

TAXONOMIC SIGNIFICANCE OF THE RACHIS, PETIOLE AND PETIOLULE ANATOMY IN SOME EUPHORBIACEAE

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ABSTRACT

Anatomy of rachis, petiole and petiolule in 43 species and 20 genera of Euphorbiaceae are investigated. The mechanical tissues in these organs are invariably sclerenchymatous and collenchymatous. The xylem elements are additionally mechanical in function. The occurrence of vascular tissues is in the form of distinct bundles, only an arc-shaped strand or a continuous cylinder. The cortical bundles are noted in *Aporosa* and *Jatropha gossypifolia* while unequal sized central vascular bundles are observed in *Mallotus nudiflorus* and *M. philippensis*. The variation in the distribution of sclerenchyma, collenchyma and vascular patterns apart from the shapes as observed in a transverse section of the leaf stalk can be used for the delineation of the taxa studied.

Key words: Anatomy, Leaf stalk, Mechanical tissues, Systematics, Euphorbiaceae.

INTRODUCTION

Euphorbiaceae *sensu lato* is one of the most cosmopolitan plant groups within angiosperm, consisting of about 334 genera (Webster, 1994) and over 8000 species, (Redcliffe-Smith, 2001). Many members of the family play an important role in supporting tropical rain forest, horticultural value for ornamental, traditional medicine and food resources. Taxonomic importance of nodal and petiolar anatomy is now widely recognized (Vesque, 1885; Hare, 1943; Howard, 1962, 1970; Schofield, 1968; Dickison, 1969, 1980; Datta and Dasgupta, 1979; Al-Nowaihi *et al.*, 1980; Stuessy, 1990; Ennos *et al.*, 2000; Shaheen, 2006; Bhadane, 2006). Many aspects of the vegetative anatomy have been covered, yet it needs further investigation in aspects that have received comparatively little attention. Very little work has been published on the petiole, rachis and petiolule anatomy of this

family (Solereder, 1908; Dehay, 1935; Metcalfe and Chalk, 1950; Miller and Webster, 1962; Dehgan and Webster, 1979; Dehgan Bijan, 1982; Khatijan *et al.*, 1996; Aguiar and Preisinger, 2000; Murillo, 2002 and Thakur and Patil, 2011). Thus, the present investigation was undertaken to record the structural details of these organs and to assess the value of this information for taxonomic purposes.

MATERIAL AND METHODS

The plant materials of *Anda gomesii* A. Juss., *Vernicia fordii* Hemsl., *Phyllanthus polyphyllus* Willd., *Baliospermum solanifolium* (Geiseler) Suresh., *Phyllanthus indofischeri* Bennet., *Acalypha fruticosa* Forssk. and *Mallotus nudiflorus* (L.) Kulju & Welzen were collected from Lalbagh Botanical Garden, Bangalore where as *Mallotus philippensis* (Lam.) Muell. Arg., *Flueggea leucopyrus* Willd., *Flueggea*

virosa (Roxb. ex Willd.) Royle., *Tragia plukenetii* Radcl.-Sm., *Putranjiva roxburghii* Wall., *Phyllanthus airy-shawii* Brunel & J.P. Roux., *Phyllanthus debilis* Klein ex Willd. And *Phyllanthus acidus* L. Skeels collected from Pachmhari. *Hevea brasiliensis* (Willd. ex A. Juss.) Muell. Arg. was collected from Kerala while *Agrostistachys indica* Dalzell., *Aporosa lindleyana* (Wight) Baill. and *Glochidion hohenackeri* (Muell. Arg.) Bedd. collected from Castlerock and that of *Manihot esculenta* Crantz. and *Acalypha ciliata* Forssk. obtained from the Pal forest. The young twigs of *Jatropha curcas* L., *Jatropha integerrima* Jacq., *Jatropha multifida* L., *Jatropha gossypifolia* L., *Jatropha podagrica* Hook., *Euphorbia milii* Des Moul., *Euphorbia neriifolia* L., *Euphorbia tirucalli* L., *Acalypha hispida* Burm., *Breynia nívosa* (W.G. Sm.) Small., *Chrozophora prostrata* Dalzell & Gibson., *Chrozophora rottleri* (Geiseler) A. Juss. ex. Spreng., *Croton bonplandianus* Baill., *Euphorbia indica* Lamk., *Euphorbia fulgens* Karw. ex Klotzsch., *Phyllanthus maderaspatensis* L., *Phyllanthus urinaria* L., *Phyllanthus virgatus* G. Forst., *Breynia retusa* (Dennst.) Alston., *Pedilanthus tithymaloides* (L.) Poit., *Euphorbia umbellata* (Pax) Bruyns. and *Phyllanthus reticulatus* Poir. were locally collected from the botanical garden of Pratap College, Amalner. The plant materials fixed in F.A.A. were preserved in 70% alcohol. Transections at the middle of the petiole, rachis and petiolule were taken by both free hand and microtome. Sections were stained in safranin and fast green and mounted in Canada balsam after the customary dehydration. The camera lucida drawings were made.

OBSERVATIONS

The family is very diverse in range, composed of all sorts of plants ranging from large woody trees through climbing lianas to simple weeds that grow prostrate to the ground. The taxa which are taken for investigation have mostly simple leaf. The leaves are 3-5 foliate in *Anda* and *Hevea*.

The shape of the petiole/rachis as observed in transverse section is generally circular. In *Aporosa*, *Flueggea leucopyrus* and *Pedilanthus*

it has well - developed short lateral wings (Fig.1 b). In *Acalypha ciliata* and *Flueggea virosa* the wings are adaxially developed with median ridge between them so that longitudinal channels are formed on the adaxial surface (Fig.1g.). The petiolule of *Anda* is more or less circular with a shallow notch adaxially (Fig.2 b) while in *Hevea* it is cylindrical in outline with two adaxial wings folded laterally forming V-shaped deep notch in between them (Fig.2 g).

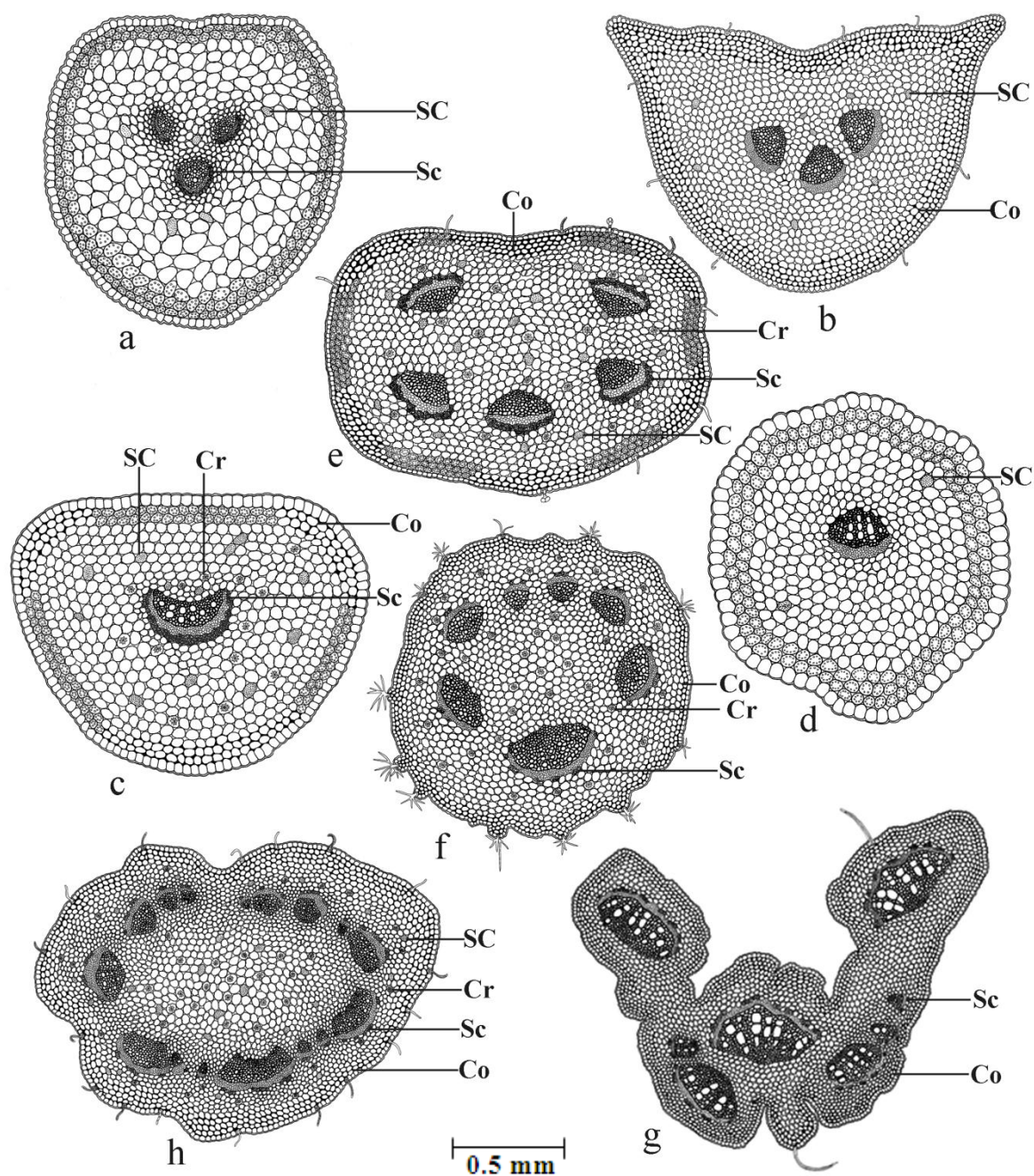
The epidermis of rachis, petiole and petiolule has small cells with thick or thin cuticle layer. Epidermal cells are generally barrel shaped or rounded except in *Aporosa* they are squarish. Various types of glandular and non glandular trichomes are found on epidermis.

A variation in the distribution of collenchyma, sclerenchyma and vascular tissue is observed.

In the petiole, few layers of collenchyma are occurs in the hypodermal region as continuous ring in *Acalypha ciliata*, *A. fruticosa*, *A. hispida*, *Agrostistachys*, *Baliospermum*, *Chrozophora prostrata*, *C. rottleri*, *Croton*, *Euphorbia fulgens*, *E. milii*, *E. umbellata*, *Jatropha curcas*, *J. gossypifolia*, *J. multifida*, *Mallotus nudiflorus*, *M. philippensis*, *Manihot*, *Pedilanthus* and *Vernicia* (Fig.1 b, f, g, h; Fig.2 a, f, h). In case of *Anda* and *Hevea* similar structure is present in both the organs- the rachis and petiolule (Fig.2 d, g). In *Flueggea leucopyrus*, *F. virosa*, *Phyllanthus debilis* and *Tragia*, 2 - 3 layered hypodermal chlorenchymatous tissue is interrupted by few layered 3-6 bands of collenchymatous tissue at adaxial, abaxial and lateral sides (Fig.1 c, e), of these adaxial ones are comparatively better developed.

A ring of sclerenchymatous patches, surrounding the vascular tissue is observed in the petiole/ rachis of most of the plant studied. In *Jatropha integerrima*, a prominent continuous ring of sclerenchyma develops. In addition, the smaller patches or groups of sclerenchyma cells are seen scattered in the ground tissue of *Euphorbia umbellata* as well. In *Acalypha fruticosa*, *A. ciliata*, *A. hispida*, *Agrostistachys*, *Baliospermum*, *Breynia nívosa*, *B. retusa*,

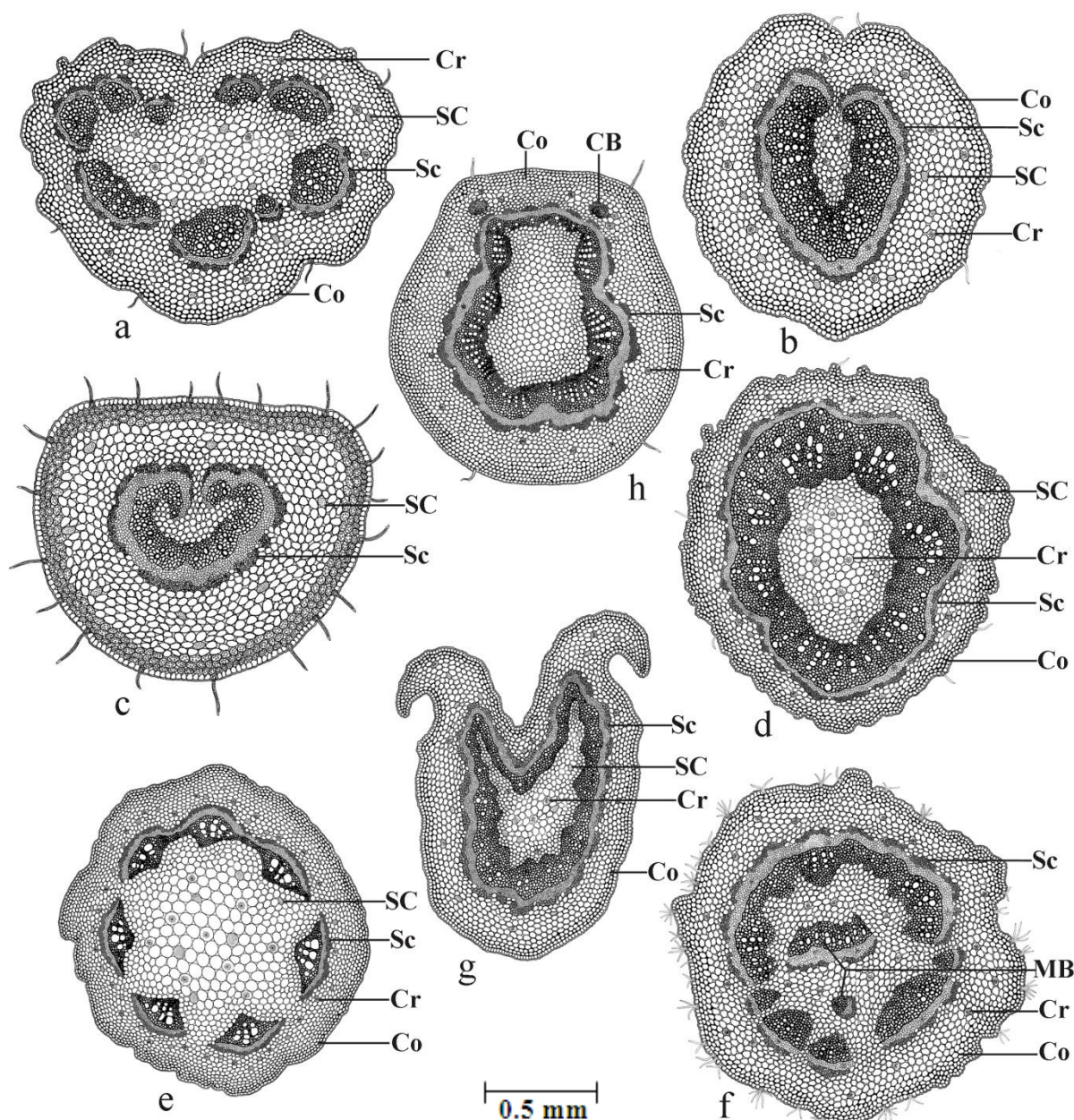
Fig. 1. T. S. of petiole: a. *Euphorbia neriifolia*, b. *Pedilanthus tithymaloides*, c. *Phyllanthus debilis*, d. *Phyllanthus airy-shawii*, e. *Tragia plukenetii*, f. *Chrozophora rottleri*, g. *Acalypha ciliata*, h. *Acalypha hispida*



Chrozophora rottleri, *C. prostrata*, *Croton*, *Euphorbia neriifolia*, *E. indica*, *E. tirucalli*, *E. umbellata*, *E. fulgens*, *Flueggea leucopyrus*, *F. virosa*, *Glochidion*, *Jatropha curcas*, *J. multifida*, *J. podagrica*, *Mallotus nudiflorus*, *M. philippensis*, *Manihot*, *Phyllanthus indo-fischeri*, *P. maderaspatensis*, *P. acidus*, *P. polyphyllus*, *P.*

reticulatus, *P. urinaria*, *P. virgatus*, *Putranjiva* and *Tragia*, individual vascular bundle have phloic sclerenchymatous patches. However, sclerenchyma is not noted in the petiole of *Euphorbia milii*, *Pedilanthus* and *Phyllanthus airy-shawii* (Fig.1b, d).

Fig. 2. T. S. of petiole: a. *Baliospermum solanifolium*, c. *Putranjiva roxburghii*, e. *Manihot esculenta*, f. *Mallotus philippensis*, h. *Jatropha gossypifolia*; **T. S. of rachis:** d. *Anda gomesii*; **T. S. of petiolule:** b. *Anda gomesii*, g. *Hevea brasiliensis*



Abbreviation used: CB – Cortical bundle, Co – Collenchyma, Cr – Crystals, MB – Medullary bundle, Sc – Sclerenchyma, SC – Secretory cell

A variation in the vascular structure is observed. The vascular tissue is in the form of distinct bundles - a central solitary vascular bundle is observed in *Phyllanthus airy-shawii* and *P. urinaria* (Fig.1 d). In the petiole of *Agrostistachys*, *Breynia nivosa*, *B. retusa*, *Flueggea leucopyrus*, *F. virosa*, *Phyllanthus*

acidus, *P. debilis*, *P. indofischeri*, *P. maderaspatensis*, *P. polyphyllus*, *P. reticulatus*, and *P. virgatus* an arc-shaped vascular strand is seen (Fig.1 c), while an open dissected arc of vascular bundles is noted in the petiole of *Putranjiva roxburghii* and petiolule of *Anda* (Fig.2 b, c).

An arc shaped distinct median and two smaller bundles occur in *Glochidion* and *Croton* while in *Euphorbia indica*, *Euphorbia milii*, *E. neriifolia*, *E. tirucalli* and *E. umbellata* and *Pedilanthus*, three distinct vascular bundles are observed (Fig.1a, b). Five distinct vascular bundles in an arc shape are noted in *E. fulgens*.

A ring of discrete bundles is observed in *Acalypha ciliata*, *A. fruticosa*, *A. hispida*, *Baliospermum*, *Chrozophora prostrata*, *C. rottleri*, *Jatropha curcas* and *Tragia* (Fig.1 e, f, g, h; Fig.2 a) while in *Jatropha multifida*, *J. podagrica*, and *Manihot* few bundles of vascular ring get interconnected (Fig.2 e). In *Anda*, *Aporosa*, *Hevea*, *Jatropha integerrima*, *J. gossypifolia* and *Vernicia* there is a continuous vascular cylinder (Fig.2 d, h, g) where as in the species of *Mallotus* a discontinuous vascular cylinder is observed (Fig.2 f).

The medullary bundles in the petiole are three in *Mallotus nudiflorus* and two in *M. philippensis* (Fig.2 f). The cortical bundles are located at the adaxial side of petiole in *Aporosa* and *Jatropha gossypifolia* (Fig.2 h).

The crystals, both solitary and/or clustered occur in the majority of the plants. Secretory cells are of common occurrence. Idioblasts are also seen in the taxa *Euphorbia umbellata*.

DISCUSSION

The taxa which are taken for investigation have mostly simple leaf. The leaves are 3-5 foliate in *Anda* and *Hevea*. The shape of the petiole/rachis as observed in transverse section is generally circular. In *Aporosa*, *Flueggea leucopyrus* and *Pedilanthus* it has well - developed short lateral wings. In *Acalypha ciliata* and *Flueggea virosa* the wings are adaxially developed with median ridge between them so that longitudinal channels are formed on the adaxial surface. The petiolule of *Anda* is more or less circular with a shallow notch adaxially while in *Hevea* it is cylindrical in outline with two adaxial wings folded laterally forming V- shaped deep notch in between them.

The epidermis of rachis, petiole and petiolule has small cells with thick or thin cuticle layer.

Epidermal cells are generally barrel shaped or rounded but in some cases they are squarish. Trichomes are variable.

The present study exhibits an interesting variation in the organization of mechanical tissues in the petiole and rachis. A similarity in the internal structure of the petiole/petiolule and rachis is noted. The mechanical tissue is sclerenchymatous and collenchymatous. The xylem elements are additionally mechanical in function.

The distribution of collenchyma is of much significance. In the petiole, few layers of collenchyma occurs in the hypodermal region as continuous ring in *Acalypha ciliata*, *A. fruticosa*, *A. hispida*, *Agrostistachys*, *Baliospermum*, *Chrozophora prostrata*, *C. rottleri*, *Croton*, *Euphorbia fulgens*, *E. milii*, *E. umbellata*, *Jatropha curcas*, *J. gossypifolia*, *J. multifida*, *Mallotus nudiflorus*, *M. philippensis*, *Manihot*, *Pedilanthus* and *Vernicia*. In the rachis and petiolule of *Anda* and *Hevea* also, a continuous ring of hypodermal collenchyma is present. Instead of a ring, four bands of hypodermal collenchyma are developed on the adaxial and abaxial side in the species of *Flueggea*. In *Phyllanthus debilis*, three band of collenchyma are developed, of them two are at adaxial corners and one is on abaxial side. In *Tragia* hypodermal collenchyma is interrupted at regular intervals by chlorenchyma and form six bands of collenchyma. Of these, the adaxial one is comparatively better developed.

The absence of any hypodermal mechanical tissue in *Aporosa*, *Breynia*, *Euphorbia indica*, *E. neriifolia*, *E. tirucalli*, *Glochidion*, *Jatropha integerrima*, *J. podagrica*, *Phyllanthus acidus*, *P. airy-shawii*, *P. indofischeri*, *P. maderaspatensis*, *P. polyphyllus*, *P. reticulatus*, *P. urinaria*, *P. virgatus*, *Putranjiva* is to be noted. Here, the petiole are adopted to support the weight of leaf lamina and therefore are inextensible and naturally possess the mechanical tissue at the central region.

The considerable variability in distribution of sclerenchyma is noticed in petiole/ rachis of

studied taxa. Phloic sclerenchymatous patches on individual vascular bundles are observed in most of the plants studied. A ring of sclerenchymatous patches, surrounding the vascular tissue is observed in *Anda*, *Aporosa*, *Hevea*, *Jatropha gossypifolia*, *Mallotus philippensis*, *M. nudiflorus* and *Vernicia*. In *Jatropha integerrima*, a prominent continuous ring of sclerenchyma develops. In addition, the smaller patches or groups of sclerenchyma cells are seen scattered in the ground tissue of *Euphorbia umbellata* as well. However, sclerenchyma is not noted in the petiole of *Euphorbia milii*, *Pedilanthus* and *Phyllanthus airy-shawii*. Apart from these, varying quantum of vascular tissue - xylem acts together with the sclerenchyma as a sort of central skeleton for the petiole/rachis.

Comparatively higher amounts of vascular variability are noticed in the petiole. The vascular tissue is in the form of a ring of discrete bundles in *Acalypha ciliata*, *Acalypha fruticosa*, *Acalypha hispida*, *Baliospermum*, *Chrozophora rottleri*, *C. prostrata*, *Jatropha curcas*, *Jatropha multifida* and *Tragia*. In the species of *Mallotus*, *Jatropha podagrica* and *Manihot* a discontinuous vascular cylinder is observed. There is a continuous vascular cylinder in *Anda*, *Aporosa*, *Hevea*, *Jatropha gossypifolia*, *J. integerrima* and *Vernicia*. An arc-shaped vascular bundle reported in *Agrostistachys*, *Breynia nivosa*, *B. retusa*, *Flueggea leucopyrus*, *F. virosa*, *Phyllanthus acidus*, *P. debilis*, *P. indofischeri*, *P. maderaspatensis*, *P. polyphyllus*, *P. reticulatus*, *P. virgatus* and *Putranjiva*. An arc-shaped distinct median and two smaller bundles occur in *Croton* and *Glochidion* while a central solitary vascular bundle is observed in *Phyllanthus airy-shawii* and *P. urinaria*. Vascular bundles are reported three in number in the centre of petiole of *Euphorbia indica*, *E. milii*, *E. neriifolia*, *E. tirucalli*, *E. umbellata* and *Pedilanthus*, their number is five in *Euphorbia fulgens*.

In the certain taxa, the medullary and cortical bundles occur in the petiole. The medullary bundles are three in numbers in *Mallotus nudiflorus*, whereas two in *Mallotus*

philippensis. Solereder (1908) and Metcalfe and Chalk (1950) have recorded medullary bundles in the petiole of *Ricinus*. Similarly, Khatijah *et al.*, (1996) and Thakur and Patil (2011) also reported presence of central bundles in the petiole of *Mallotus* species. The cortical bundles are notable in *Aporosa lindleyana* and *Jatropha gossypifolia*, which is located at the adaxial side. Such bundles are also reported in the species of *Jatropha* studied by Dehgan (1982).

Lignier (1887) is of the opinion that the vascular arc increases in size within the petiole to develop folds, which separate towards inner and outer side to result in the medullary or cortical bundles.

The present study reveals comparatively higher amount of vascular variability than that of other tissues. It is presumed that the structure of the rachis/petiole of different taxa is related to the mechanical requirement of the leaf/leaflets.

In the comprehensive survey of petiole anatomy, De Candolle (1879) recognized a principle and accessory system, the latter composed of the cortical and or the medullary bundles. The principle system has open and closed types. According to Petit (1886, 1887) an open system is one in which vascular bundles are distinct or separated and closed system has fused bundles. Petit holds that herbaceous plants show distinct bundles and shrubby or woody taxa exhibit fused (closed) bundles to form an arc or ring. Further, he noted that perivascular or pericyclic sclerenchyma is lacking in herbaceous plants and occurs in woody taxa.

This investigation demonstrates the variable vascular pattern- the accessory bundles in *Mallotus nudiflorus*, *Mallotus philippensis*, *Aporosa lindleyana* and *Jatropha gossypifolia* apart from the variation in the main vascular system. These attributes along with the distribution of sclerenchyma, occurrence of collenchyma in some species and the shapes in the transverse section of the rachis, petiole and petiolule can be used as adjuncts for the delineation of the taxa studied. Howards (1962) upheld the importance of petiolar vasculature as

an aid to horticultural taxonomists. The study on petiole structure emphasizes its utility in Meliaceae (Bhadane, 2006).

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