



(RESEARCH ARTICLE)



## Studies on Biology, Seed dispersal and Host interaction of *Dendrophthoe falcata* (L.f.) Etting. - A stem parasite of *Mangifera indica* L. (Mango)

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### Abstract

The hemiparasitic plant, *Dendrophthoe falcata* (L.f.) Etting. known as *Loranthus* is a stem parasite, mostly prefers *Mangifera indica* L. (mango) as its host. Remarkable damage of the mango crop due to the adverse effect of *Loranthus* was identified in the field area. The occurrence and host preference of the *D. falcata* was systematically studied at eight field sites of Vizianagaram District. The vegetative, reproductive and parasitic characteristics of *D. falcata* were recorded periodically. The effective management strategies to control *Loranthus* were not employed in the study area because of the lack of knowledge on the host-parasite interaction. Keeping in mind, the investigation was conducted (October 2018 to June, 2019) in mango fields of Vizianagaram District of Andhra Pradesh to explore the biology, the host specificity, the occurrence, the pollination, the bird-host-parasite interaction and the effective control methods of *D. falcata*.

**Keywords:** Bird pollination; *Dendrophthoe falcata* (L.f.) Etting.; Haustoria; Hemiparasite; *Loranthus*; *Mangifera indica* L.; and Viscin

### 1. Introduction

Mango (*Mangifera indica* L. f: Anacardiaceae) is a familiar fruit crop cultivated in and around tropical and sub-tropical regions of the world [1], [2]. Mango is the most popular and commonly consumed fruit because of its rich nutrient compounds such as carbohydrates, proteins, fats, minerals, vitamin A (Beta-carotene), vitamin B1, vitamin B2 and vitamin C (Ascorbic acid) [1]. Mango is ranked second only to banana both in quantity and quality (nutrient value) and fifth in total production among major fruit crops worldwide [3]. Some angiospermic families such as Loranthaceae, Orobanchaceae, Convolvulaceae, Scrophulariaceae, Lauraceae, Santalaceae and Balanophoraceae contain parasitic plant species which can flourish according to their season. They can damage the host plants through exhaustion of nutrients, release of toxins and restriction growth of the host plants. They produce viable seeds dispersed by wind, bird and other animals and also through soil. They act as very destructive pests of several economically important fruit crops such as Mango and field crops like Mustard, Legumes, Tobacco, Berseem, Lucerne etc. The species *Dendrophthoe falcata* widely grow on the branches of woody trees like mango [4]. It is commonly known as *Loranthus* or Giant Mistletoe [5]. It is a hemi parasite (Photosynthetic), obtains water and mineral nutrients from the host plant. Around 60-90% of the mango trees are infected by *D. falcata* in Northern India. A total of 343 hosts have been listed in India, which included all the common horticultural and forest trees. *D. falcata* spread with huge branching on host and form a dense cluster of small twigs bearing smooth broad leaves and long, tubular, orange coloured flowers with red berries [4], [6], [7]. It is a member of *Loranthaceae* (Mistletoes), severely infect mango crop and capture food from the host tissue by means of penetrating haustorial roots. This epiphyte found generally on various host plants in large amount and causes much damage to economic crops in India. Nevertheless, the comprehensive reports on the occurrence, the host range, and the management practices are not available in the country. Under the above circumstances, the present investigation

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was under taken to study the biology, phenology and host-parasite interaction of *D. falcata* in and around Vizianagram District of Andhra Pradesh.

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## 2. Material and methods

The systematic field study was conducted (October 2018 to June, 2019) on *D. falcata* to identify the adverse effects of the plant in study area. The information related to vegetative, reproductive, parasitic characteristics *D. falcata* were systematically recorded. Moreover, the number of dead host plants with special reference to mango also recorded.

### 2.1. Study Area

An organized investigation was conducted to identify the adverse effects of *D. falcata* parasitizing mango crop in and around Vizianagram District, Andhra Pradesh. The District is a part of the Northern Coastal plains of Andhra Pradesh and lies between 17° - 15' and 19° - 15' of the Northern Latitude and 83° - 0' to 83° - 45' of the Eastern Longitude. Although the District was one of the major mango cultivated area of the state, many challenges were faced by farmers and agronomists due to the terrible effects of *D. falcata* in mango orchards. The species was popularly called as Jiddu, Yelinga, Badanika, Bajinika, Vajinika and Velagabandanika in Andhra Pradesh and Telangana. The famous mango cultivated areas are Vizianagram, Bondapalli, Gajapathinagaram, Ramabhadrapuram, Salur, Pachipenta, Seethanagaram and Bobbili were periodically visited to observe and record morphological, reproductive, parasitic and phenological aspects of *D. falcata*.

### 2.2. Field survey

Field survey was conducted (October, 2018 to June, 2019) to observe and identify *D. falcata* on its common host plant *Mangifera indica* L. (mango). Live plant specimens of *D. falcata* were collected from infected mango plants and their morphological, reproductive and parasitic characters were recorded with the help of relevant manuals and literature. International Plant Name Index was accessed for the taxonomic nomenclature of parasitic plant and host species. Live specimens were collected carefully to prepare herbarium specimens according to the standardized method of Bridson and Forman (1992) [8]. The plant specimens of *D. falcata* were submitted to Andhra University Herbarium (AUH) with accession No. 23324, 23325, 23326, 23327 and 23328. During the field investigation the cooperation between birds and mistletoe plants (Host-Parasite-Bird Relationship) was critically observed. The birds act as both pollinated vectors as well as seed dispersers were carefully recorded without disturbing birds in early hours (6.00 AM to 8.00 AM).

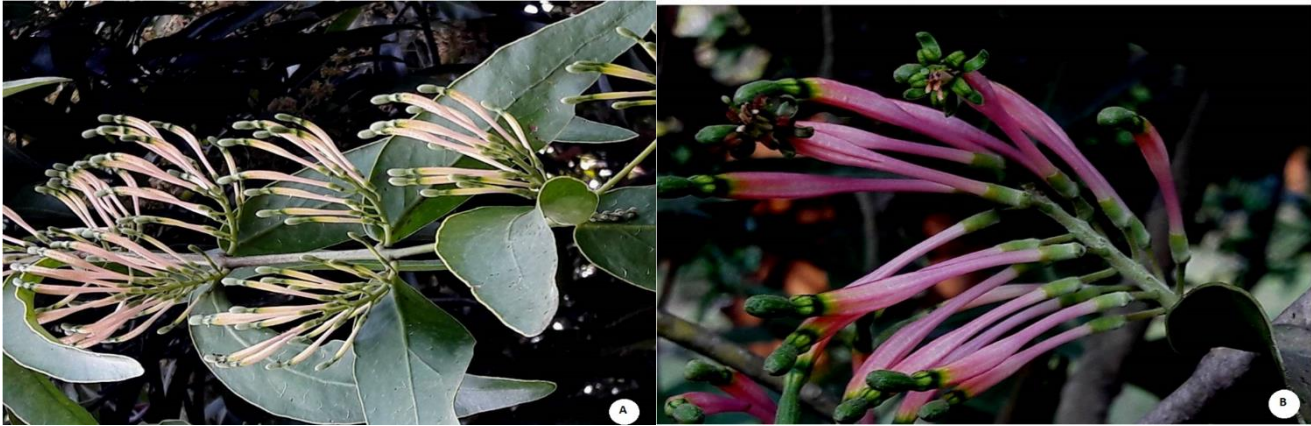
### 2.3. Diagnosis of hemiparasite

The infected plant parts and propagules were collected randomly from host plants. Plant materials were taken into sterilized polythene bags and brought to the laboratory for the extensive study on hemiparasitic symptoms of *Loranthus* such as haustorial roots and other plant propagules. The leaves, stems, inflorescence, fruits, seeds and haustorial parts were critically examined and stored in the plant pathology laboratory of Department of Botany, Andhra University.

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## 3. Results

The field sites were periodically visited to observe and record *D. falcata* on its host plants in order to develop effective control methods. Mango trees are highly infested with *D. falcata*, mostly spread on the branches of host with the help of specialized organ, haustoria. Two varieties of plant species namely *Dendrophthoe* var. *falcata* (white coloured flowers) and *Dendrophthoe* var. *coccinea* (pink coloured flowers) were reported in all localities of the study area (Fig - 1). Taxonomically, it is a large bushy shrub, dichotomously branched, perennial, partial stem parasite, glabrous with grey-smooth bark, having twiggy and woody branches. Leaves thick, sub-sessile, coriaceous, elliptic ovate to oblanceolate, mostly opposite, obtuse, sometimes acute, entire, slightly shining, variable in size and shape, midrib prominent, usually red with attenuated base; Flowers whitish yellow, red, orange-red or yellowish red and sometimes pink, 5-15 cm. long, axillary to supra-axillary, unilateral spikes with persistent bract. Calyculus (a cup like structure below the calyx) 4 mm. long, glabrous and persistent with 4-5 lobes, stamens 5, filament approximately 3-5 mm. long or even up to corolla and epipetalous, glabrous; Style 2.5-3.5 cm. long with capitate stigma; Fruit berries 7-11 mm. long, bright red, globose to ovoid-oblong; seeds minute and oblong (Fig-2).



**Figure 1** Two plant varieties of *Dendrophthoe falcata* (L.f.) Etting.

(A) – *Dendrophthoe* var. *falcata*. (B) – *Dendrophthoe* var. *coccinea*



**Figure 2** Morphological characteristics of *Dendrophthoe falcata* (L.f.) Etting.

(A) - Stem with greenish leaves; (B) - Inflorescence; (C) – Flower; (D) - Fruit

### 3.1. Occurrence

The occurrence of *D. falcata* were observed in a total of eight localities /areas including Vizianagaram, Bondapalli, Gajapathinagaram, Ramabhadrapuram, Salur, Pachipenta, Seethanagaram and Bobbili. A total of five mango orchards were selected from each study site and a total of 100 plants from each site were carefully observed. A total number of individual plants of mango infected with *D. falcata* were recorded. Among them, the host plants severely swamped with

*D. falcata* were counted. The occurrence of *D. falcata* was systematically recorded in eight localities, among them the mango orchards of Vizianagram was severely infected (63%) with *D. falcata* followed by Salur (62%) and Pachipenta (60%) where climatic conditions play a major role in host-parasite interaction (Table 1).

**Table 1** The occurrence of *Dendrophthoe falcata* on host plant mango

S.No	Location	Number of fields observed	Occurrence of <i>Loranthus</i> (%)	No of individual host plants with dry branches
1	Vizianagram	5	63	24
2	Bondapalli	5	48	6
3	Gajapathinagaram	5	54	16
4	Ramabhadrapuram	5	39	5
5	Salur	5	62	20
6	Pachipenta	5	60	18
7	Seethanagaram	5	42	6
8	Bobbili	5	53	12

Gradient of Effect: 1 – 10 (Light); 11 – 50 (Moderate); > 50 (Severe)

### 3.2. Host preference

The host preference of *D. falcata* was carefully observed in study area. A total of 10 host plants of *D. falcata* were identified throughout our investigation (Table 2). Excluding mango, other plant species such as *Achras zapota*, *Annona reticulata* L., *Annona squamosa* L., *Bombax ceiba* L., *Bauhinia purpurea* L., *Cassia fistula* L., *Casuarina equisetifolia*, *Eucalyptus globules*, *Ficus religiosa* L., *Nerium odorum* and *Psidium guajava* also serves as host to *D. falcata*. Among the host plants recorded, *Mangifera indica* was highly infested with *D. falcata* followed by another fruit yielding plants *Annona squamosa* L. (Annonaceae) and *Achras zapota* (Sapotaceae). The maximum infestation and mortality rate of host plant was reported on *M. indica* due to ferocious effects of the stem parasite *D. falcata*.

**Table 2** Host preference of *Dendrophthoe falcata* in and around Vizianagram District

Host plant	Family	No of effected individuals	No of dead plants identified
<i>Achras zapota</i>	Sapotaceae	14	1
<i>Annona reticulata</i> L.	Annonaceae	12	0
<i>Annona squamosa</i> L.	Annonaceae	20	2
<i>Bombax ceiba</i> L.	Bombacaceae	15	0
<i>Bauhinia purpurea</i> L.	Caesalpiniaceae	12	1
<i>Cassia fistula</i> L.	Caesalpiniaceae	3	0
<i>Casuarina equisetifolia</i>	Casurinaceae	5	0
<i>Eucalyptus globules</i>	Myrtaceae	6	0
<i>Ficus religiosa</i> L.	Moraceae	8	0
<i>Mangifera indica</i> L.	Anacardiaceae	54	18
<i>Nerium odorum</i>	Apocynaceae	1	0
<i>Psidium guajava</i>	Myrtaceae	3	0

### 3.3. Life cycle of the *D. falcata*

*D. falcata* is a large woody, evergreen, semi parasitic shrub with abundant branching. The leaves are oblong or elliptical, rounded at the base. The fruit is a berry, oblong, smooth, pink, crowned by cup shaped calyx. Berry type fruits are abundantly produced on branches of *D. falcata* in summer season. Birds upon consuming these berries disseminate the seeds, which remain adhered on tree trunks at the branching junctions of the host with the help of a sticky viscin known as “bird glue”. Seeds on the host surface (tree trunk) germinate on the onset of monsoon and directly penetrate into the host bark. Initial growth of the parasite is slow, but after penetration into the host, sucking organ ‘haustorium’ was produced by the parasite. The haustorium penetrates into host tissue and absorbs water and nutrients from the conductive tissue of the host. Establishment of parasitic relationship results into the development of big knob or gall-like overgrowth and the point of contact of the parasite and host called as woodrose which is a chief characteristic feature of mistletoes. *D. falcata* has true functional leaves however it lacks a true root system and therefore, it is unable to sustain in absence of host plants. Nutrients and water absorbed by the roots of the host plant are diverted for the growth of the parasite; as a result, the growth of the host above the point of penetration show marked reduction. Simultaneously, parasite develops at a faster rate. Development of many *Loranthus* branches completely weakens the host. Vigour of the host plant is markedly reduced and automatically, there is a reduction in yield and quality of fruits of the host plant (mango). A unique morphological feature, the development of epicortical roots from *D. falcata* was observed on respective host. These adventitious roots developed from just above the primary haustorium of *D. falcata*. Epicortical roots with haustoria helps to secure the parasitic plant on its host and allow the parasite to grow larger. *D. falcata* maintained a favourable position in the host crown by captivating sunlight for photosynthesis.

### 3.4. Host-Parasite-Bird Relationship

The fruits of *D. falcata* were berry-like, single seeded, and of different colour depending on species. The seed was either completely surrounded or capped with sticky viscin tissue. The viscin tissue located inside the fleshy outer layer of the fruit was thoroughly eaten by birds. Viscin has both gluing and elastic properties and serves to glue the seeds to branches of a potential host. Birds recorded as the main dispersers of nearly all loranth, often the same birds (flowerpeckers f: Dicaeidae) serve both as pollinators and dispersers (Table 3). These little birds eat the berries of several loranth and seem always to perch along the branch. This behaviour is an advantage for the parasite since the seeds pass the digestive canal and the dropping are likely to be placed directly on a branch of a potential host. In other cases, the defecated seeds may stick together like rosaries or string of pearls. It has been shown that seeds defected by mistletoe birds have high germination rates, suggesting it is an advantage for the parasite. This cooperation between birds and mistletoe plants can play a crucial role in the host-parasite interaction.

**Table 3** Seed dispersal of *Dendrophthoe falcata* on host by various birds

Study area	Host plant	Birds observed on host plant
Vizianagram	Mango	Tickell’s Flowerpecker, Purple-rumped Sunbird
Bondapalli	Mango	Tickell’s Flowerpecker, Purple Sunbird, Bank Myna
Gaiapathinagaram	Mango	Tickell’s Flowerpecker, Baya Weaver, Sunbird
Ramabadrhapuram	Mango	Tickell’s Flowerpecker, Thick billed Warbler
Salur	Mango	Tickell’s Flowerpecker, Purple Sunbird, Bank Myna
Pachipenta	Mango	Tickell’s Flowerpecker, Purple Sunbird, Bank Myna
Seethanagaram	Mango	Tickell’s Flowerpecker, Bank Myna
Bobbili	Mango	Tickell’s Flowerpecker, Thick billed Warbler

## 4. Discussion

The study explores that several mango fields are highly infested with *D. falcata*. The age and height of the host plant, the seed dispersal, the haustorial formation of parasite on host surface, several agricultural practices and environmental factors influenced the occurrence and spread of *D. falcata*. Apart from mango as common host plant, *D. falcata* also reported on other fruit and timber yielding plants namely *Achras zapota*, *Casuarina equisetifolia*, *Bombax ceiba*, *Bauhinia purpurea*, *Cassia fistula*, *Psidium guajava*, *Eucalyptus globules*, *Pterospermum acerifolium*, and *Annona squamosa*. Predominantly *D. falcata* prefers to grow only on top of the canopy of host to conduct photosynthesis. The plant species

*D. falcata* are typically Ornithophilous (pollinated by birds) and also the seeds dispersed by birds, mainly "Flowerpeckers". *D. falcata* was disseminated mainly through its seeds, carried by birds. The birds are attracted by the brilliant colour of the berries, the pulp is sticky and viscous and so birds easily carry the seeds. The fruit is comparatively succulent, brilliantly coloured and is attractive to birds [7]. *D. falcata* causes severe damage to host plant by preventing the growth [5], [7]. *D. falcata* does not have any root system of its own but develops root-like absorbing organs called haustoria, which penetrate deeply into host. The haustorium act as a primary root of the seedlings of *D. falcata* developed on host stem. Through these organs, water and minerals were absorbed by the parasite from the conducting tissue of the host. Hence, there is a continuous drain of nourishment from the host to the parasite will appeared. In many cases the branches of the host are killed by *D. falcata* due to the tapping of most of the vascular bundles [5], [7], [9]. Nowadays *D. falcata* was a serious threat to economically valuable fruit trees, flowering plants, forest trees and orchards [10]. Selection of variable host is one of the characteristic features of the *D. falcata* and the increase of host range was reported [11].

During the field study, the phenology, life cycle, pollination and seed dispersal of *D. falcata* were systematically recorded for further research and management of mango orchards. Some interesting features of *D. falcata* were reported on its host plant (mango) such as well-organized haustorial root system for the attachment and nourishment. The assemblage of flowers in dense inflorescences with attractive colour is another adaptation of *D. falcata* for bird pollination. Small birds such as Tickell's Flowerpecker, Purple-rumped Sunbird and Purple Sunbird can play dual role in pollination as well as in seed dispersal of *D. falcata*.

There is a lack of knowledge among farmers and agronomists to control *D. falcata* (*Loranthus*). Only mechanical weeding by cutting (pruning) of *Loranthus* branches on host trees is a common practice in mango cultivation. Chemical weeding by Ethephon (20 ml/L), Metribuzin (1%) and 2, 4-D powder also not effective and leads to pollution. Moreover, biological control of *D. falcata* was not reported successfully perhaps it is in the infant stage in India. Therefore, the study can enlightens the awareness of farmers, agronomists and researchers concerning mango weed, particularly *D. falcata*, in the areas of morphology, pollination biology and seed dispersal, and host-parasite interaction, to take further effective control methods in mango cultivation. Finally, authors recommended some agricultural practices in mango orchards to control bird pollination, pollen development and seed dispersal of *D. falcata*. They are: 1). The cultivation of some alternative crops/ fencing crops to attract birds 2). The use of small concentrations of chemicals or plant growth regulators to cause male sterility of *D. falcata*, and 3). The degradation of viscin tissue (bird glue) to control seed adhesion and seed dispersal of *D. falcata*.

After extensive study on phenology, seed dispersal, and host-parasite-bird relation of *D. falcata*, authors were suggested the above agricultural practices in mango orchards of Vizianagram District to control the spread of *D. falcata*. Bird pollination was one of the reason for the effective spread of *Loranthus* population, which commonly visited by Flowerpeckers (small birds). These birds can play dual role as pollinators and seed dispersers. Therefore, the cultivation of alternative crops or fencing crops is needful to avoid the bird population in mango fields. These birds may attracted by beautiful flowers and berries of these fencing crops for their food and sanctuary. It leads to the reduction of bird pollination and seed dispersal of *D. falcata* due to the less recurrent visits of the same birds. The plant species of *Muntingia calabura* L. (Muntingiaceae), *Sterculia colorata* Roxb. (Malvaceae) and *Woodfordia floribunda* L. (KURZ) (Lythraceae) are pollinated by Tickell's Flowerpecker, therefore, they may act as fencing crop or alternative to Tickell's Flowerpecker birds. Purple-rumped Sunbird also pollinate the species of *Hamelia* (Rubiaceae) and Purple Sunbird pollinate *Butea monosperma* (Lam.) Taub. (Fabaceae), *Salvadora persica* (Salvadoraceae), *Woodfordia floribunda* L. (KURZ). (Lythraceae) and *Hamelia* species (Rubiaceae). These plant spices may grow as fencing crops in mango fields to avoid bird pollination of *D. falcata*. The use of some less amount of chemicals to inhibit the pollen development (male sterility) may be an effective control method of *D. falcata*. Some plant hormones namely Ethrel, Isothiazole, Gibberellins and Abscisic acid may use for male sterility of *D. falcata* at different growth stages of pollen. And also the degradation of Viscin mucilage by using ethylene diamine tetra acetic acid, sodium carbonate or Sodium borohydride may be the effective control of seed dispersal.

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## 5. Conclusion

The outlook on biology, seed dispersal and host interaction of *D. falcata* (*Loranthus*) will assist to develop weed control methods in mango orchards. Authors provided systematic information on bird pollination of *Loranthus* as new report.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The authors declare that they have no conflict of interest.

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