateral	1	1	0	1	1
	Androecium	Initial traces	Numerous	1	1	1	1	1
	vasculature	Origin	Androsepalous + petalous complexes	1	1	1	1	1
		Final bundles	Infinity, one in each filament	1	1	1	1	1
	Gynoecium	No. of carpels	2	0	0	1	0	0
	vasculature		3	1	0	0	1	0
			4	0	1	0	0	0
			4-5	0	0	0	0	1
		Initial dorsal	2	0	0	1	0	0
		carpellary traces.	3	1	0	0	1	0
			4	0	1	0	0	0
			4-5	0	0	0	0	1
		Final dorsal	2	0	0	1	0	0
		carpellary bundles	3	1	0	0	1	0
			4	0	1	0	0	0
			4-5	0	0	0	0	1
		Carpellary wall traces	Numerous	1	1	1	1	1
		Origin	Dorsal carpellary bundles	1	1	1	1	1
		Initial ventral	2	0	0	1	0	0
		carpellary traces	3	1	0	0	1	0
			4	0	1	0	0	0
			4-5	0	0	0	0	1
		Final ventral	2	0	0	1	0	0
		carpellary bundles	4	0	1	0	0	1
			6	1	0	0	1	0
		Septal bundles	Numerous	1	1	1	1	1
		Origin	Ventral carpellary bundles	1	1	1	1	1
		Nature of inferior	Appendicular	1	1	1	1	1
		ovary						

the position of given species. Also, in the available bibliography of Myrtaceae there is an emphasis on the anatomy of the leaf blade, but the anatomy of the petiole can also provide data for the taxonomists[13,15,32]. Khatijah *et al*.[15] and Paula[43] recommended that the leaf anatomy play an important role in the systematics of certain families.

In agreement with those the petiole and lamina anatomical characteristics in the current study provide data which enclose the studied species of tribe Myrteae with *Eucalyptus camaldulensis* from Leptospermeae in one series (Table 2 and Plate I). This is supported by the dendrograms produced from the cluster analysis of 29 petiole anatomical characters and 42 lamina characters (Fig. 3 and 4).

The pathway of the vascular traces to the different floral organs in all investigated species is the same. The vascular supply at the receptacular region in all the

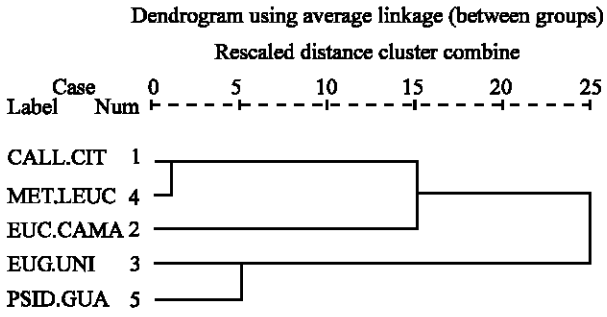


Fig. 1: Morphology

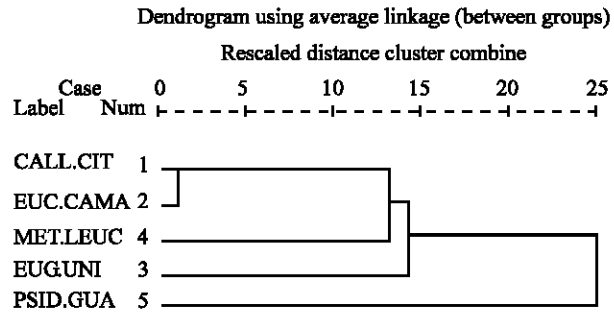


Fig. 2: Stem anatomy

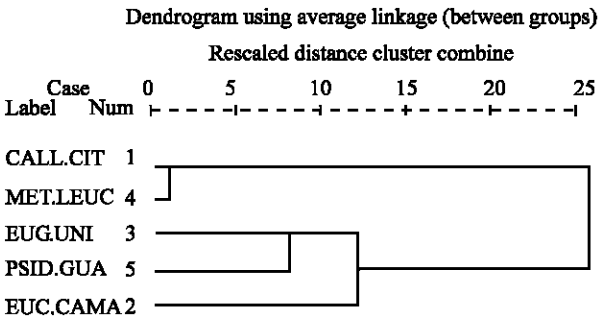


Fig. 3: Petiole anatomy

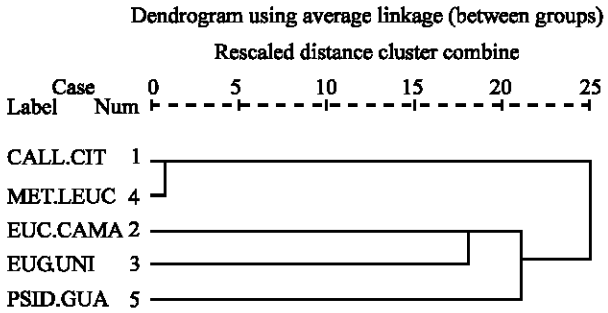


Fig. 4: Lamina anatomy

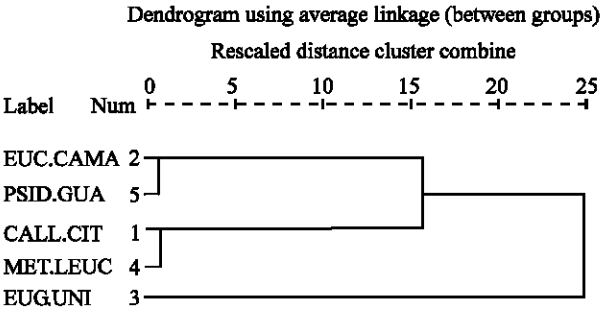


Fig. 5: Floral anatomy

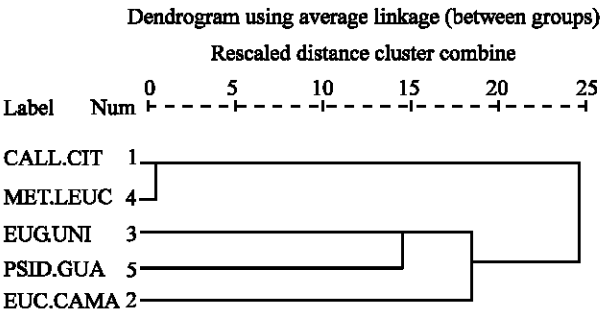


Fig. 6: All combined characters

studied species show continuous siphonostelic structure. Few micrometers above the central stele diverges into group of protrusions ranging from eight as in *Eugenia uniflora* and ten as in the rest of the studied taxa. These protrusions represent vascular complexes to the sepals, petals and stamens. Four outer and four inner as in *Eugenia uniflora* and five outer and five inner as in the rest studied taxa. After the departure of these complexes, the remaining central stele is differentiated into group of separate vascular bundles. Four as in *Eugenia uniflora*, six as in *Callistemon citrinus* and *Melaleuca leucadendra*, eight as in *Eucalyptus camaldulensis* and eight to ten as in *Psidium guajava*. These bundles representing two ventrals and two dorsals carpellary bundles as in *Eugenia uniflora*. Three ventrals and three dorsals as in *Callistemon citrinus* and *Melaleuca leucadendra*. Four ventrals and four dorsals as in *Eucalyptus camaldulensis*. Four to five ventral and the same dorsal as in *Psidium guajava*. The septal bundles are numerous and derived from the ventral bundles whereas the wall carpellary bundles are derived from the dorsals. At higher level and beneath the level of locules differentiation the outer complexes migrate through the receptacular tissue to the sepals, petals with numerous ramifications to the sepals and petals margins and to the numerous filaments. From the former data it was observed that the behavior of the traces is consistent amongst the taxa of tribe Myrteae and Leptospermeae. The only difference is the number of the traces to each whorl (Plate III). The phenogram

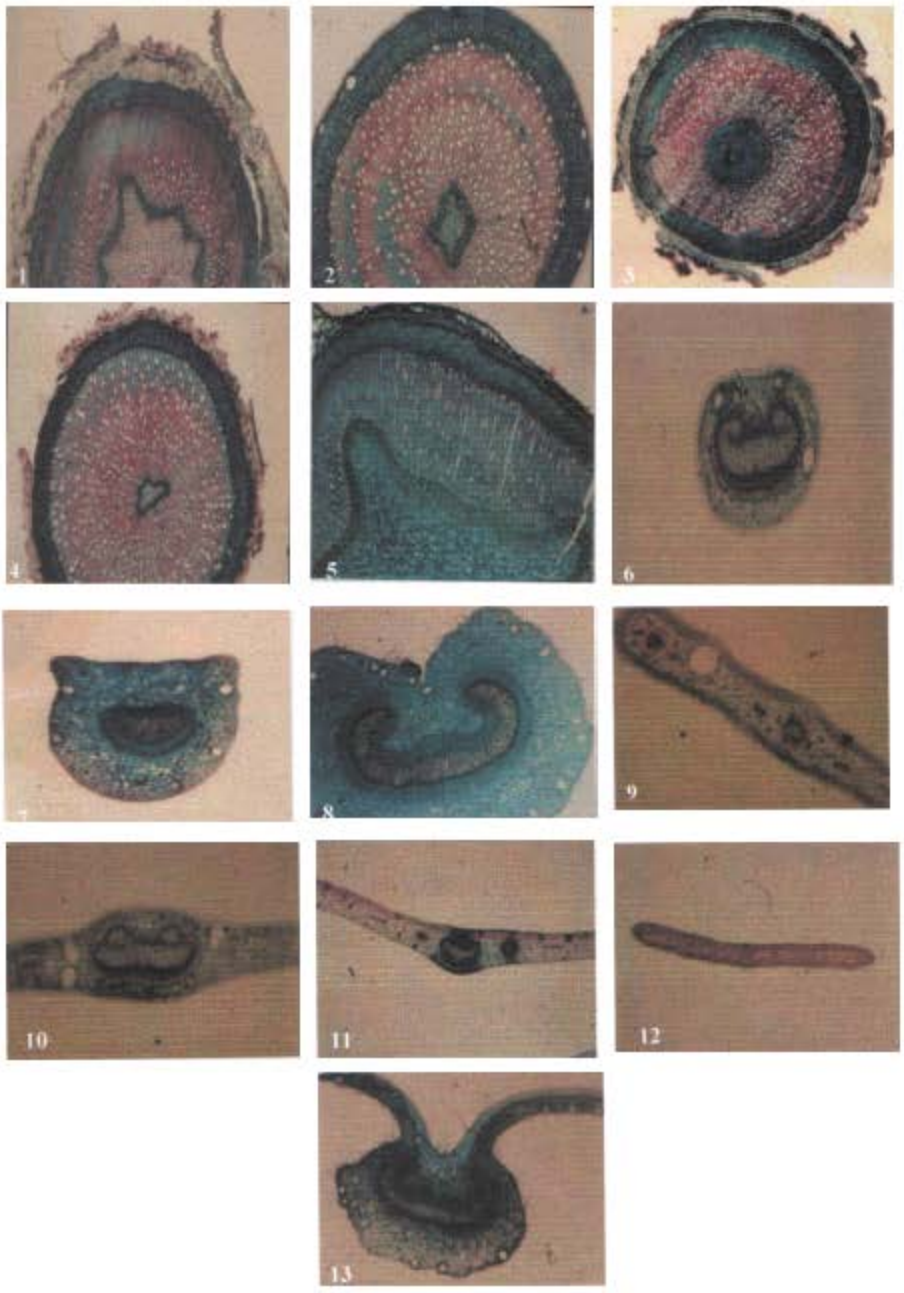
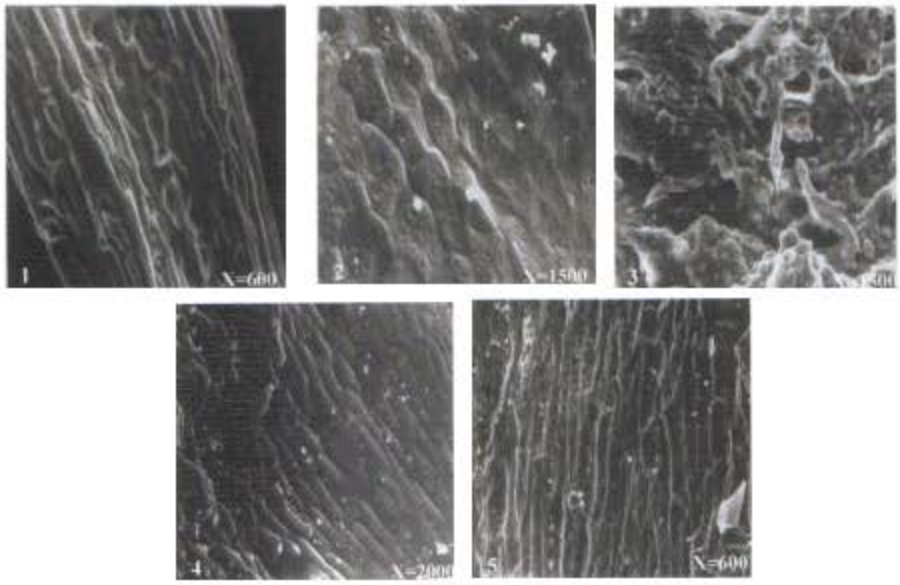


Plate I: Fig. 1-13: Microphotographs
1: *Callistemon citrinus* (stem), 2: *Eucalyptus camaldulensis* (Stem), 3: *Eugenia uniflora* (Stem);
4: *Melaleuca leucadendra* (Stem), 5: *Psidium guajava* (Stem), 6: *Eucalyptus camaldulensis* (petiole)
Scale bar (x = 3.2x3.2).

7: *Eugenia uniflora* (petiole); 8: *Psidium guajava* (Petiole) 9: *Callistemon citrimus* (blade)
10: *Eucalyptus camaldulensis* (blade) 11: *Eugenia uniflora* (blace) 12: *Melaleuca leucadendra* (blade)
13: *Psidium guajava* (blade). Scale bar (x=3.2x5.3)



Palte II: Figs. 1-5: SEM microphotographs of seed. 1: *Callistemon citrinus*, 2: *Eucalyptus camaldulensis*, 3: *Eugenia uniflora* 4: *Melaleuca leucadendra*, 5: *Psidium guajava*

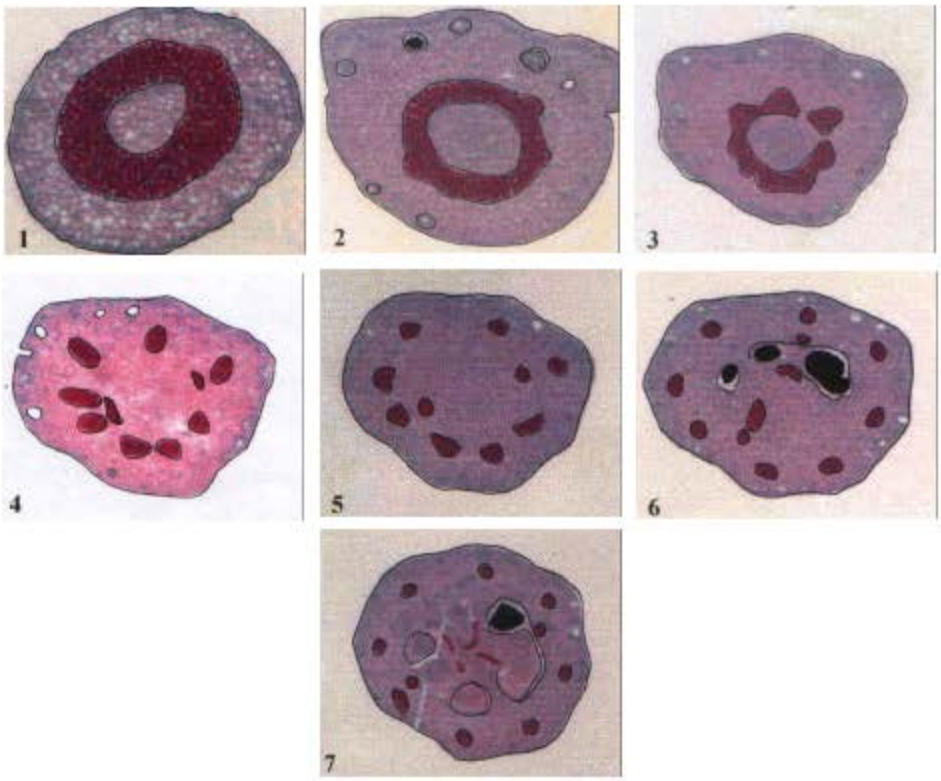


Plate III: Fig. 1-7: Floral microphotographs of Eugenia uniflora from pedicel upwards showing the appendicular nature of the inferior ovary. Scale bar (x =x 3.2x5.3)

produced from the cluster analysis of 35 floral micro-characters encourage the separation of *Eugenia uniflora* from the rest of studied species in one series (Fig. 5) which consider the more advanced in its floral characters.

In view of the above data in the Table 2, it is of primary importance to draw attention towards what is meant by epigyny.. The phenomenon of epigyny is the reversed topographical position of the ovary relative to the other floral organs.

The interpretation of data obtained from the vasculature of the flower of the selected studied taxa clarified the state of epigyny as follow, the ovary in all the flowers is wholly appendicular, where the vascular traces to all the floral organs arise free from the early beginning as totally independent traces which run distinct at a level lower than that of the locules and remain as such. This indicates that the flower in Myrtaceae is false epigyny. This is in agreement with the work of Barabe[44] on the pistillate flower of *Begonia handellii*. His results showed that the inferior ovary is formed by the union of appendicular organs. Awasthi and Kumar[45] studied the floral histogensis in *Amaryllis belladonna* L. and *A. vittata* Ait.(Amaryllidaceae) and suggested that the stylar part of gynoecium is formed by zonal growth below the carpel primordia. On the basis of ontogeny the inferior ovary is interpreted as appendicular, thus supporting the observation of earlier workers based on floral anatomy. Also the criteria here is compatible with the work of Stephen and David[10] on the development of hypanyhium of *Acmena smithii* and *Syzgium australe* (*Acmena alliance*).

When employing all available morphological and anatomical characters of the vegetative and floral organs including the phenogram produced from the cluster analysis of 312 characters Fig. 6 in which the species have highest average taxonomic distance of about 25. The phenogram based on the combination of all characters shows two main series; Series I includes *Eucalyptus camaldulensis* in one sub-series of one cluster and *Eugenia uniflora* and *Psidium guajava* in another sub-series. Series II includes *Callistemon citrinus* and *Melaleuca leucadendra* in one cluster as closely related taxa with great affinity.

The combination of all morphological and anatomical characters of both vegetative and floral organs of the studied taxa for computation and illustrated phenogram (Fig. 6) support the position of all taxa under the specific tribes as cited previously by Willis[2] except *Eucalyptus camaldulensis* which shares important morpho-anatomical features with the taxa studied under the tribe Myrteae. Finally we recommend to do extensive morphological and molecular studies to obtain more criteria to interpret the relationships and affinity between the studied taxa.

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