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Anatomical relationship between the parasite: *Dendrophthoe falcata* (Loranthaceae) and their host plants, South India

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ABSTRACT

Dendrophthoe falcata (L.f.) Ettingsh. of the family Loranthaceae is a common non-host specific mistletoe occurring along the Coromandel Coast of Tamil Nadu. Through literature survey the host range, morphological mimicking of the host, haustorium formation, types of haustorium and their defence mechanism between the host and parasite, molecular and genetic evolution of the family have known, but the anatomical and phyto-chemical relationships between them has not known. This study has attempted to understand that how the host and parasite's stem anatomy are similar and/or differ each other. A total of six month regular botanical inventory from four natural and eco-restored sites, young and matured stems of host and their parasites were collected and fixed in a solution. In general, through the cross and longitudinal sections, this study observed the presence or absence of sap and hardwood, their growth rings, vessel size and number, and arrangement of primary and secondary xylem are almost similar between the host: *Hardwickia binata*, *Morinda coreia*, *Strychnos nux-vomica* and their parasite: *Dendrophthoe falcata*. In comparison, the same study from *Albizia*, *Casuarina*, *Dolichandrone*, and *Gmelina* with their parasite have share both similarities as well as differences between them.

Keywords: Anatomy, *Dendrophthoe*, Differences, Host, Loranthaceae, Mistletoe, Parasite, Similarity.

1. INTRODUCTION

Among the plant parasites, mistletoes are one of the essential component of biodiversity (Watson, 2001; Shaw et al., 2004). They are the predominant group of angiospermic shoot parasite that has found in wide range of ecosystem and environment (Nickrent, 2002). Generally, the infection of mistletoes is positively related to tree size, canopy cover, water, and nutrient status (Press & Phoenix, 2005). The Indian Mistletoe: *Dendrophthoe falcata* (L.f.) Ettingish. is remarkable because it attacks a significant number of native as well as introduced trees in different habitats. In addition, the relationship between parasite and their host plant is variable and this

variation creates a significant challenge to understand how hemiparasites interact with their hosts and their environment (Arumugam et al., 2014). Besides, Balachandran et al. (2022) recorded the parasite *Dendrophthoe* is mimicking the morphological features of the host.

The effect of mistletoes on their hosts may reduce the vigor and growth rate, poor fruit yield or seed set, malformation of woody tissues, sparse foliage, top dying, predisposition to insect, disease attack and premature death (Arumugam et al., 2014). This parasite can affect host productivity by extracting water, nutrients, and organic compounds from the host's vascular resources (Scholes et al., 1999). The extent of this impacts on host may depend upon the degree of autotrophy of the parasite, the relative ability between the host and parasite which sinks into attract the resources, and the tolerance or resistance of infection with the host species (Rispaill et al., 2007).

The so called haustorium is the contact organ to obtain the nutrients which formed between the parasite and host (Weber, 1982). Based on the location of origin of the haustorium, it was categorized into three, viz. root, shoot, and leaf parasitism (Weber, 1980). It may also be broadly classified into aerial parasitism and root parasitism. In root parasitism, haustoria are root initiated and in shoot parasitism the contact organs, i.e. the stem develops the secondary haustoria, (Raugh, 1937; Kuijt, 1969; Kuijt and Toth, 1985).

Stem Anatomy of Loranthaceae

A transverse section of the young stem of *Dendrophthoe falcata* shows a single-layered epidermis has covered by a thick cuticle at outside. The epidermal cells are somewhat loosely arranged, more or less isodiametric, with small papillae on the outer tangential wall and filled with tannin (Johri and Bhatnagar, 1972). The epidermis followed by a broad zone of cortex which is distinguishable into two zones: an outer zone has 6 or 8 layers of cells which are densely filled with tannin and packed with starch, and an inner cortical zone cells are larger some of which also contain tannins.

Frequently, idioblasts or branched sclereids with simple pitted and striated walls occur in the cortex. The sclereids may be branched and sometimes contain solitary crystals in the lumen (Balle and Halle, 1961). The strands of fibers with thick walls has recorded in the pericycle of some species of Loranthaceae (Metcalf and Chalk, 1950). These strands are opposite to the vascular bundles (Johri and Bhatnagar, 1972). Cortex have a collateral ring, with open and endarch vascular bundles. They are separated from each other by one or two layers of radially elongated cells, i.e. medullary rays. The pith is usually large and parenchymatous. Most of the cells are filled with tannin, whereas others are lignified and develop simple pits on their walls. In some species, the pith is made of parenchyma cells which contain starch granules (Balle and Halle, 1961).

Mucilage canals have reported in some species. They first appear in the pith, and later in the phloem. The pith contains a central mucilage canal, and peripheral ones situated opposite to the large vascular bundles. They do not branch any further but become considerably swollen here and there. The secondary growth is profuse, and has prominent growth rings. The secondary phloem is much less when compared to the xylem. These cells are arranged in radial rows and are frequently associated with phloem parenchyma cells. The secondary xylem consists of a large number of vessels. The wood is diffuse, porous, and the vessels has exhibiting variable arrangement. They may be present in clusters or multiples or short tangential groups or rows, as in some species. The vessels are tiny in some species.

In some species of *Loranthus*, is slightly larger than 50 microns. Perforations are simple. Intervascular pitting is alternate with small to large, sometimes coalescent apertures. The parenchyma shows large and simple pits, similar to intervacular pitting (Johri and Bhatnagar, 1972). In *Dendrophthoe falcata*, the secondary xylems are arranged in clusters or in multiples. The vessels have small perforation in the lateral walls, and each ray has a single crystal. This study is approaching to understand the exact stem anatomical (primary and secondary wood) relationship (similarity or differences) between the host and parasite, *Dendrophthoe falcata*.

2. MATERIALS AND METHODS

Three artificial forests viz. Aranya, Merve, Shakti, and a sacred grove at Puthupet, Villupuram district of Tamil Nadu, have selected to study the plants that was infected by *D. falcata* and to know the relationship between the host and parasite. Of which 'Aranya' and 'Shakti' is belonging to Auroville whereas 'Merveille' is attached with Sri Aurobindo Ashram Education Trust. Regular field visit was under taken about two days in every week between the month of September and February in all the four sites.

Anatomical Study

During the survey stem pieces with pencil thickness and 2 cm long were collected from both host *Albizia lebbek* of Leguminosae, *Casuarina equisetifolia* of Casuarinaceae, *Dolichandrone falcata* of Bignoniaceae, *Gmelina arborea* of Lamiaceae (=Verbenaceae), *Hardwickia binata* of Leguminosae, *Morinda coreia* of Rubiaceae, *Strychnos nux-vomica* of Loganiaceae, and their parasite *Dendrophthoe falcata*. The collected stem pieces were fixed in FAA (Formalin 20 ml + Acetic acid 7.5 ml + Alcohol (Ethanol) 300 ml) solution. Microtome apparatus (MIKROT L WSL lightweight G.S.L.-1 microtome) was used to take CS (cross section) and MLS (median longitudinal sections) of the stem at 2-3-micron thickness. If the sample feels so hard to take the section, then it was subjected again to treat with Glycerol or 5% NaOH for softening. Generally, the sections were used to stain either with Safranin or TBO, and sometimes with a mixture of both. A well stained section has mounted on the slide with Glycerin, as a medium. Similarities and differences of cell complex between the host (*Hardwickia binata*, *Morinda coreia*, and *Strychnos nux-vomica*) and parasite, and the DF stems samples from the hosts of *Albizia lebbek*, *Dolichandrone falcata*, and *Gmelina arborea* have sectioned, photographed, and studied.

3. OBSERVATION AND RESULTS

Anatomical Relations – Stem Anatomy

The FAA fixed stem samples of 3 hosts and their respective DFs underwent microtome sections at 2-3-micron thickness. Both cross-section (CS) and longitudinal section (LS) was taken from the DF stems and their respective host *Hardwickia binata*, *Morinda coreia*, and *Strychnos nux-vomica* stems. In addition, three stem samples of DF from the host, *Albizia lebbek*, *Dolichandrone falcata*, and *Gmelina arborea* have sectioned, studied, and analyzed their anatomical similarities and differences among them.

Hardwickia and DF (Plate 1.)

General features – In comparison, both host and parasite have distinct sap and heartwood.

Growth ring – The growth ring was distinct in both species, but the parasite has differed by the deposition of starch and tannins near the summerwood.

Vessels - the primary and secondary xylems, especially the arrangement of vessels, are similar in both host and parasite. The summer and springwood is prominent in both host and parasite, but comparatively the number of vessels are less in the parasite. In contrast, the summerwood of parasite, especially the tracheids and ray parenchyma cells has filled with starch and tannins.

Fibres – Thick-walled, non-septate, xylem, and phloem fibres were also standard between the parasite and host.

Tracheids - were also arranged well with vessels, whereas the sclereids were found at the pith and cortex regions in both plants.

Gum ducts - were found and it was scattered in pith, vascular, and cortical regions in both plants.

Pith – The DF, irrespective of any host has retained its genesis, representing parenchyma cells, and it was interrupted by thick-walled sclereids. The parenchyma cells are always filled with starch and tannin. The ray cells of *Hardwickia* have 1-2 cell thicknesses, throughout the stem, whereas the parasite has 1-2 in primary wood and 3-6 cells thickness in secondary wood. Like the host, the parasite has also recorded uneven size of vessels, they are 2-4 in clusters, and it is round to oval all along the wood.

Morinda and DF (Plate 2)

General features: In comparison, both host and parasite have no distinct sap and heartwood.

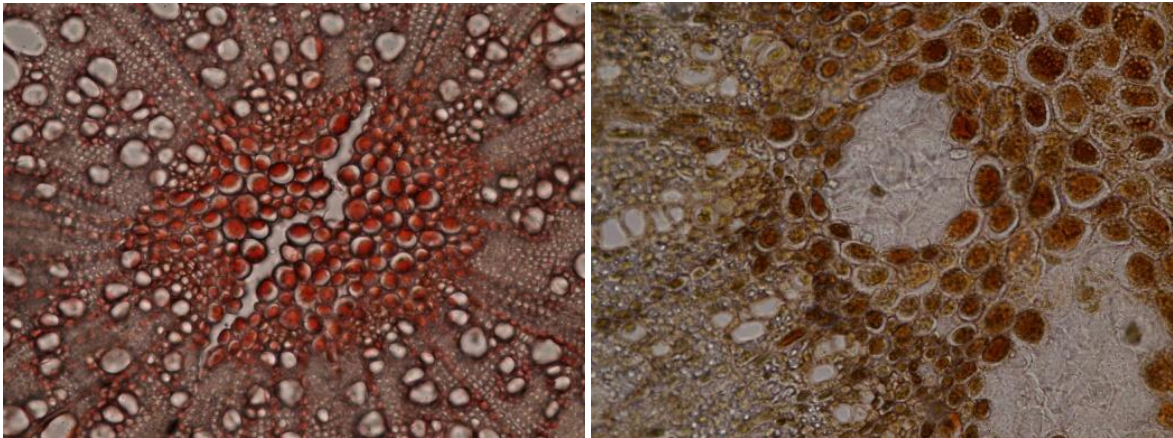
Anatomical features: Both host and parasite are devoid of distinct growth rings

Ray cells – In DF, rays 1-3 cells thickness at the primary region, and 3-7 at the secondary regions. Interestingly, sclereids were recorded at the broader portion of rays in the secondary wood.

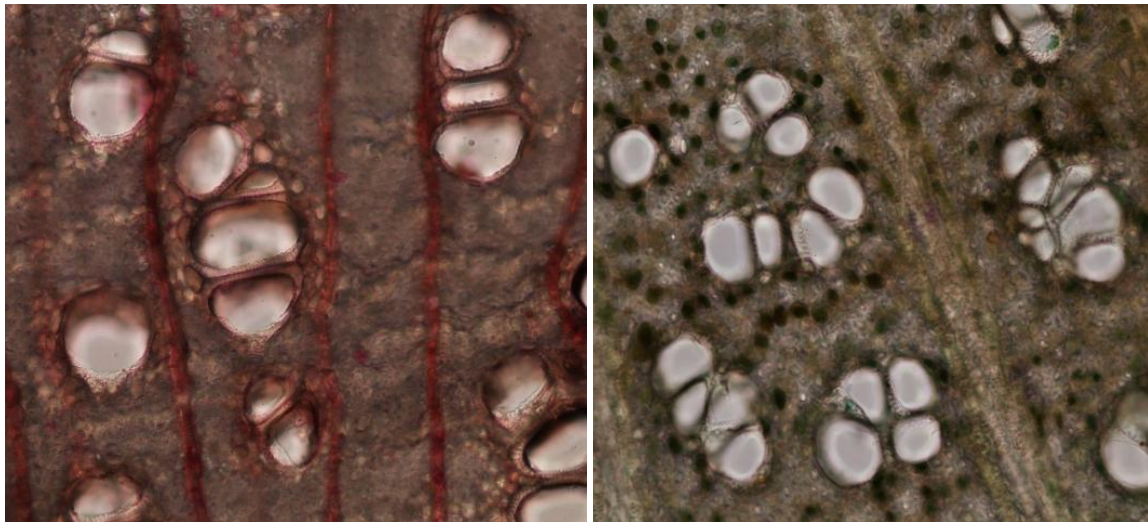
Pith – In *Morinda*, only parenchyma cells are found, whereas in the pith of DF, as usual, the parenchyma cells are disrupted by sclereids. Raphids are distributed scatteredly at pith and the cortex regions of *Morinda*, but it was absent in the DF stem. These parenchyma cells are stuffed with starch and tannins. Rarely gum ducts are also found in the pith of DF.

Xylem – the vessels of the primary xylem of both host and parasite have uniformly arranged one above the other, but at the secondary wood region, 1-3 medium (but uneven) sized vessels are found in both species. The pits are simple and circular. As usual, tracheids and fibers are common in both species. In the secondary phloem, it is also mixed with sclereids. The fibres and tracheids are rarely filled with starch and tannins. Interestingly, the cross and longitudinal sections of vessels of DF were recorded with tannin content.

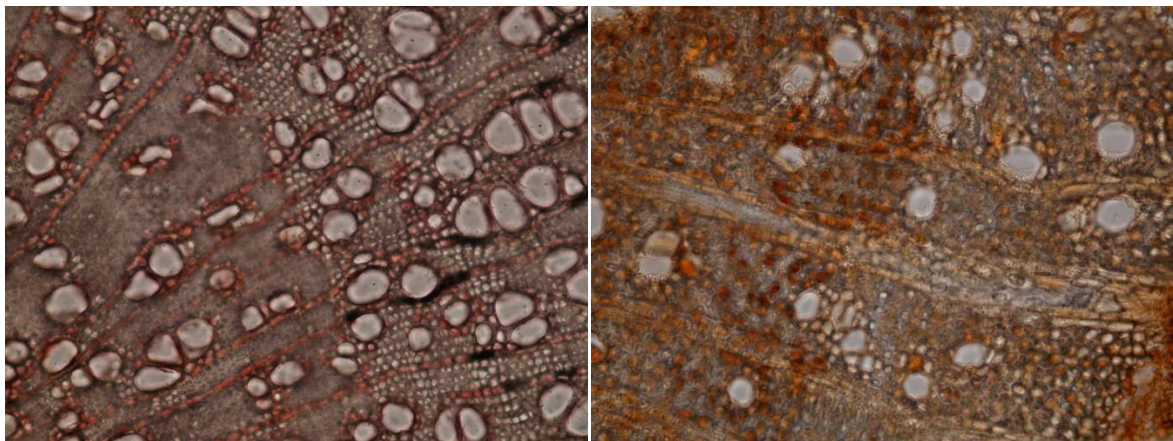
Cortex - a mixture of parenchyma, and sclerenchyma with ellipsoid oil ducts.



Pith: Only parenchyma in *Hardwickia*; Parenchyma and Sclerids in DF

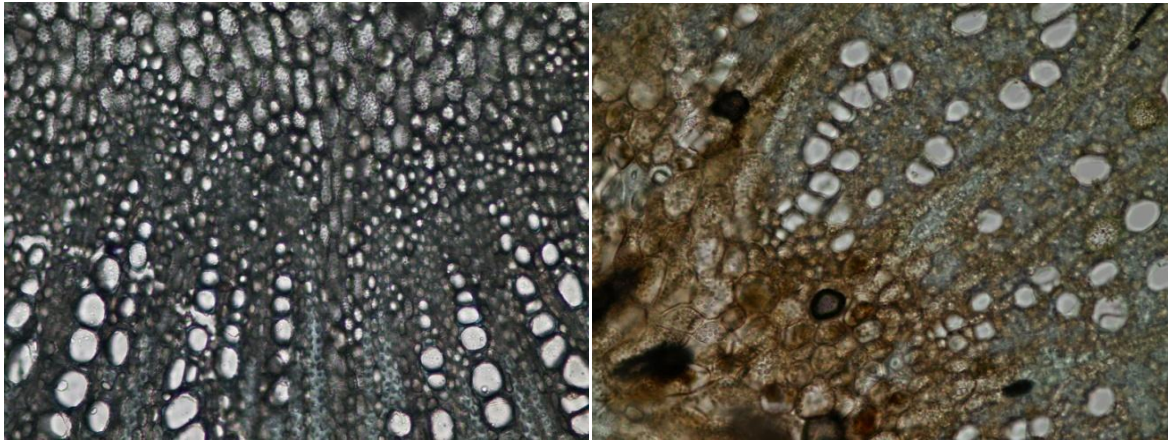


Vessels and Ray cells: similar size, shape and arrangement between host and DF

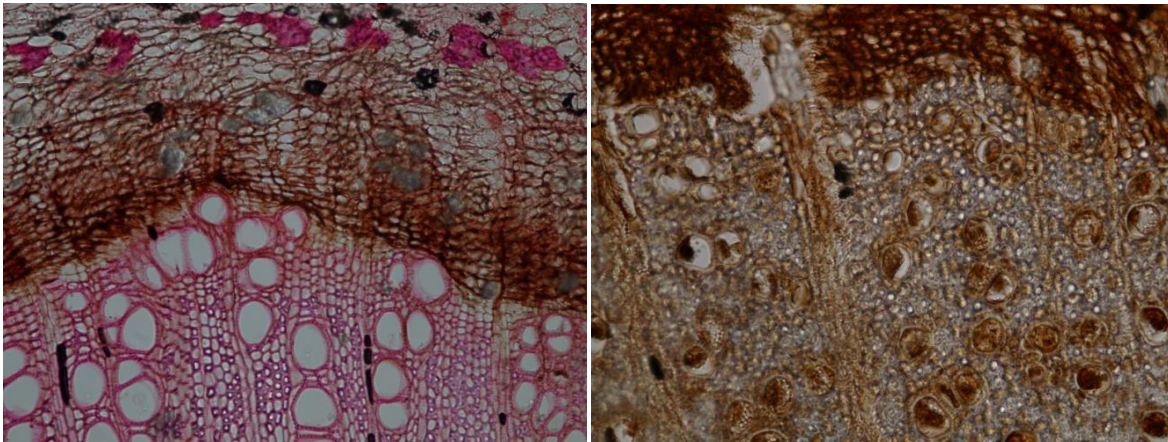


Spring and summer wood: distinct region between the host and DF

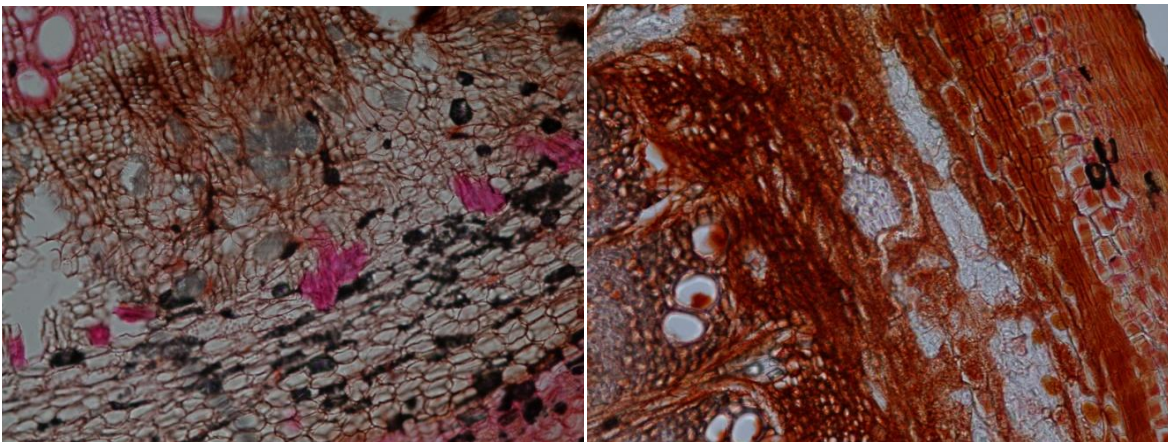
Plate 1. Stem anatomy - similarity and difference between *Hardwickia* (a) and DF (b)



Uniform size and arrangement of vessels at Primary wood of both host and parasite

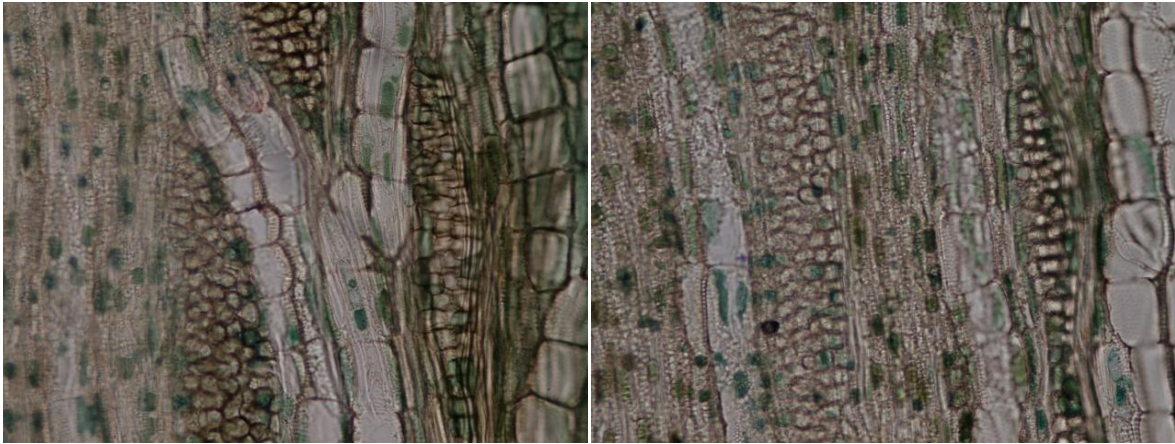


Evenness of vessels and tracheids arrangement at secondary wood of host and parasite

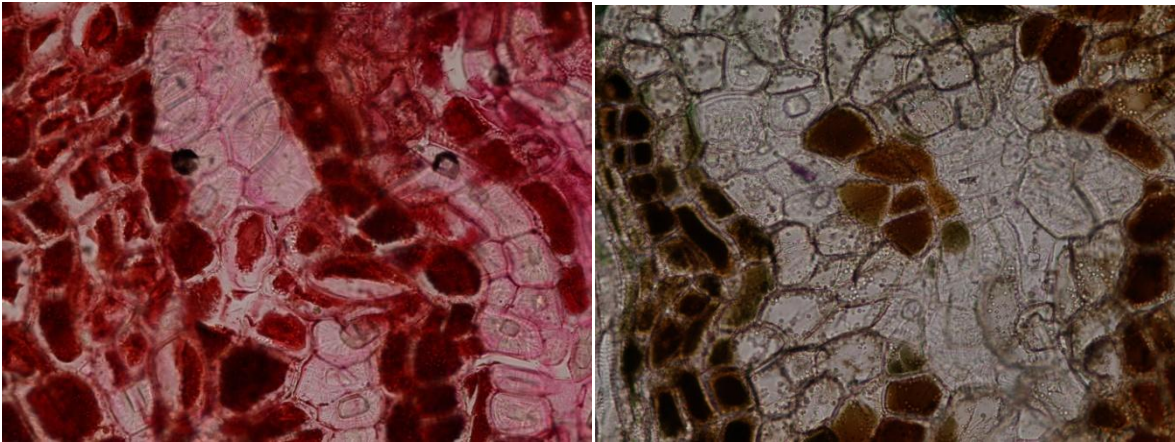


Difference: a Crystals at cortex and pith, b Sclereids, gum ducts and tannins at cortex and pith

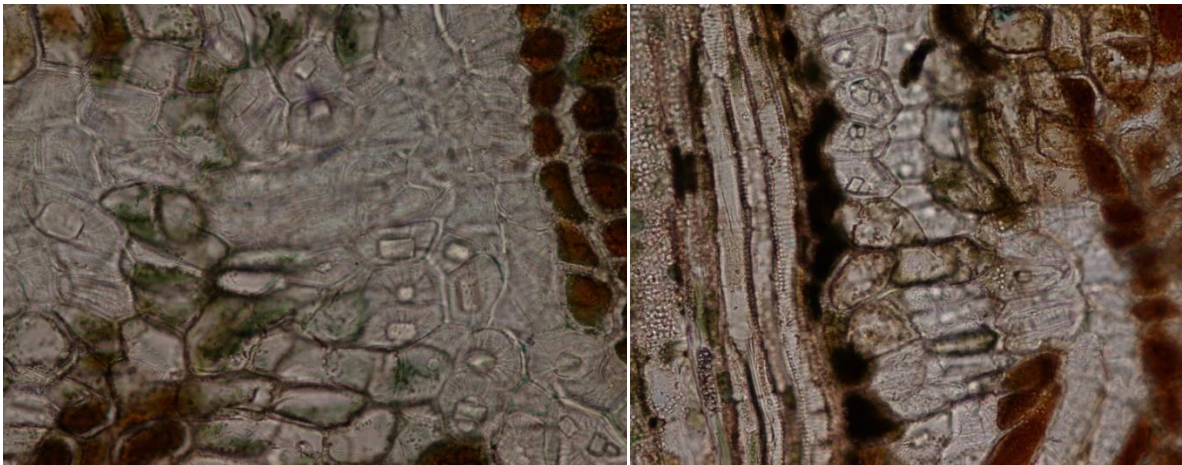
Plate 2. Stem anatomy - similarity and difference between Morinda (a) and DF (b)



Similarity in vessel size, pits and ray cells between *Strychnos* and DF



Relation in lignin deposits at pith region of host and parasite

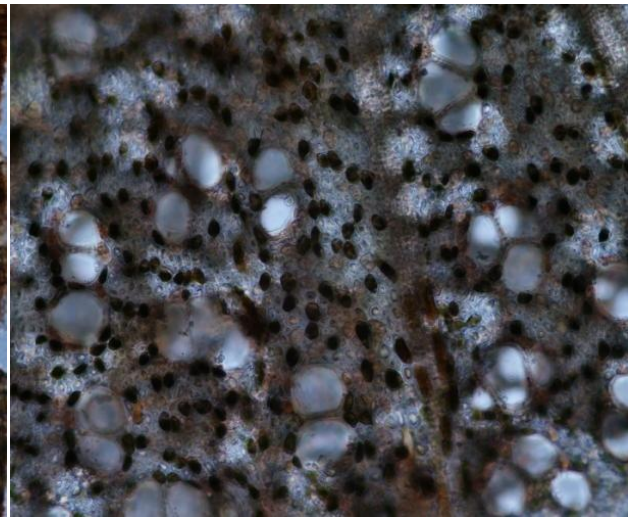


Occurrence of rectangular crystals at Sclereids in both host and parasite

Plate 3. Stem anatomical similarity and difference between *Strychnos* (a) and DF (b)



a - Rhomboidal crystals & Sclereids at Ray cells,



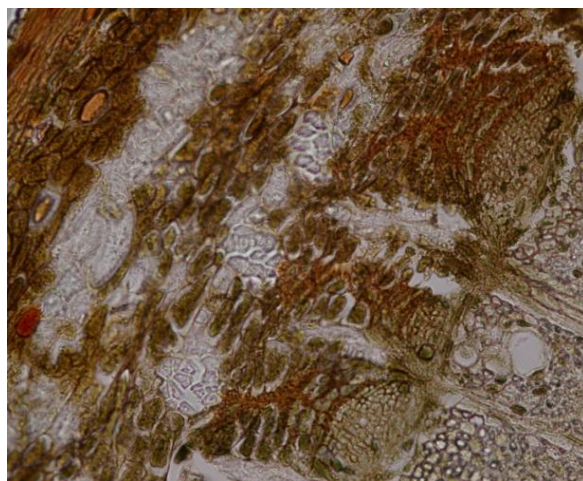
b - Starch grains at secondary wood



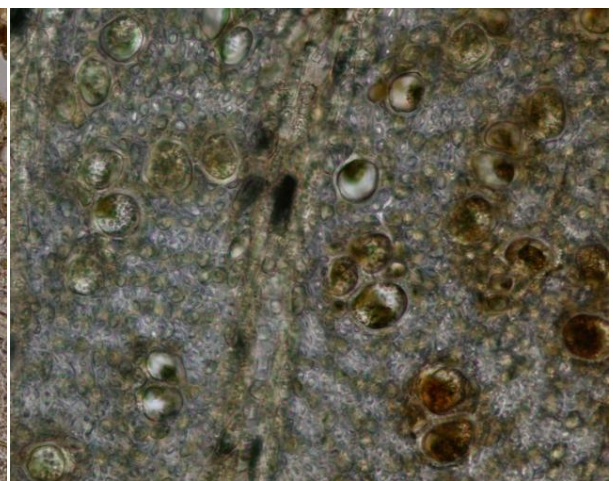
Gmelina DF with long vessels



Morinda DF vessels with tannin



Hardwickia (Tannin duct at cortex)



Vessels filled with starch and tannin in Morinda

Plate 4. Anatomical differences found in DF stems from different host - DF on Albizia

***Strychnos* and DF (Plate 3)**

General features- In comparison, both host and parasite have distinct sap and heartwood.

Anatomical features – distinct partition of primary and secondary growth rings.

Xylem - The host and parasitic vessels are exhibit considerable variation in size and number (1-4). The vessel pits are simple and similar in both species. Tracheids are intermixed in both species.

Phloem – radial strands of phloem in both host and parasite but, the DFs secondary phloem has inter mixed with sclereids.

Ray cells – LS study shows that they are 3-12 cells wide and intermixed with sclereids in both host and parasite.

Fibres – simple, medium sized, and in clusters.

***Differences among the DF stems* (Plate 4)**

The anatomical similarity and differences between the host and DF has studied. In addition, CS and LS of DF stem alone studied from the host of *Albizia lebbek*, *Gmelina arborea*, and *Morinda coreia*. In which the DF stem from *Albizia*, *Hardwickia*, and *Strychnos* ray cells have thick-walled sclerenchyma with rhomboidal crystals, but they are scattered. The occurrence of crystals in the DF stems have not been influenced by other host species. In contrast, the starch grains were evident in the summerwood of *Albizia*, and it is also recorded in the DF of *Hardwickia*.

LS of DF stem from the host *Albizia*, *Casuarina*, *Gmelina* and *Morinda* were also studied. The vessel length of DF growing on *Casuarina* and *Gmelina* stems is longer than the host, *Albizia* and *Morinda*. The tannin duct has found with the vessels in CS and LS of DF stem from the host plants, *Albizia*, *Dolichandrone*, *Gmelina*, *Hardwickia*, and *Morinda*. The vessels are recorded from the primary and secondary wood regions. Special ellipsoid-shaped ducts are also found in the cortical areas of the stem. Occurrence of sclereids in the ray cell is another significant difference among the DF stem which comes from different host. It is recorded in *Albizia*, *Casuarina*, *Hardwickia*, *Morinda*, and *Strychnos*. In addition, the vessels got filled with starch grains and it is found only in the DF stem which is growing on the host, *Morinda*.

4. DISCUSSION & CONCLUSIONS

Anatomical study (CS and LS) was attempted to know the relationship between the stems of a parasite, *Dendrophthoe falcata* and their host plants, *Hardwickia binata*, *Morinda coreia*, and *Strychnos nux-vomica*. In general, the features like, the presence or absence of sap and heartwood, growth rings, the vessel's size (small to moderately large), number (1 to 4 in groups), and arrangement of primary and secondary xylem area are almost similar between the host and parasite.

The number and shape of ray cells in between the host and parasite of summer and spring woods are also the same, except the secondary wood of DF stems from the host *Morinda*, which has 3-7 cell thickness. The tracheids and fibres, as usual, are arranged along with xylem and phloem regions whereas the sclereids are scattered in pith and secondary cortical portions along with parenchyma cells, which is found in all DF stems but it has not found in host plants. Like sclereids, *Morinda* has acicular raphids (calcium oxalate crystals), it is an essential character of Rubiaceae. They are found at the pith and cortical portion, but it has absent in DF stem section. Presence of tracheids, gum ducts at the cortical and pith regions, and occurrence of the starch grains and tannins in the primary and secondary wood regions of DFs, which are the unique representative characters of Loranthaceae.

This piece of work is strengthening the study of Balle and Halle (1961), i.e. the occurrence of parenchymatous cells in the pith has filled with starch and tannin, which is one of the characteristic feature of the family, Loranthaceae. Chauhan and Rao (2003) stated that the vessels of *Hardwickia binata* has filled with gummy deposition. Presence of rhomboidal crystals within the sclerenchyma or scleried cells of *Albizia* and *Hardwickia* (Chauhan and Rao, 2003), and *Morinda* and *Strychnos* (Metcalf and Chalk, 1957) was already recorded. However, occurrence of the rhomboidal crystals in DF stems which is growing on these host plants, is considered as a first record. This study, is so significantly evident that anatomically the host and parasite has promising relation.

In all, the present and the recent studies on morphology, anatomy, phytochemical and phytolith made by Suvaathimani (2018), Vinothini (2018), and Balachandran et al. (2022), to understand the relationship between different host plants and the parasite (DF) reveals that the results have more positive and less negative correlations. Further to know the detailed relationship between the host and parasite, more number of samples needs to be studied in all aspects, and in addition to molecular and genetical studies.

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Author Contributions

The first author conceived the study, identified the study area and host species, framed the methodology, analysed the data and concluded; all authors conducted the field survey and collected voucher samples; Barathan taken all anatomical sections, SS and VK drafted the manuscript; and all authors approved final version for the publication.

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Conflict of Interest

The authors declare that there are no conflicts of interests.

Informed consent

Not applicable.

Ethical approval & declaration

In this article, as per the plant regulations followed in the Ecology Department, French Institute of Pondicherry, Pondicherry, India; the authors observed the anatomical relationship between the parasite: *Dendrophthoe falcata* (Loranthaceae) and their host plants, South India. The ethical guidelines for plants & plant materials are followed in the study for species observation, identification & experimentation.

Data and materials availability

All data related to this research described in the article.

REFERENCES

1. Arumugam R, Venkatesalu V, Rajkumar R. Characteristic variation in pigment composition, photosynthetic carbon assimilation and phytonutrients content of *Dendrophthoe falcata*, a hemiparasite growing on host trees of saline and non-saline environments. *Russian journal of plant physiology*, 2014; 62 (5): 641-646.
2. Balachandran N, Suvaathimani S, Vinothini K, Barathan N. Morphological mimicking and defense mechanism between the hosts and mistletoe: *Dendrophthoe falcata* of Loranthaceae. *Species*, 2022; 23(72): 554-565.
3. Balle S, Halle N. Les Loranthacees de la cote d'Ivoire. *Adansonia*, 1961; 1: 208-265.
4. Chauhan L, Vijendra Rao R. Wood anatomy of the legumes of India. Their identification, properties and uses. Bishen Singh Mahendra Pal Singh, Dehra Dun, India, 2003.
5. Johri BM, Bhatnagar SP. Loranthaceae - Botanical Monograph. Council of Scientific and Industrial Research, New Delhi, 1972; 8: 1-155.
6. Kuijt J. The Biology of parasitic flowering plants. University of California press, Berkeley, 1969; 168: 1081-1082.
7. Kuijt J, Toth. Structure of the host-parasite interface of *Boschniakia hookeri* Walpers (Orobanchaceae). *Acta Bot. Neerl*, 1985; 34: 257-270.
8. Metcalfe CR, Chalk L. Anatomy of Dicotyledons II. Clarendon press, Oxford, 1950.
9. Metcalfe CR, Chalk L. Anatomy of the Dicotyledons. II. Clarendon Press, Oxford, 1957.
10. Nickrent DL (ed). Phylogenetic origins of parasitic plants, in parasitic plants of the Iberian Peninsula and Balearic. Madrid: Mundi-Prensa, 2002: 29-56.
11. Press MC, Phoenix GK. Impacts of parasitic plants on natural communities. *New phytol*, 2005; 166: 737-751.

12. Raugh W. Die building von hypokotyl-und Wurzelsprossen und ihre bedeutung fur die Wuchs formen der pflanzen. Nova Acta Leop, 1937: 4: 410-551.
13. Rispaill N, Dita MA, Gonzalez- Verdejo C. Plant resistance to parasitic plants: molecular approaches to old foe, New phytology, 2007: 173: 703-711.
14. Scholes JD, Press MC, Barker MG (eds.). Parasitic plants: physiological and ecological interactions with their hosts. Oxford: Blackwell, 1999: 175-197.
15. Shaw DC, Watson DM, Mathiasen RL. Comparison of dwarf mistletoes (*Arceuthobium* spp. Viscaceae) in the Western United States with mistletoes (*Amyema* spp. Loranthaceae) in Australia—ecological analogs and reciprocal models for ecosystem management Australian J. Botany, 2004: 52: 481–498.
16. Suvaathimani S. Morphological and Phytochemical relationship between the host and parasite: *Dendrophthoe falcata*. Integrated MSc Life Science Dissertation, Central University of Thiruvvarur, 2018: 1-52.
17. Vinothini K. Relationship between the host and parasite: *Dendrophthoe falcata* – Approaching through anatomy and Phytolith. Integrated MSc Life Science Dissertation, Central University of Thiruvvarur 2018; 1-57.
18. Watson M. Mistletoe - A keystone resource in forests and woodlands worldwide. Annu. Rev. Ecol. Syst, 2001: 32: 219–49.
19. Weber H, Chr. Zur evolution des parasitismus bei den Scrophulariaceae und Orobanchaceae. Pl.syst. Evol, 1980: 136: 217-232.
20. Weber H, Chr. Wurzelparasitismus terrestrischer Blütenpflanzen. Doctorate thesis, Ulm, 1982.