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RESEARCH ARTICLE

STUDIES ON THE HOST RANGES OF ANGIOSPERM PARASITES *Dendrophthoe falcata* var. *coccinia* AND *Cassytha filiformis* IN ANNAMALAI RESERVE FOREST, THIRUNANNAMALAI, TAMIL NADU, INDIA.

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Abstract

This study pertains to the evaluation of host ranges of angiosperm parasites *Dendrophthoe falcata* (L.f.) Ettingsh var. *coccinia* (Talb.) Sant. (Loranthaceae) and *Cassytha filiformis* L. (Lauraceae) on various angiosperm host plants in the Annamalai reserve forest, Thiruvannamalai District, Tamil Nadu, India. *D. falcata* was found growing on five host trees belonging to four families of Dicotyledons in a localised area of the hill but *C. filiformis* had a wide range of 26 host plants belonging to 18 families of Dicotyledons which grew from the plains to the hill top. Study revealed that *C. filiformis* had managed to increase its host ranges rather than *D. falcata*. Polymorphism of leaves were also observed in *D. falcata*. Instances of double parasitism were found on *Acacia chundra* and *Diospyros ferrea*.

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Introduction:-

About 4100 species of flowering plants belonging to 277 genera are reported to be parasitic on different host plants, out of which 25 genera can cause negative impacts (Nickrent and Musselman, 2004). Angiosperm parasites *Dendrophthoe falcata* var. *coccinia* (Loranthaceae) is otherwise called as mistletoe and *Cassytha filiformis* (Lauraceae) also called as dodder cause serious problems for the host plants (Mathur, 1949). Dodder infests woody plants and also damages certain economically important crops. *D. falcata* grows on *Mangifera indica* L., *Dalbergia sisso* Roxb., *Albizia lebbek* (L.) Benth. and *Ficus benghalensis* L. (Wellman, 1964) and also attacks horticultural and other woody angiosperms, viz., *Punica granatum* L., *Callistemon lanceolatus* (Sm.) Sweet., *Psidium guajava* L., *Syzygium cumini* (L.), *Aegle marmelos* (L.) Correa., *Ficus religiosa* L., *Ficus rumphii* Bl., *Citrus maxima* Merr. and *Eucalyptus* sp. These parasites never kill the host plants but they live unhappily together (Nickrent, 2002). *D. falcata* attacks on at least 110 tree species in Chennai (Brand, 1938). Anuradha (2005) had observed that infestation of *D. falcata* on 44 arborescent species in the forest of Shakthi Auroville of Tamil Nadu. It poses a serious loss to economically valuable horticultural plants and other valuable plants growing in forests, orchards or gardens (Sridhar and Rao, 1979). *Madhuca latifolia* is also a common host to mistletoe (Mehrotra, 1983).

Cassytha filiformis is a leafless, vine-like, climbing and hemi-parasite which parasitizes on a wide variety of woody hosts including plants of agricultural, horticultural and economic values. The host ranges of *C. filiformis* is broad

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(Nickrent and Musselman, 2004). Nelson (2008) had stated that the parasite obtains nutrients and water from the host plants without quickly killing the host cells. The pathogen does not create immediate fatal damages to the host cells and their metabolic processes. Rather the host plants can die a long protracted death by starvation and desiccation. Heavy infections can eventually smother and kill host plants. *Cassytha filiformis* is reported to be capable of transmitting phytoplasma from palms (*Cocos nucifera* L. and *Areca catechu* L.) and a viral disease such as citrus mosaic caused by citrus mosaic badna virus (Nelson, 2008). It is a common stem parasite of *Lantana camera* L. and *Toddalia* sp and certain other plants in south India (Rangaswamy and Rangan, 1963). Werth *et al.* (1979) had listed out 81 species which were affected by *C. filiformis* in the Bahamar, including grasses, ferns, gymnosperms as well as board-leaved angiosperms. *Cassytha filiformis* has a wide host ranges such as grasses, broad leaved angiosperms, ferns and gymnosperm (Mukhtar *et al.* 2010; Kokubugata and Yokota, 2012). In this parasite fruits are dispersed by birds (David *et al.*, 2015). Balasubramanian (1990) noted that seeds were taken by white-browed bulbul (*Pycnonotus luteolus*). Following germination, the primary root fails to develop but adventitious roots may provide anchorage for a short period (Mahadevan and Jayasuriya, 2013). Seedlings can then survive up to eight weeks, without a host, growing to a length of 30 cm or more relying on the seed reserves (Nelson, 2008).

Thiruvannamalai district harbours rich vegetation including medicinal plants. Vijayasankar *et al.* (2010) have reported that 1365 taxa of angiosperms including 1278 species, 18 subspecies, 16 varieties in 713 genera spread over 158 families. Of these 1365 taxa, 1111 occur naturally and 254 taxa are cultivated in the district. About 80.5% taxa are dicots while the monocots are 19.5%. Poaceae is the largest family comprising 60 genera and 108 species. The aim of the present study is to identify the habitats, host plants, extent of host ranges of two angiosperm parasites viz., *D. falcata* and *C. filiformis*, in the Annamalai reserve forest.

Material and Methods:-

Study Area:-

Thiruvannamalai District lies between 12° 00' and 12° 49' N latitude –78° 38' and 79° 45' E longitude covering 6191 km² with a human population of 24.68 lakh and is 185 km from Chennai (13°5'N–80°17'E). The principal occupation of residents here is agriculture. Annamalai reserve forest, a part of the Eastern Ghats occurs between 12° 11'N latitude and 79° 02'E longitude with an extent of 699 hectares (Fig 1). Annamalai or Thiruvannamalai or Arunachala or Arunai hill denotes 'Holy fire hill'. Annual Karthigai Deepam is a very old festival and is observed in the Tamil month of Karthigai (mid-November to mid-December) on the day when the moon is in conjunction with the constellation Karthigai and Pournami. A huge fire lamp is lit up (Mahadeepam) on the hill top (814m above mean sea level) and it continues to be on fire for twelve days. The average annual precipitation for the past 20 years (1997–2016) is 1037.8 mm. The forest experiences a maximum temperature of 38°C during summer and 20° C to 26° C winter. Geologically the Annamalai hill consists of Charnockite, Gneiss and Granite rocks. Southern tropical thorn forest flourishes on the plains and hills except on barren rocks.

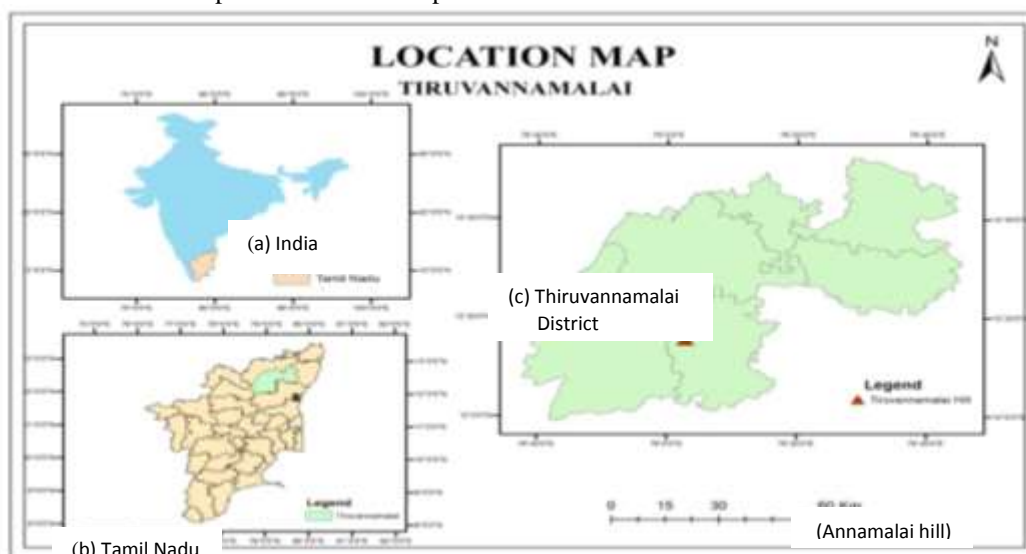


Fig 1:- Location Maps: (a). India, (b). Tamil Nadu and (c). Thiruvannamalai District showing Annamalai hill.

We visited the study area between January 2016 and January 2017 covering all the four seasons. We laid 20 quadrats each measuring 10x10m and ensured a distance of 100 meters between two quadrats. We identified angiosperm parasites *D. falcata* and *C. filiformis* and enumerated and identified host plants in each quadrat to assess the host ranges of these two parasites. All the host plants were identified using “The Flora of Presidency of Madras” (Gamble and Fischer, 1959), “The Flora of Tamil Nadu Carnatic” (Mathew, 1983) “Flora of Tamil Nadu” (Nair, N. C. and Henry, A. N. 1989) and “Plant Resources of Tiruvannamalai District” (Vijayasankar et al. 2010). The leaf area of *D. falcata* was measured by using the Kemp formula (1960): Leaf area = L x B x K; Where, L= length of the leaf, B= Breadth and K= Kemp’s constant (0.66 for Dicotyledons). Movements of sunbirds were observed between 0600 hours and 09.30 hours in the morning and 15.00 hours and 17.30 hours in the evening.

Results and Discussion:-

Dendrophthoe falcata produces tubular, bisexual and red coloured flowers arranged in spikes. Pollination is entomophilous because the red coloured perianth and nectar attracts insects. The seeds are carried and dispersed by sunbirds *Cinnyris asiatica* (*Passeriformes: Nectariniidae*). Our study revealed that the parasite *D. falcata* was found growing on five host trees belonging to four families in undisturbed areas of the hill. The leaves of *D. falcata* exhibited polymorphism on different host plants. The shape and size of leaf lamina varies depending on the host plants on which it grows. (Fig 2 a, b & c). The leaf areas of this parasite on various host trees were calculated using Kemp’s formula. The maximum leaf area (53.85 cm²) was found in *Azadirachta indica* followed by *Cassia fistula* (25.74 cm²), *Acacia chundra* (6.86 cm²), *Flacourtia ramontchi* (6.45 cm²) and *Acacia leucophloea* (5.77 cm²).

Table 1:- Host trees of *D. falcata* in Annamalai reserve forest.

S.No.	Host plant	Family	Habit	Indigenous/exotic
1.	<i>Azadirachta indica</i> Adr.Juss.	Meliaceae	Tree	Indigenous
2.	<i>Cassia fistula</i> L.	Caesalpiniaceae	Tree	Indigenous
3.	<i>Acacia leucophloea</i> (Roxb.) Willd.	Mimosaceae	Tree	Indigenous
4.	<i>Acacia chundra</i> (Roxb. Ex. Rottler) Willd.	Mimosaceae	Tree	Indigenous
5.	<i>Flacourtia ramontchi</i> L’Her.	Flacourtiaceae	Tree	Indigenous

Selvi and Kadamban (2009) had observed that 26 species of angiosperms were infested by this parasite. Calvin and Wilson (2009) had stated that the parasite has rapidly increased its host range. However in the present study, *D. falcata* had infested five tree species belonging to four families, found in the undisturbed reserve forest and was absent in other parts of the human impacted forest, even though the host trees were found predominant (Table 1). It is observed that frequent movement of the general public and pilgrims to ashrams situated in the foot hills daily, particularly during festive seasons in the eastern, north-eastern and south-eastern sides of the hills, prevents the visit of sunbirds which were found active in dispersal of seeds from the fruits of *D. falcata*. The parasite, hence was found only in the undisturbed forest where sunbirds visit frequently. Visits of such birds on the parasite and consumption of its fruits were noticed during morning (06.00-10.00 hrs) and evening (15.00-17.30 hrs) in the undisturbed forest. This attributes that sunbirds were active in dispersal of the seeds in the undisturbed forests and hence *D. falcata* had confined its host ranges in a localised area and did not extend beyond five species. It had not infested any host plants belonging to Monocotyledons.

In *C. filiformis* also the fruits are dispersed by birds (David *et al.*, 2015). Balasubramanian (1990) noted that seeds were taken by white-browed bulbul *Pycnonotus luteolus* (*Passeriformes: Pycnonotidae*). Following germination, the primary root fails to develop but adventitious roots may provide anchorage for a short period (Mahadevan and Jayasuriya, 2013). Seedlings can then survive up to eight weeks, without a host, growing upto a length of 30 cm or more relying on the seed reserves (Nelson, 2008).

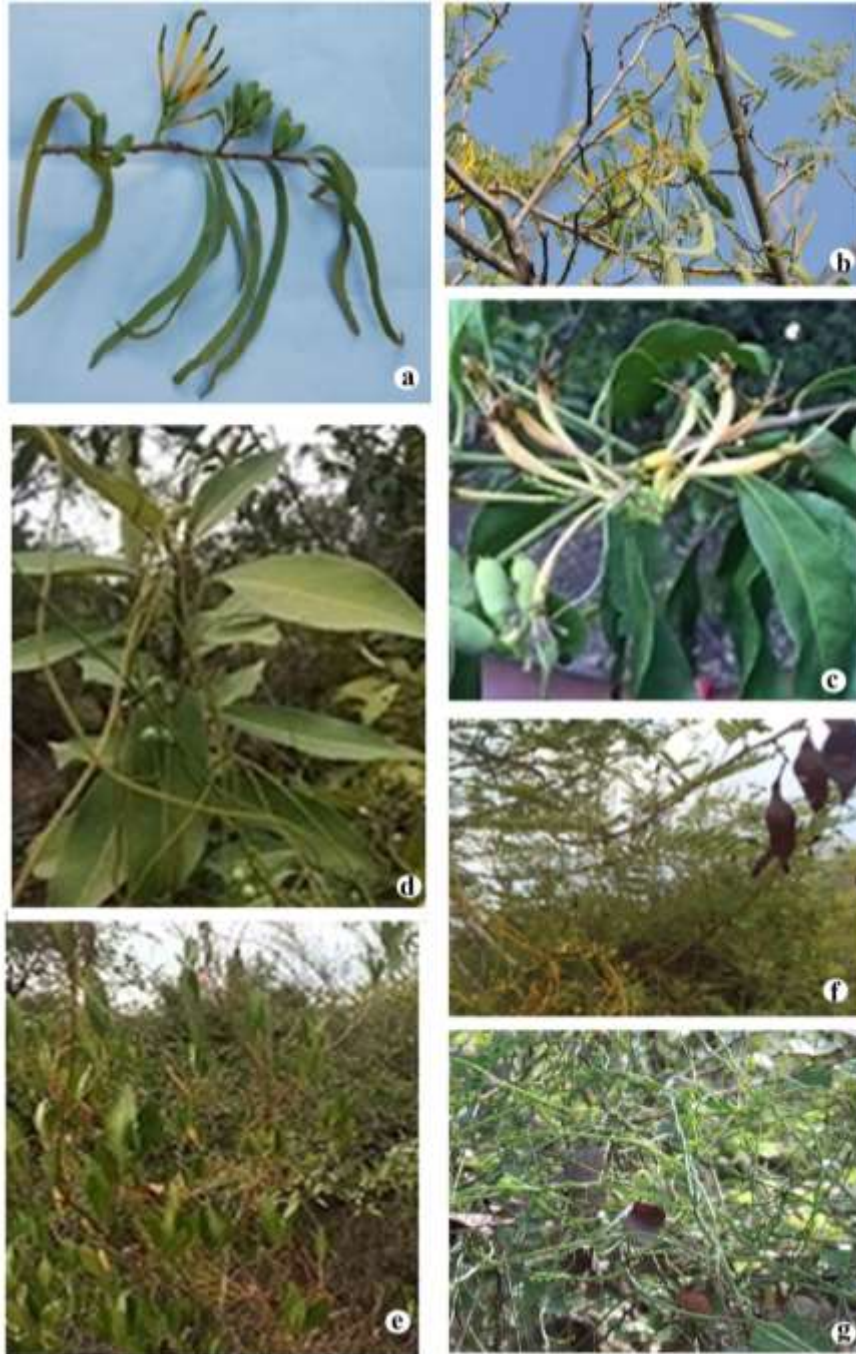


Fig 2:- (a) *Dendrophthoe falcata*- flowers and fruits; (b). *D. falcata* on host *Acacia chundra* – flowers and fruits; (c). *D. falcata* on host *Azadirachta indica*-flowers and fruits; (d). *Cassytha filiformis* infested on host *Syzygium cumini*; (e). *C. filiformis* infested on host *Dodonaea viscosa*; (f). *C. filiformis* infested on host *Pterolobium hexapetalum* and (g). *C. filiformis* infested on host *Bauhinia racemosa*.

Study revealed that *C. filiformis* was found infested on 26 hosts plants in the study area belonging to 18 families. Twenty-four plants are indigenous, one is exotic and another one is cosmopolitan. When compared to *D. falcata*, the parasite *C. filiformis* had exhibited a wide host ranges in the Annamalai reserve forest. It affects the host plants with various habits such as trees, shrubs, sub-shrubs, herbs and climbers (Fig 2 d, e, f & g). Out of 26 hosts infested by *C. filiformis*, 11 are trees, 12 are shrubs, 2 are climbers and one is a herb. Infestation of hosts by *C. filiformis* were found in all parts of the forests ranging from altitudes 200 m to 730 m above mean sea level (Table 2).

Table 2:- Host plants of *C. filiformis* in Annamalai reserve forest.

S. No.	Host plant	Family	Habit	Indigenous/exotic
1.	<i>Cassia auriculata</i> L.	Caesalpinaceae	Herb	Indigenous
2.	<i>Cassia fistula</i> L.	Caesalpinaceae	Tree	Indigenous
3.	<i>Pterolobium hexapetalum</i> (Roth) Santapau & Wagh	Caesalpinaceae	Shrub	Indigenous
4.	<i>Canthium coromandelicum</i> (Burm.f) Alston	Rubiaceae	Shrub	Indigenous
5.	<i>Morinda tinctoria</i> Roxb.	Rubiaceae	Tree	Indigenous
6.	<i>Benkara malabarica</i> (Lam.) Tirv.	Rubiaceae	Shrub	Indigenous
7.	<i>Waltheria indica</i> L.	Malvaceae	Subshrub	Exotic
8.	<i>Pavonia zeylanica</i> (L.) Cav.	Malvaceae	Herb	Indigenous
9.	<i>Acacia chundra</i> (Rottler) Willd.	Mimosaceae	Tree	Indigenous
10.	<i>Acacia ferruginea</i> DC.	Mimosaceae	Tree	Indigenous
11.	<i>Chloroxylon swietenia</i> DC.	Rutaceae	Tree	Indigenous
12.	<i>Glycosmis pentaphylla</i> (Retz.) DC	Rutaceae	Shrub	Indigenous
13.	<i>Wrightia tinctoria</i> (Roxb.) R.Br.	Apocynaceae	Tree	Indigenous
14.	<i>Carissa spinorum</i> L.	Apocynaceae	Shrub	Indigenous
15.	<i>Rivea hypocrateriformis</i> (Desr.) Chosy	Convolvulaceae	Climber	Indigenous
16.	<i>Terminalia arjuna</i> (Roxb. ex DC.) Wight & Arn	Combretaceae	Tree	Indigenous
17.	<i>Euphorbia antiquorum</i> L.	Euphorbiaceae	Shrub	Indigenous
18.	<i>Diospyros ferrea</i> (Willd.) Bakh.	Ebenaceae	Tree	Indigenous
19.	<i>Erythroxylon monogynum</i> Roxb.	Erythroxylaceae	Tree	Indigenous
20.	<i>Flacourtia ramontchi</i> L'Her.	Flacourtiaceae	Tree	Indigenous
21.	<i>Bauhinia racemosa</i> Lam.	Fabaceae	Shrub	Indigenous
22.	<i>Hugonia mystax</i> L.	Linaceae	Shrub	Indigenous
23.	<i>Syzygium cumini</i> (L.) Skeels	Myrtaceae	Tree	Indigenous
24.	<i>Azadirachta indica</i> A.Juss.	Meliaceae	Tree	Indigenous
25.	<i>Dodonaea angustifolia</i> L.f.	Sapindaceae	Shrub	Cosmopolitan
26.	<i>Grewia hirsuta</i> Vahl	Tiliaceae	Subshrub	Indigenous

Seeds of *C. filiformis* were easily dispersed by white-browed bulbuls which were observed commonly at all parts of the study area and characteristic features such as survival of seedlings for even eight weeks without host substratum, ability to grow on soil independently and later become obligate parasite when it comes into contact with host plants might have helped this parasite to extend its host ranges. Whereas *D. falcata* which required sunbirds for dispersal of seeds and seedlings need immediate host substratum for successful survival might have resulted in failure of extending its host ranges beyond five trees. These two parasites never infest any of the host plants belonging to Monocotyledons. Though the angiosperm parasites were part of bio-diversity of the forest vegetation, its impact on the forest vegetation, transmission of diseases and economic loss to the woods of trees need further study.

Selvi and Kadamban (2009) had reported instances of double parasitism of these two parasites on host plants, viz., *Anacardium occidentale* L. and *Azadirachta indica* L at Pondicherry Engineering College campus. Similar instances of double parasitism were found in the case of two indigenous species namely, *Acacia chundra* (Rottler.) Willd. and *Diospyros ferrea* (Willd.) Bakh. in the study area. Both *D. falcata* and *C. filiformis* had infested and grew extensively on these two host trees.

Conclusion:-

The parasite *D. falcata* had so far not extended its host ranges in the forest, beyond 5 host trees belonging to four families, but *C. filiformis* had extended its host ranges up to 26 host species belonging to 18 families. *D. falcata* was confined in the undisturbed western side of the Annamalai reserve forest, but *C. filiformis* had widened its habitats from plains to an altitude of 814m AMSL. It depends on the host trees and the morphology of leaves (polymorphism) vary in *D. falcata*. Double parasitism was observed on two indigenous trees such as *Acacia*

Chundra and *Diospyros ferrea*. Though parasites were part of the bio-diversity of the forest vegetation its impact on the economic loss to the woods of trees needs further study.

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