# Bionomics and damage estimation of a phlaeothripid *Dolichothrips indicus* (Hood) in a new host in Tamil Nadu, India


## ABSTRACT

Bionomics and damage of a polyphagous and an enigmatic phlaeothripid *Dolichothrips indicus* (Hood) has been described on a profitable and popular agro-forestry crop *Melia dubia* (Malabar Neem) in Tamil Nadu, a southern state of India. This little-known target thrips species, previously known to feed flowers, leaves and shoots of different plant families has come out as a pest of *M. dubia* which is persistent in nurseries and regular in plantations. Molecular aided taxonomic identification of *D. indicus* performed during the study revealed their highest compatibility with the type specimens of *D. rambhutanae* (Ananthakrishnan) and *D. pumilus* (Priesner). Population assessment and mapping of *D. indicus* for over a year showed nil to very high population. Population density with individuals <50 had occurred in 3 out of total 23 study locations comprised of 13 districts of TamilNadu triggered by positively correlated (r=0.384) relative humidity. Whereas other weather parameters did not impact the population significantly. Alteration in food plant selection from *Ailanthus excelsa* shoots feeder to ravenous shoot and leaf feeder of host *M. dubia* was documented. Infected leaves of *M. dubia* encountered the development of boundless branched stellate trichomes on the abaxial surface. The feeding and egg laying damage of *D. indicus* on *M. dubia* resulted the loss of average 52% of chlorophyll content and 80% of total leaf lamina compared to the healthy one after heavy infestation. Other secondary infection symptoms seen in the adaxial surface of leaves during infestation are yet to be investigated.



*Keywords: Melia dubia thrips, Thrips Damage, Thrips bionomics, Feeding behaviour, Nursery pests.*




## 1.INTRODUCTION

Thrips are known as opportunists for their versatile functional dynamics in nature such as pests, vectors, pollinators, gall makers, treehopper ectoparasites, Kleptoparasites, fungivores and predators [1,2,3 and 4]. Out of two sub-orders of Thysanoptera namely Terebrantia and Tubulifera; Terebrantia contains major pests and vectors (eg. *Frankliniella occidentalis, Thrips palmi* etc.) In contrary, Tubulitera is larger and also much more diverse in containing gall makers, fungivores, pollinators, phytophagous and predators (eg. *Mesothrips sp., Dolichothrips sp*., *Plectrothrips sp., Hyidiothrips sp.* etc). Phlaeothripidae, the only one extant family of Tubulifera according to modern classification [5] has 3500 described species round the globe with 460 genera and sub-family Phlaeothripinae comprises of 2845 species with 376 genera which is highest among any sub-family of order Thysanoptera [1]. Monomorphic genus *Dolichothrips* falls under sub-family Phlaeothripinae consists of 21 species out of which 20 species reported from Asian region [6] and the target species *D. indicus* further belongs to *Haplothrips*-lineage, the group that feeds on flowers or predatory in nature [7]. *D. indicus* was first described as *Neoheegeria indica* by Hood (1919) [9] found from Coimbatore, Tamil Nadu, India later on the species was described by different scientists in different names from various places, hosts and times such as *D. pumilus* [9]; *D. rambhutanae* [10]; *D. nesius* [11]. Later all are synonymised by Scientist Mound and Okajima and the species considered as *D. indicus* might be due to its frequent and first occurrences from India. Tubulifera thrips are generally not considered as pests except a few (eg. *Holopothrips fulvus, Liothrips oleae etc)* and *D. indicus* has been found as one among the exceptions. An

enigmatic species widely distributed in tropics and sub-tropics reported as polyphagous when found feeding on inflorescence of Rambhutan, leaves of *Melastoma marianum*, *M. malabathricum, Cassia marginata*, *Capsicum annuum* and *Solanum melongena*, shoots of *A. excelsa,* flowers of *Jasminum sambac* and *Mallotus sp*., members of Lamiaceae family, also observed in *Macaranga tanarius, M. hullettii* and *Hibiscus tiliaceus* as putative pollinator[12,13 and 14].Taxonomically *D. indicus* was well studied species but, apart from the description 'widespread, polyphagous and variable' by Mound et al 2015; very little is known about the ecology of this target species. As marked in earlier literature that there is gap in behavioural studies of diverse species rich group Phlaeothripinae [7], this investigation aims to report the bionomics, feeding behaviour and pest status of *D. indicus* on a new host *M. dubia* from Meliaceae family*;* commonly known as Malabar Neem.

$$\text{Population densit} = \text{Total number of insects of a species in all blocks} / \text{Total number of blocks studied}$$

## 2. MATERIALS AND METHODS

### 2.1. Study sites and period

*M. dubia* plantations of the age group 3 to 60 months were screened for *D. indicus* population throughout a year in various farmer's fields of Tamil Nadu including research nurseries of Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore as an experimental site. 23 study sites were randomly selected based on availability of plantations comprising of 13 districts of Tamil Nadu namely; Coimbatore, Tiruppur, Karur, Tiruchirappalli, Erode, Sivagangai, Thanjavur, Cuddalore, Kallakurichi, Vellore, Tirupattur, Krishnagiri and Dharmapuri. Representative fields covered five agro-climatic zones such as North Eastern Zone, North Western Zone, Western Zone, Cauvery delta zone and Southern zone (https://tnhorticulture.tn.gov.in/agroclimatic) [15]. No plantation was found in high rainfall and hilly zones.

### 2.2 Sampling method

Symptomatic saplings and young trees were surveyed for *D. indicus* population. Sampling was done by both delayed and direct count method [16] using random block designing (RBD) technique. Number of blocks and their size varied depending on the plantation area. An average value of *D. indicus* on young shoots in each block was calculated for final estimation. Sampling concept of this investigation was a modified version of earlier studies. The following formulae had been used to calculate the population density and frequency of *D. indicus* in field.

$$\text{Frequency (\%)} = (\text{Number of blocks in which the species occurred} \times 100) / \text{Total number of blocks studied}$$

Population density was further classified into five groups following the rating system given by Banks (1954) in relation with damage scale such as nil (0), low (1-15), medium (16-30), high (31-50), very high (>50). Similarly, frequency data was categorized as 0 = nil, 1-10 % = low, 11-50 %= moderate and 50 - 100%= high. Based on the population level distribution map of thrips were prepared using ArcGIS (10.8 version) software.

Specimens were collected in AGA solution (60% Ethanol: Glycerine: Acetic acid in 10:1:1 ratio) and 80% ethanol with pointed brush for taxonomic and molecular identification respectively (EPPO 2018). For molecular work specimens were stored in - $80^0$C and live

specimens were also collected using zip lock covers with pinned holes on it for aeration. Using digital thermo-hygrometer, the real time temperature and humidity was measured in each field location. Cumulative precipitation had been extracted from grided data for the year 2021 from IMD website (https://www.imdpune.gov.in/cmpg/Griddata/Rainfall_1_NetCDF.html) and long-term analysed windspeed data was collected from Tamil Nadu State Disaster Management Authority where the districts of Tamil Nadu has been divided into four groups namely Very high (50 m/s), High (47 m/s), Moderate (39 m/s) and Low (33 m/s) damage risk zone.(https://tnsdma.tn.gov.in/app/webroot/img/document/map/2021/tn_wind_cyclone_hazard_zone.pdf)

### 2.3 Identification

Though there are several methods developed for the identification of thrips so far namely marker-based identifications (eg. SSR, RAPD, RFLP), COI or ITS gene-based diagnosis, LAMP Assay, transcriptome, high throughput imaging, RPA, PSR techniques etc. but, for the current study cost effective and widely used morphometric key-based identification and mitochondrial gene sequencing methods were adopted for species confirmation [17]. For molecular identification of thrips, Hebert et al. (2003) [18]. DNA extraction method had been followed with some modifications. For PCR amplification of COX1 gene, 25 µl volume of reaction mixture was taken containing 1 µl of template DNA,12 µl of dreamtaq green thermofischer pcr master mix, 11 µl of sterile distilled water, 0.5 µl universal forward primer (5'-GGTCAACAAATCATAAAGATATTGG-3') and 0.5 µl of reverse primer (5'-TAAACTTCAGGGTGACCAAAAAATCA-3'). PCR programme was with 35 cycles where initial denaturation was at 94 °C for 5 minutes, denaturation at 94 °C for 30 seconds, annealing temperature 57°C for 1:30 minutes, extension at 72 °C for 1 minute and final extension at 72 °C for 10 minutes was set. Three reaction tubes were taken in replications along with one negative control (without template DNA). During the agarose gel electrophoresis documentation of PCR products 1Kb ladder was used. After purification and sequencing by Eurofins the raw data was submitted to NCBI. Simultaneously, for morphometric identification permanent slides were prepared for field collected thrips specimens using simplified method described by Mound and Kibby (1998) [19] and specimens were observed under Magnus trinocular microscope. Permanent slides were then used for dichotomous key based identification provided in prior studies [8,20].

### 2.4 Biology

After evaluating the requirement of target thrips species, life cycle study had been conducted in controlled condition with the concept of previous studies [21,22]. Fresh young shoot of *M. dubia* with 2 to 3 tender leaves were collected and screened under microscope to ensure that the experimental material was healthy. The material was then placed in a breeding dish with wet germination sheet and wet cotton plug tied at the base of it to retain moisture. A pair of mating adults were collected from the infected plant and introduced in the experimental set up and continued till the emergence of 1$^{st}$ instar larva by hydrating the tissue. 1$^{st}$ instar larva was further transferred by brush to a healthy seedling containing young shoots and few tender leaves; kept inside cage and given the natural condition. Screening was done under microscope time to time to avoid missing any life cycle stages and replacing back by brush. Careful handling was done due to their delicate nature. The method was repeated multiple times during different time of the year for confirmation and to get accuracy. The duration difference of each consecutive developmental stages has been mentioned as average range.

### 2.5 Feeding behaviour and host preference study

Feeding behaviour of *D. indicus* was studied by monitoring the feeding habit of *D. indicus* on nursery seedlings as well as surveillances on feeding pattern of different stages of reared thrips under light microscope and stereo-zoom microscope and through clearing technique and leaf peeling technique. Target host *Melia dubia* saplings in nurseries and farmers' plantations were monitored on a regular basis to know the feeding nature of each life cycle stages and feeding effect on leaf epidermis was also checked by leaf clearing technique (Mohan Ram et al 1978). Choice and no choice experiment was performed to assess host preference using previously reported host *A. excelsa* [8] and target host *M. dubia*. Though occurrence of polyphagous D. *indicus* had been documented from numerous plant species, however, similar feeding behaviour from another important forestry crop Ailanthus, made this crop ideal for the experiment. Free choice experiment was carried out using a glass Y-tube olfactometer set up where both side arms contained shoots and tender leaves of food plants. Ailanthus in one side and *M. dubia* at the other end and 40 adults of *D. indicus* were released from the main arm and tightened with cotton plug. The complete set up was fixed straight to avoid error. Data was taken every half an hour interval till the last individual settled either of the side arms. For no choice experiment the similar number of adult thrips (30 in each) were introduced to *A. excelsa* and *M. dubia* in separately cages under favourable condition where no alternative hosts are available. Data was collected till the survival of last individual.

### 2.6 Damage estimation

To assess the damage and pest status of sap feeder *D. indicus* on *M. dubia* leaf sectioning was carried out using Micros microtome and also chlorophyll estimation had been done in thrips infected and healthy young leaves sets of *M. dubia* in replications from the same series of leaves with same age group and tested for chlorophyll loss using 80% acetone method [23]. Chlorophyll content was calculated using following formulae.

Chlorophyll a: 12.7(A663) – 2.69(A645); Chlorophyll b: 22.9(A645) – 4.68(A663) and Total Chlorophyll: 20.2(A645) + 8.02(A663) Damage caused by *D. indicus* was also analysed with Image Analyser Leica Qwin software and difference represented by graph and pictorial diagram.

## 3. Results

### 3.1 Identification and life cycle

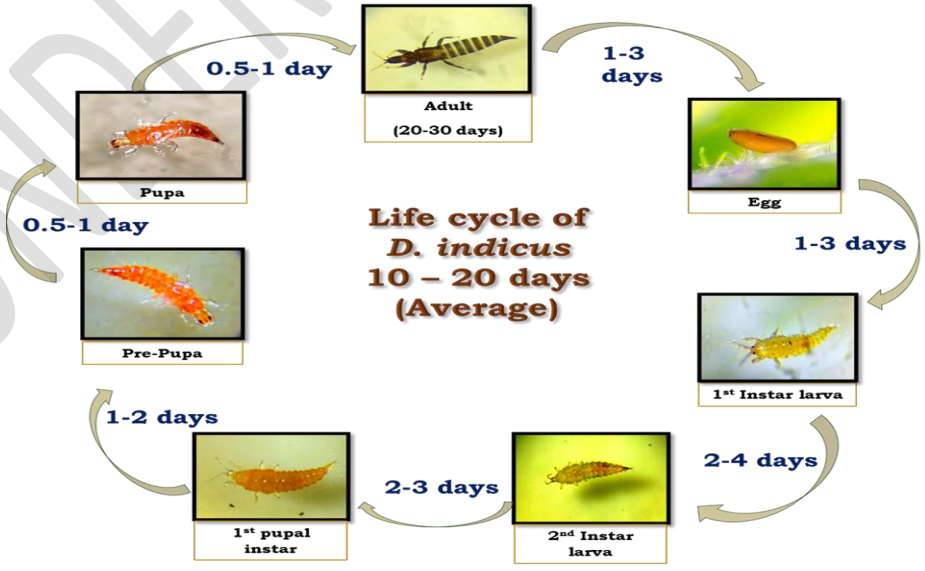


**Fig. 1. Life cycle of *D. indicus***


**Fig. 2. a) Female macroptera ventral view (inset ovipositor), b). Male macroptera ventral view (inset genitalia)**

Dichotomus keys of holotypes and syntypes specimens of prior research were used to identify male, female macroptera of *D. indicus* (Mound et al 2006). Identification of adult male and female was done after completion of life cycle study (Fig 1). Male specimens observed were comparatively thinner and smaller than that of the female. The differences between male genitalia (with both side crescent shaped opening) and female ovipositor also displayed (Fig 2). The main morphometric characters found in the specimens were described here such as antennal segments 7-8 in numbers, no sense cones, wings were colourless in third antennae segment, some female specimens without antennae, lateral margin of the head is parallel, mid and hind tibiae similar in colour with apex paler yellow, finely pointed a pair of postocular setae not blunt at the tip, S2 setae in tergite IX is shorter and bent at the tip in compare to iS pair (Fig 3).

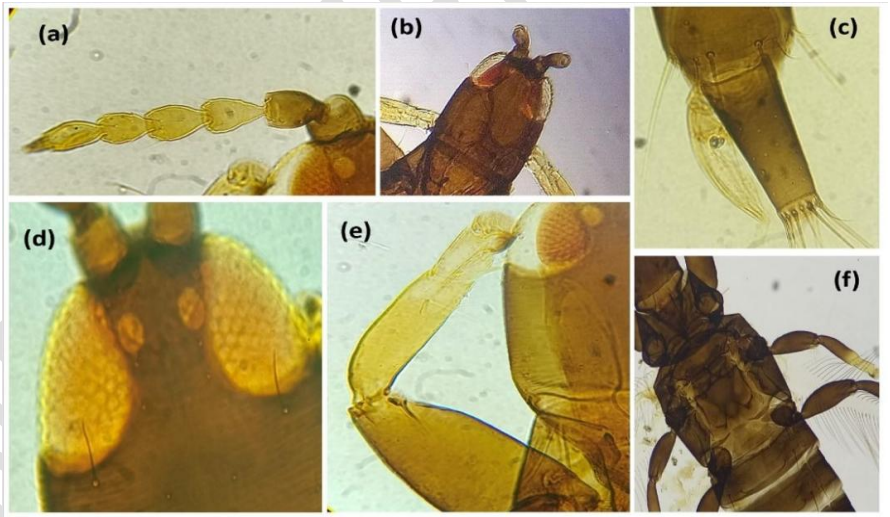


**Fig. 3. (a, b) Antennae, (c) S2 and iS in tergite IX, (d) postocular setae, (e) mid and hind tibiae, (f) mesonotum and metanotum**

Taxonomic identification of *D. indicus* had been arduous job due to their variable characters such as the dilation of postocular setae on apex for Indian specimens, fluctuation in the colour of mid and hind tibiae [20]. In view of the variation in certain and other characters, molecular method was also adopted to confirm the species. Purified and PCR amplified COX1 gene sequences showed close proximity with the genus *Dolichothrips* in NCBI BLAST (Fig 4). Hence, the sequences were published with accession number OL308090 (583bp) and OL308086 (495bp) as *D. indicus*.

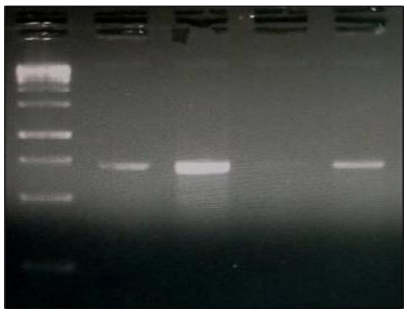

**Fig. 4. PCR Gel image of D. indicus (495bp-583bp)**

During the study of life cycle, it was observed that during favourable weather conditions *D. indicus* completed its life cycle on an average 10 to 20 days in *M. dubia*. 8 to 10 days life cycle was observed during summer and during pre-monsoon whereas number of days were doubled during dry and winter season. Life span of the adult was not more than a month. Both male and female macroptera specimens were seen during identification. Throughout the study female population was found dominant with average sex ratio female: male 9:1 respectively. An adult female was seen copulating more than once in its lifetime and laid eggs discretely within 1-3 days after mating. Adult female of *D. indicus* glued the eggs mostly on abaxial surface of the tender leaves, internodes, apical bud and axillary bud regions. Number of eggs varied from one to three per leaf at a time. Eggs are kidney shaped and dark mustard yellow in colour and 250-300 µm in size. Healthy eggs hatched within 1 to 3 days depending on the environmental conditions. $1^{st}$ to $2^{nd}$ instar larvae development takes average 2-4 days, subsequently $2^{nd}$ instar larvae to $1^{st}$ pupal instar develops in another 2-3 days. Pre-pupae formation takes place in half to 1 day in some cases maximum 2 days and further development of pupae takes almost similar time period. Hence, frequent hourly observation at this stage is recommended. Larvae are light yellow in colour, elongated body with tiny head and red eyes. Legs and antennae are transparent at this stage. Pre-pupae and pupa stage colour of the body turns orange but, legs and antennae remain transparent like before. In this stage wings starts forming and antennae curved backward due to no feeding. The adult male and females are brownish black in colour with antennae and legs yellow. Size of adults' ranges from 1.5 mm to 1.8 mm. Length of antennae average 200 µm . Due to short life cycle and high fecundity rate the species showed overlapping generations during investigation.

### 3.2 Habitat and distribution

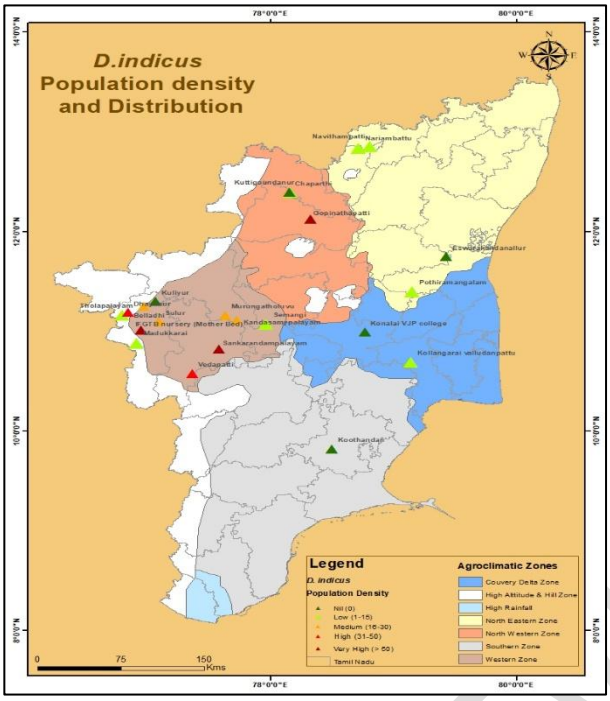


**Fig. 5. Population distribution map of *D. indicus* in selected *M. dubia* plantations of Tamil Nadu**

**Table 1. Multiple Pearson's Correlation (1-tailed) between Insect Population and Other Weather Parameters**

| MULTIPLE CORRELATION | | | | | | |
|---|---|---|---|---|---|---|
| | | **Temperature** | **Relative humidity** | **Cumulative Rainfall** | **Windspeed** | **Insect Population** |
| Temperature | Pearson Correlation | 1 | 0.132 | -0.206 | -0.127 | 0.267 |
| | Sig. (1-tailed) | | 0.279 | 0.179 | 0.287 | 0.115 |
| | N | 22 | 22 | 22 | 22 | 22 |
| Relative humidity | Pearson Correlation | 0.132 | 1 | -0.199 | .441* | .384* |
| | Sig. (1-tailed) | 0.279 | | 0.188 | 0.020 | 0.039 |
| | N | 22 | 22 | 22 | 22 | 22 |
| Cumulative Rainfall | Pearson Correlation | -0.206 | -0.199 | 1 | -0.073 | -0.269 |
| | Sig. (1-tailed) | 0.179 | 0.188 | | 0.374 | 0.113 |
| | N | 22 | 22 | 22 | 22 | 22 |
| Windspeed | Pearson Correlation | -0.127 | .441* | -0.073 | 1 | -0.028 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Sig. (1-tailed) | 0.287 | 0.020 | 0.374 | | 0.451 |
| | N | 22 | 22 | 22 | 22 | 22 |
| Insect Population | Pearson Correlation | 0.267 | .384* | -0.269 | -0.028 | 1 |
| | Sig. (1-tailed) | 0.115 | 0.039 | 0.113 | 0.451 | |
| | N | 22 | 22 | 22 | 22 | 22 |
| *. Correlation is significant at the 0.05 level (1-tailed). | | | | | | |

*D. indicus* had occurred throughout the year at medium to high level in experimental site i.e., the mother bed of IFGTB nursery and population reached its peak (>50 individuals average) during south-west monsoon i.e., mid-June till September. In comparison to other times of the year, the humidity during this period was found highest around 69% to 79% though the nursery open bed plantation obtained medium population. Distribution of *D. indicus* had been documented during the survey in different agro-climatic zones and important abiotic factors such as temperature, humidity, precipitation and windspeed were checked for influencing the population. During surveillance in 23 different locations; IFGTB nursery (11.01667 N,76.95111 E) mother bed in Coimbatore, Sankarandampalayam (10.82555556 N, 77.58527778 E) plantation in Tiruppur and Gopinathapatti (12.1275 N,78.33027778 E) plantation in Dharmapuri district plantations obtained very high population density and frequency of *D. indicus*. On the other hand, Kuliyur (11.30111111 N,77.06638889 E) in Coimbatore, Eswarakandanallur (11.75138889 N, 79.43111111 E) in Kallakurichi, Chaparthi (12.39694444 N, 78.155 E) in Krishnagiri, Koothandan (9.82444444 N, 78.49944444 E) in Sivagangai and Konalai VJP college (10.99555556 N, 78.77166667 E) plantations in Tiruchirappalli recorded zero population. A distribution map had been generated using ArcGIS (version 10.8) based on population density in different agro-climatic zones (Fig 5). During the whole investigation period the real time temperature varied from 24.6°c to 38.2 °c, relative humidity 42% to 80% and precipitation 892 mm to 4124.03 mm, spacing maintained minimum 1 ft in nursery bed to maximum 5 meter in field condition. Agroforestry crop Malabar neem found in inter-cropping or mixed cropping with coconut, teak, mango, jackfruit, guava, banana, red sander, teak, mahogany etc. To evaluate the impact of the weather parameters on insect population multiple Pearson's correlation (1-tailed) was calculated using SPSS software from the field data (Table 1) where 'r'= 0.384 (correlation coefficient) was found significant when insect population was compared with relative humidity.

### 3.3 Feeding behaviour and host preference study

Feeding pattern of thrips was documented during the nursery and field surveillance. The adults of *D. indicus* could be considered as diurnal due to their peak activities in daytime such as feeding and mating. However, egg laying was not noticed in daytime during entire study period. Age of plants less than 3 months were not seen fed by *D. indicus* and also till the developments of apical shoots. The larvae are highly specific in feeding tender leaves of *M. dubia* whereas adults were seen to congregate in terminal shoots and axillary buds but, mating on the abaxial surfaces of the leaves. Mating adults could be found inside the leaf wrinkles resulted by their feeding.

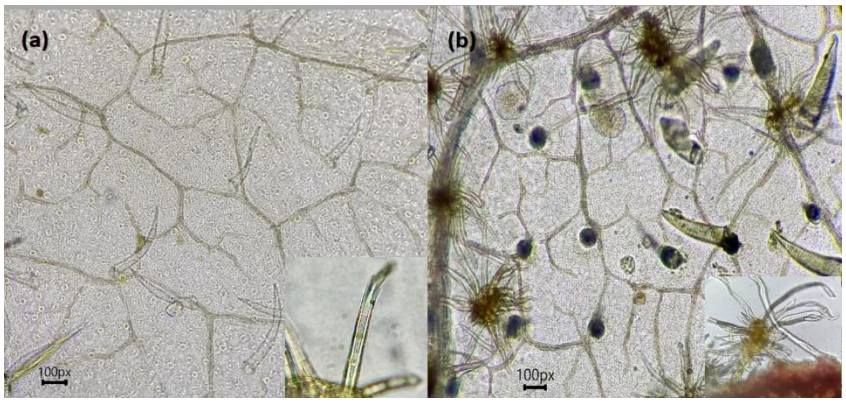


**Fig. 6. Trichomes (40X) in the abaxial surface of *M. dubia* leaf (a)Septate unicellular trichomes in the healthy leaf (b) Stalked stellate trichomes in *D. indicus* infected leaf**

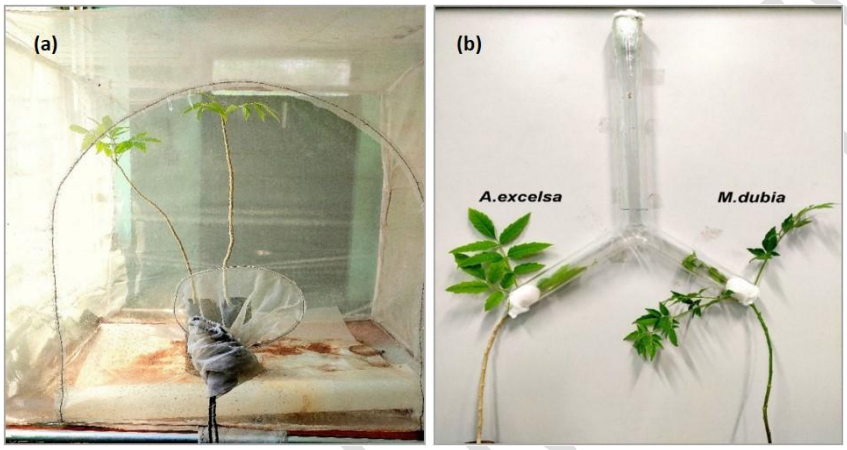


**Fig. 7. (a) No choice experiment with *A. excelsa* (b) Free choice experiment with *A. excelsa* and *M. dubia***

Leaf clearing and leaf peeling experiment revealed the differences in epidermis between healthy and thrips infected leaves. After scrutinizing several healthy and infected leaves it was noticed that healthy tender leaves of *Melia* possess few thin and long septate unicellular trichomes on the abaxial leaf surface of it whereas infected leaves contained much shorter and thick unicellular trichomes and a large number of stalked stellates trichomes. (Fig 6 a, b). Stellate trichomes made a visible difference by forming layer on the abaxial surface of the leaves. Among wide range of hosts of *D. indicus;* the free choice feeding experiment was conducted with already reported and economically important forestry crop *A. excelsa* along with *M. dubia.* In this laboratory tests, out of 40 released adults 6 individuals were found absorbed in cotton plug, 10% were unoriented and remaining 65% were settled in *M. dubia* after *24* hours. Remaining insects moved towards *A. excelsa* but, didn't settle even after 72 hours. On the other hand, released thrips on Ailanthus in no choice condition found completely dead inside cage within 96 hours from the starting of experiment without leaving any visible damage symptom or life cycle stages behind in the plant while in *M. dubia* the adults aggregated in the apical shoot region and continued its life cycle (Fig 7 a, b).

### 3.4 Damage estimation

After counting the numbers of thrips from each study plot with respect to their visual damages seen in plants, the population levels were classified into five groups namely nil, low, medium, high and very high as mentioned in the methodology. High population density observed in nursery mother bed and in a few field plantations. Densely populated fields also showed high frequency of *D. indicus*. The damage symptoms of sap-feeders were not prominent but, could cause underlying risks to the plant. Major damage symptoms of *D. indicus* noticed in tender leaves were the loss of chlorophyll and reduction of leaf lamina and

in mature infected leaves showed symptoms such as zigzag midvein, vein greening etc. To assess the damage level and pest status chlorophyll loss experiments, microtome leaf sectioning and leaf lamina reduction estimation were carried out.

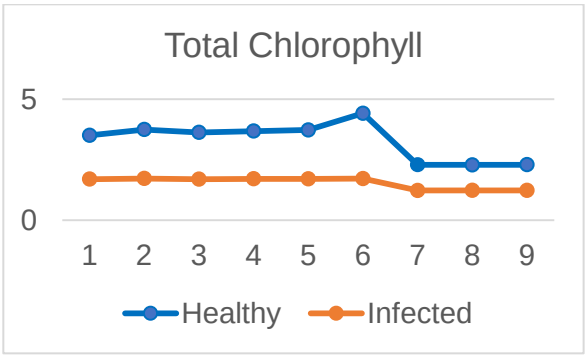


**Fig. 8. Chlorophyll estimation for both healthy and infected leaves in replications**

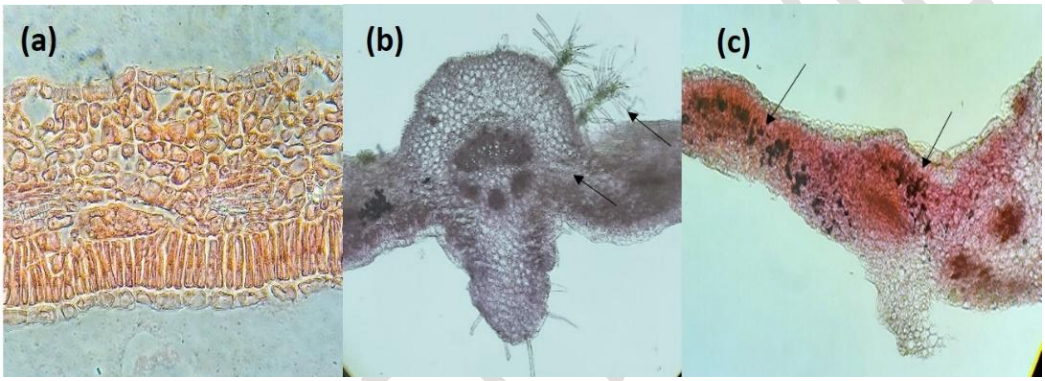


**Fig. 9. *M. dubia* leaf anatomy (a)Vascular bundle of healthy leaf, (b) Low level of infestation and stellate trichome growth on the abaxial surface, (c) Mesophyll spongy cell death and contraction of spongy and palisade cells after high feeding of *D. indicus***


**Fig. 10. *M. dubia* leaflets a). Healthy tender leaflets b). *D. Indicus* infected leaflets**

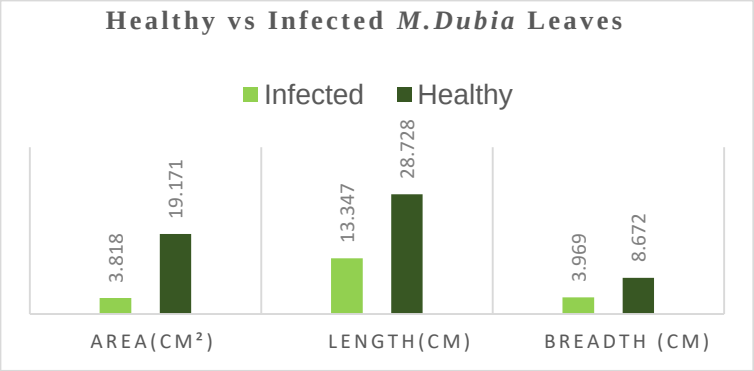


**Fig. 11. Average area, length and breadth differences between infected and healthy tender leaves of *M. dubia***

After evaluation of chlorophyll in total nine replications of healthy and highly infected leaves, it was found that the infected leaves have almost 52% less amount of chlorophyll than that of the healthy one. The result has been represented graphically (Fig 8). Close observation of microtome sectioned leaf anatomy revealed the differences among healthy, low and highly infested tissues. In the vascular bundle of healthy leaf tissue proper arrangement of palisade parenchyma, spongy parenchyma, air space was seen whereas in low and highly infected tissues, shrinkage of palisade parenchyma and dead cells in the spongy mesophyll tissue were noticed respectively. (Fig 9 a, b, c). The crucial damage symptom i.e., highly infected leaves got average 80% loss of total leaf lamina when measured in terms of length, breadth and total leaf area in compared to healthy leaves (Fig 10 a, b and 11).

## 4. DISCUSSION

The present study reports bionomics and damages by sap-feeder *D. indicus* on the host *M. dubia,* a money-spinning tree for farmers and tree growers with multiple usage [24,25,26]. In recent past *D. indicus* and other sap-feeders such as *Tetranychus urticae*, *Ferrisia virgata* were reported from *M. dubia* in Tamil Nadu [27,28] and thereafter, *D. indicus* got special attention as a regular pest of *M. dubia.*

Numerous numbers of field and nursery collected *D. indicus* specimens from *M. dubia* across Tamil Nadu during identification shared similar keys mostly with the type specimens of *D. rambhutanae* and *D. pumilus* although in previous research *D. nesius* and *D. pumilus* were considered best synonyms. However, the term ‘variable’ described about *D. indicus* by Mound et al. (2015) [20] was found appropriate during present study. The investigation on life cycle stages showed sensitivity against microclimatic conditions. The fluctuation of life cycle period in different seasons such as shorter during summer and longer in winter indicated the role of weather parameters in their growth and development which was found similar with other thrips species namely *Thrips tabaci, Frankliniella bispinosa* etc on cotton, mung bean and green bean respectively [29,30,31,32]. However, during present investigation apart from seasonality specific effect of temperature and humidity was not measured for each developmental stage. Hence, a detailed study could be designed in this line to map their population outbreak as these are interlinked with the rate of fecundity and number of generations.

During the assessment of habitat and distribution in nurseries and plantation fields, IFGTB nursery mother bed received persistent population of *D. indicus* as compared to fields unlike the previous study [27] where the pest was reported seasonal. Population density in many fields presumed not severe due to the following reasons such as more spacing between trees, mixed cropping, occurrence of natural enemies or predators etc. In distribution mapping based on the population density, no specific pattern of distribution of *D. indicus* were seen in different agro-climatic zones of Tamil Nadu instead when different weather

parameters such as temperature, humidity, precipitation and windspeed were measured, relative humidity was found weakly but positively correlated with *D. indicus* population. Not for the first time, the study of mango thrips by Gundappa et al. (2016) [33], the investigation of Amjad Bashir et al. (2022) [34] on thrips also revealed the positive correlation of thrips population with humidity. Therefore, no wonder why highly humid nursery mother bed of IFGTB recorded maximum population compared to open nursery bed. During field observation windspeed and precipitation was assumed inversely related to *D. indicus* population although no significant correlation was found after statistical analysis. Hence, re-evaluation is recommended with real time data for further confirmation.

*D. indicus* seemed a major shoot pests of *M. dubia* in nurseries which resembles their reported feeding habit in *A. excelsa* [8]. Feeding pattern and host preference was recorded in the study clearly indicated their preference of *M. dubia* over *A. excelsa*. Despite the fact that *D. indicus* was once described as shoot feeder of *A. excelsa*, throughout the present study period, the thrips were no longer found feeding on it. Flower feeding thrips (eg. *Thrips hawaiiensis*) were seen to choose their host depending on host's fitness, facilities of oviposition, colour of flowers etc [35] but, mechanism of host plant selection by shoot feeding thrips are yet to be studied.

Estimation of injury and damage by insects are necessary in order to know their pest status and to manage them. While assessing an extensive loss of leaf area resulted by prolonged *D. indicus* feeding, it resembled the damages caused by *Thripidae* thrips on *Gossypium hirsutum* [36,37]. It was noticed that the plants with a greater number of young shoots tend to get more thrips attack as adult *D. indicus* were aggregating and feeding on shoot regions and laying eggs on tender leaves. Little leaves symptoms in terminal region and side branches therefore exposed the feeding damage prominently. Scrapping and sap feeding habit of early instars and adults of *D. indicus* through stylet in mesophyll layer perhaps resulted the loss of water content inside the leaves which is why the contraction or shrinkage of mesophyll tissues happened and in order to retain the water content for photosynthesis the development of a thick bushy layer of branched spike stellate trichomes might have grown as a plant defence system which was not seen in healthy one [38,39]. In accordance with this earlier non-glandular branched stellate trichomes were seen impeding *Manduca sexta* caterpillar from feeding on Solanaceae crops [40]. Notably, in some cases caterpillars are destroying plants defences by removing these trichomes before they initiate feeding [41,42]. However, in some cases trichome-independent plant defence assisted by foliar metabolites or artificial inoculation of phytohormones were seen effective against thrips resistance [43,44,45]. Low to medium population did not cause any significant damage to nursery saplings or young trees but high to very high population did. High population significantly destroyed the vigour of the plant showing the growth retardation with the decline of chlorophyll content as it is directly related to the Nitrogen content as well as photosynthetic capacity [46] Nevertheless, various disease symptomatology developed post thrips attack whether associated with insect damage are yet to be investigated because the insect vectors in forest ecosystem is still unexplored [47].

## 5. CONCLUSION

An economically important agro-forestry crop, *M. dubia* from family Meliaceae is the new addition in *D. indicus* food plant list along with many other tree species, agriculture crops and flowering plants documented earlier on the other hand *A. excelsa* an already existing food plant is not anymore consumed by the pest indicated their changing hood habit. Throughout the study the persistent nature of thrips *D. indicus* inside nursery mother bed and fluctuation in the field showed how the thrips are prevalent when the humidity was congenial. However, the severity has not ended with casualty perhaps due to the deciduous nature of the host. Further investigation on impact of two other weather parameters namely windspeed and precipitation on thrips population with real time data is advised and surveillance on

symptomatology of *D. indicus* borne disease development and their molecular characterization is also recommended. This may help the farmers and tree growers to predict the pest outbreak and protect the crop by prophylactic management measures.

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