



# Studies on Fruit Infestation and Biology of Gall Psyllid *Trioza fletcheri* Minor Crawford (*Trioziidae*) on *Terminalia elliptica* Willd. (*Combretaceae*) in South India

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

*Terminalia elliptica* Willd. commonly as called Indian laurel is a deciduous tree of the family Combretaceae and found native to South and South- East Asia. The tree is mainly harvested for the hard wood timber, ethno medicine, tannin extraction and also used as the primary hosts for the

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production of good quality tasar silk in Central India. The tree is attacked by several insect pests among them leaf gall infestation by the psyllid *T. fletcheri* cause severe economic loss to tasar silk cultivation. The present study documented the occurrence of gall infestation on the flowers and fruits of *T. elliptica* by *T. fletcheri*. The psyllid usually induces galls in leaves and stem of *T. elliptica*. This is the first report of psyllid *T. fletcheri* inducing galls on flowers and fruits of *T. elliptica*. Infestation level in few locations in Western Ghat forest areas of Kerala and Tamil Nadu is assessed. Biology of the gall insect is also studied. The impact of psyllid infestation in the flowers and fruits on the seed production of this important tree species is discussed.

**Keywords:** Fruit and bud gall; infestation level; *Trioza fletcheri*.

## 1. INTRODUCTION

*Terminalia elliptica* Willd. is commonly called as Indian laurel is a medium to large deciduous tree of the family Combretaceae and found native to South and South- East Asia, particularly in India and Myanmar. In India it is commonly distributed in the low land regions of tropical forests in the states of South India, North East and Central India. The tree is mainly harvested for the valuable timber and also for the use in ethno medicine and tannin extraction. *T. elliptica* and *T. arjuna* are also the primary hosts for the production of good quality tasar silk from the wild silk worm, *Antheraea mylitta* (Saturniidae) in North- East and Central India [1,2]. Large quantity of *T. elliptica* seeds from wild population has been collected by the State Forest Departments for raising seedlings in nursery for the enrichment and afforestation planting activities in South India [3].

Several insect pests in *T. elliptica*, such as defoliators such as *Myllocerus viridanus* Fab., *Tricliona picea* Jacoby, *Anomala blanchardi* Blanch and *Notolophus antiqua* Linn., stem borer *Aelosthes holosericea* and the psyllid leaf gall maker *Trioza fletcheri* minor Crawford (*Trioziidae*) were reported (<https://crtti.res.in/>). The leaf gall infestation by *T. fletcheri* on *T. elliptica* during the cultivation period of tasar silk worm damages 40-50 percent of foliage and cause severe economic loss [4]. Psyllid forms about 90 per cent of galls in leaves and very few in stem, flower, bud and fruits [5]. The gall inducing psyllids possess high level of host specificity and show conservative nature of bio geographical distribution [6]. Generally, psyllid gall formation initiates with the injection of chemicals in to the host plant tissues by the first instar larva during the initial feeding process [7].

Chauhan et al, [8] reported the infestation by psyllid *Pauropsylla tuberculata* Crawford

(Homoptera: Psyllidae) on the flowers of *Alstonia scholaris* (Apocynaceae) which later on transforms as green galls on fruits. *Phylloplecta hirsute* (syn. *Trioza hirsuta*) (*Trioziidae*) induce gall in *T. paniculata* on different parts of branch, bud, flower and fruit in south India [5]. Likewise, both *Trioza fletcheri* minor Crawford and *Trioza hirsuta* induce leaf galls on *T. arjuna* Bhatia and Yousuf, [4] while the later also forms galls on flower of the similar host [9].

Other insects inducing galls on flowers, fruits and seeds include Cecidomyiidae such as seed gall midge *Centarinia dalbergiae* (Sisoo gall midges) which forms flower galls in *Dalbergia sisoo* Roxb. Kulkarni and Joshi [10]. *Schizomyia cocculi* induce amorphous gall on flowers of *Cocculus hirsutus* (Menispermaceae) Desai and Sathe, [11] while *Asphondylae pongamiae* induce bud gall on the flowers of *Pongamia pinnata* (Jacob and Senthil, 2015). Cone gall midge *Contarinia oregonensis* create seed galls on Douglas-fir [12]. Santos et al. [13] documented braconid wasp *Allorhogas* sp. (Hymenoptera: Braconidae) forming gall on the seeds of *Inga laurina* (Leguminosae) in Brazil. The eulophid wasp species belonging to the genus *Anselmella* viz. *A. malacia* and *A. miltoni* (Hymenoptera: Eulophidae) were found infesting on developing fruits of water apple *Syzygium samarangense* and forms seed galls within the fruits Oanh et al., 2019 and Lin et al., [14-18]. Mendhei and Hate [19], reported flower gall in an important medicinal plant *T.chebula* which can significantly reduce fruit production in Central India. The gall inducing insects on reproductive structures of plant species reduce the production of quality seeds which in turn adversely alter the genetic diversity of a plant species in their habitat. The current study documents the gall formation in flowers and fruits of *T. elliptica* by psyllid *Trioza fletcheri* minor Crawford which is otherwise so far reported as a species inducing galls on leaves [20].

## 2. MATERIALS AND METHODS

### 2.1 Study Sites and Period

*T. elliptica* flowers during June to August and fruits mature during February to April. Fruits are ovoid, measures about 3.5x 5.5 cm and longitudinally 5 winged with single seed. The gall formation on the fruits of *T. elliptica* at Anamalai Tiger Reserve (ATR), Coimbatore (N10.474611 E76.849719) was first recorded in 2021. Field survey recognized the similar fruit gall infestation in *T. elliptica* at Sadvayal forest (N 10.951533 E 76.70355) Coimbatore in Tamil Nadu and Parambikulam Tiger Reserve (N 10.4477, E 76.8003) Nilambur forest (N 11.3087E 76.2448), Ranni Forest (N 9.368578 E 76.914074) in Kerala during the study period 2021 to 2023 (Fig. 1). The gall infested fruits and seeds were

collected from four trees in a population from various study sites.

### 2.2 Identification of Gall Insect

The bud galls and galls on immature fruits were opened by making a slit on transverse axis and the various developmental stages of larvae were extracted and preserved in 70 per cent ethyl alcohol as wet preservation. Adult psyllids emerged from the bud and fruit galls in closed container were card mounted and preserved as dry specimens [21]. The collected insect specimens were identified by the taxonomists using morphological taxonomic keys at National Centre for Biological Sciences, TIFR, Bengaluru, Karnataka. Type specimens are deposited at the National Forest Insect Collection (NFIC) at Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore, Tamil Nadu.

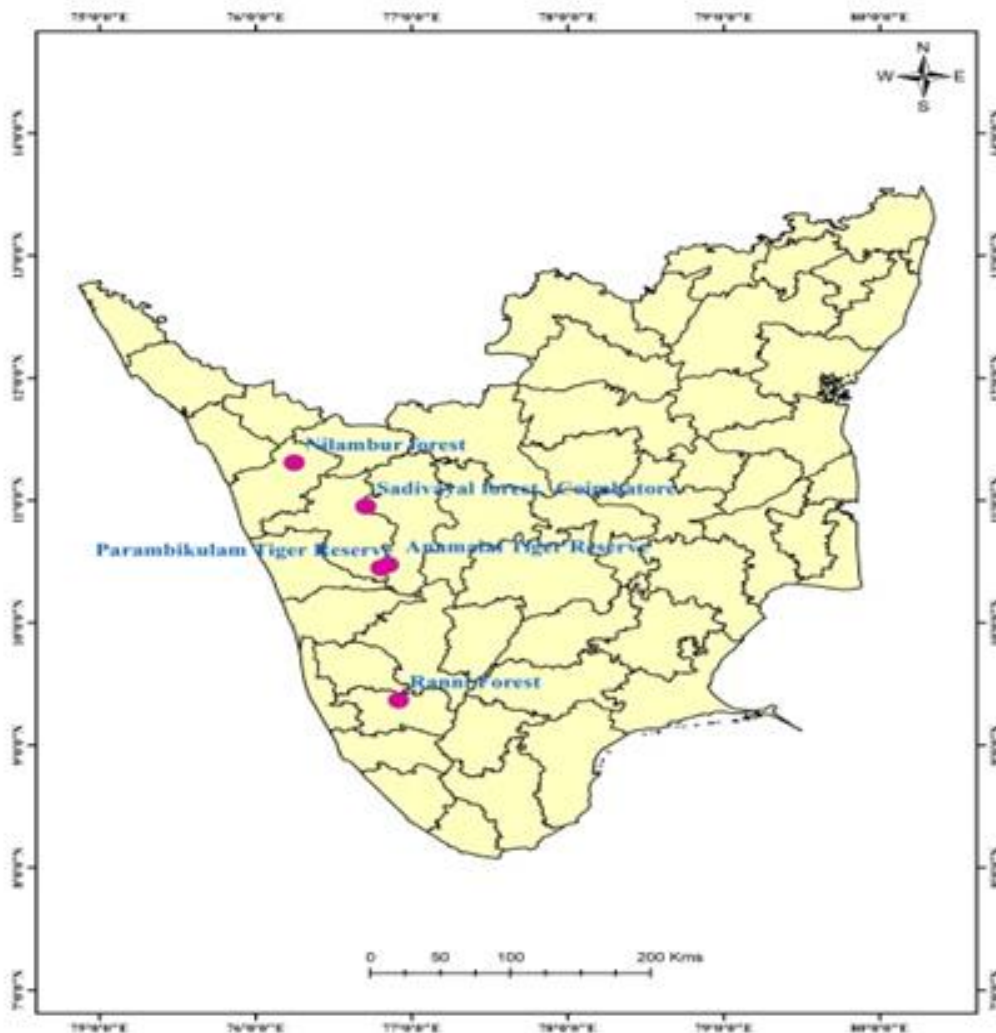


Fig. 1. Map of the study area

### 2.3 Infestation Level

Infestation levels from various locations were recorded during the study period 2021 to 2023. The gall infested trees were observed and randomly selected four fruiting branches of one meter length from various corners of the trees. Infestation level was recorded from each branch on four trees in the tree populations existing in five study sites. The level of infestation is recorded separately for bud and fruit galls in various study areas. The mature bud and fruit gall were cut opened and diameter is measured using digital vernier caliper. One- Way ANOVA followed by post- hoc analysis (DMRT) test for varietal difference in five locations was used to assess the significance of the percentage of infestation by psyllid gall using SPSS software.

### 2.4 Biology of gall Insect in Bud and Fruit Gall

The regular observations on gall infestation started with the flowering period and continued till fruit dehiscence of *T. elliptica* trees in Sadivayal, Tamil Nadu. Developing galls were collected every two months from the early stage of gall induction till insect emergence to study the biology of gall insect in buds and fruit galls. The larval stages were observed under stereo binocular microscope (SMZT 10) and the sizes of each larval stages and adult psyllids from 20 galls were measured using stage micrometer.

## 3. RESULTS AND DISCUSSION

The present study documented the occurrence of gall infestation in the reproductive structures such as flowers and fruits as bud gall and fruit gall respectively on *T. elliptica* in the Western Ghat forest areas in addition to the gall occurrence in leaves. The insect inducing these galls in *T. elliptica* was identified as Psyllid *Trioza*

*fletcheri* minor Crawford (Hemiptera: Triozidae) which forms the leaf galls on the same host. This is the first report of *T. fletcheri* induced galls on flowers and fruits of *T. elliptica* recorded in Anamalai Tiger Reserve during 2021. Gall inducing psyllids showing host specificity and gall formation on various plant parts of the same host is reported previously as in- *Phylloplecta hirsute* (Crawf.) (syn. *Trioza hirsuta*) (Triozidae) induce gall infestation on various plant parts such as branch, bud, flower and fruits of *T. Paniculata* [5]. The flower galls in *T. arjuna* by the *Trioza hirsuta* which otherwise induce leaf galls was reported by Sokhi and Kapil [9]. Similarly, flowers and fruit galls formation in *A. scholaris* by *Pauropsylla tuberculata* was also documented by Chauhan et al, [8].

### 3.1 Gall Infestation Level in Various Study Areas

The percentage of bud and fruit gall infestation on *T. elliptica* tree populations infested by *T. fletcheri* in various study locations is given in the Tables 1 & 2. The gall infestation specifically on flowers as bud gall and on fruits was recorded separately. During the three year observation highest infestation was recorded during 2023. Although the percentage of bud gall infestation was higher than the fruit gall infestation in all the study locations, the intensity of gall infestation in general tends to increase during the study period in most of the locations. During the study period significantly high incidence of bud galls was recorded in Sadivayal forest area (65±6.91%) followed by Anamalai Tiger Resreve (51±3.91%) in Tamil Nadu and least infestation was recorded in Nilambur (29±4.54%) in Kerala. The infestation of fruit galls also showed a similar trend with high level of incidence (30.25±5.25%) at Sadivayal forest area, Tamil Nadu. However, only slight variation in the fruit gall incidence was recorded among three years of study other than Sadivayal.

**Table 1. The percentage of bud gall infestation in various study areas**

Location	2021	2022	2023
ANAIMALAI TR	33.25±4.03 <sup>d</sup>	45.00±5.09 <sup>d</sup>	51.00±3.91 <sup>d</sup>
SADIVAYAL	<b>39.25±5.37<sup>e</sup></b>	<b>59.25±4.03<sup>e</sup></b>	<b>65.00±6.91<sup>e</sup></b>
NILAMBUR	22.25±3.59 <sup>a</sup>	32.00±3.16 <sup>a</sup>	29.00±4.54 <sup>a</sup>
PARAMBIKULAM TR	28.00±2.16 <sup>b</sup>	38.75±6.44 <sup>c</sup>	48.00±6.48 <sup>c</sup>
RANNI	31.00±4.16 <sup>c</sup>	36.75±3.30 <sup>b</sup>	42.75±4.42 <sup>b</sup>

Values within a column followed by single letters (a, b, c, d, e) show varietal difference Duncans test

**Table 2. The percentage of fruit gall infestation in various study areas**

Region	2021	2022	2023
ANAIMALAI TR	19.25±3.71 <sup>b</sup>	<b>25.75±3.77<sup>e</sup></b>	22.00±2.16 <sup>d</sup>
SADIVAYAL	<b>27.50±5.97<sup>e</sup></b>	23.75±3.30 <sup>d</sup>	<b>30.25±5.25<sup>e</sup></b>
NILAMBUR	13.50±3.10 <sup>a</sup>	17.50±3.31 <sup>c</sup>	14.25±3.86 <sup>a</sup>
PARAMBIKULAM TR	22.25±2.62 <sup>d</sup>	17.00±3.16 <sup>b</sup>	21.50±6.24 <sup>c</sup>
RANNI	19.50±3.41 <sup>c</sup>	15.00±3.55 <sup>a</sup>	17.75±4.03 <sup>b</sup>

Values within a column followed by single letters (a, b, c, d, e) show varietal difference by Duncans test

### 3.2 Biology of Gall Inducing Psyllid *Trioza fletcheri*

*T. fletcheri* forms two types of galls such as bud and fruit galls during the early stage of fruit formation. The gall infestation is arising with the start of monsoon rain as the tree blooms. After mating the gravid adult females got attracted towards the flowers and laid eggs randomly in to the lower portion of ovary. Generally, the adult females of *T. fletcheri* lays about 200-500 eggs singly on host plant leaves in field condition [22]. The egg incubates for 48-72 hours and newly hatched larva crawls towards the fertilized ovary. The first instar larva starts to feed on the ovary tissues and stimulate gall formation by the secretion of cecidogen substances. Following the insect feeding, the changed chemistry in the tissues alters the cell differentiation process of fruit development and forms bud gall (Fig. 2) instead of normal fruit formation (Fig. 3). Ovule development is not occurring inside the bud gall and the inner lining of gall chamber is lined with modified parenchymatous tissues for supply nutrition to nymphal stage [23]. The late adult female psyllids emerge after the flowering season and deposits eggs on the surface of developing fruits which forms the galls on fruits (Fig. 4).

**Fig. 3. Uninfected fruits of *T. elliptica*****Fig. 4. Fruit gall****Fig. 2. Bud gall**

Numerous and multiple chambered galls are found on fruit galls (Fig. 5) while the bud galls are single chambered with single individual larva in each gall (Fig. 6). Bud galls are globose in shape; however, fruit galls are semi spherical in shape arising from the ovary of fruit. However, galls were not found occurring on wings of the fruits.

Mature bud gall measures about (10±3 mm) in diameter and fruit galls are comparatively smaller in size measures (7±3 mm). The bud gall is green colour in early form and changes to light brown colour which resembles the colour of bark of fruiting branches. The early fruit galls are greenish which match with the colour of normal



fruit and later becomes brownish as fruit matures. Development of larval stage occurs inside the gall chamber and passes through five nymphal instars to complete the life cycle (Fig. 7) and transforms to adult in 12 months (Figs. 8a & 8b). The measurements such as length and width of each larval instars were recorded from the average of 20 individuals given in the (Table 3).



**Fig. 5. Multiple gall chambers on fruit gall**



**Fig. 6. Single chamber on bud gall**



**Fig. 7. Nymphal stages of *T. fletcheri* (1st instar to 5th instar)**



**Fig. 8a. Adult *T. fletcheri***



**Fig. 8b. Live adult *T. fletcheri* Inside the bud gall**

The adult emergence took place only when the gall cavity ruptures as the bud and fruit galls imbibe water during the following rainy season (Fig. 9). This unique phenomenon is taking place due to the gall cavity wall thickness of bud and fruit gall. Normal fruits fall during March to April month while the gall infested buds and fruits remain in the tree as drupes until the monsoon rain. During this period the fifth instar larva undergoes diapause. Usually, *T. fletcheri* shows multivoltine in leaf gall and produce 6-7 generations a year whereas in the bud and fruit gall it exhibits single generation in a year. Anamika and Anantanarayanan, [7] reported the winter diapause and univoltinism in *T.jambolanae* which forms leaf gall on *Syzygium cumini* in Himalayan hill ranges, whereas it actually produce 6-7 generation in the same host in peninsular India. The psyllid *Trioza* sp. producing oval galls on peduncle and petioles of leaf and flowers of *Cinnamomum osmophloeum* took almost one year to complete the life cycle [24]. The leaf and stem gall infestation are also found in the similar trees in the study areas [25].



**Fig. 9. Bud gall absorb water and bursted**

**Table 3. Measurements of the nymphal instars of *T. fletcheri***

Life Stages of <i>T. fletcheri</i>	Length (mm)	Width (mm)
1 <sup>st</sup> instar nymph	0.667	0.405
2 <sup>st</sup> instar nymph	1.014	0.638
3 <sup>st</sup> instar nymph	1.567	1.09
4 <sup>st</sup> instar nymph	1.905	1.163
5 <sup>st</sup> instar nymph	2.357	1.193

#### 4. CONCLUSION

*Terminalia elliptica* is an economically important tree for hard wood timber, wild silk cultivation and also included in various afforestation programs in South India. This is the first report of *T. fletcheri* inducing gall on reproductive structures of *T. elliptica*. The new gall infestation in flowers and fruits of *T. elliptica* drastically reduces the reproductive capacity of the host tree. Recent climatic changing scenarios facilitate the ability of insect pest to thrive on host species by spreading the infestation to various plant organs and this drift averts the sexual reproduction of host plant and eventually affects the genetic diversity. The incidence of gall formation diminishes the production of good quality seeds for natural regeneration and also for nursery raising in afforestation programs. There is a chance of spread of this gall inducing psyllid on flowers and fruits of *T. elliptica* to other *Terminalia* populations in India and other countries and may become a serious threat in future. So, the standardization of suitable management measures is required to control the pest population before it becomes an epidemic.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models

(ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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