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Monitoring of seasonal flight activity of *Trioza fletcheri* Minor through yellow sticky traps at different spacing in *Terminalia arjuna*. (Roxb.) Wight & Arn. Plantation

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Abstract
Non-chemical management of *Trioza fletcheri* infesting *Terminelia arjuna* is one of the major challenges in Tasar culture considering the safety of Tasar silkworm *Anthereae mylitta*. In this study we have monitored the seasonal flight activity of *T. fletcheri* in *Terminelia arjuna* plantation at different spacing with the view of the fact that yellow sticky traps can be used for mass trapping of gall fly adults during their peak flight period. Results shown that yellow sticky traps found effective in trapping of the gall fly adults and it has been confirmed based on visual observations on the number of gall fly adults trapped across the different treatments and replications. During the study it has been observed that maximum gall fly activity was recorded between 28 to 32 metrological standard weeks. During the study influence of plant spacing on gall fly incidence was also assessed by comparing the activity of gall fly on different plant spacing and it has found that between the different plant spacing's 4′ x 4′ (Pollarded) plantations recorded highest gall fly incidence (76.28 gall flies/week/trap) which was followed by 4′ x 4′ (Pruned) with 62.42 gall flies/week/trap. Whereas comparatively lower gall fly activity was recorded in the 6 ′ x 6 ′ plant spacing (5.368 gall flies/week/trap) and 10′ x 10′ spacing (55.92 gall flies/week/trap). With respect to influence of pruning and pollarding on gall fly incidence it has been found that gall fly activity was more in the plantation where pollarding has been done as compared to the pruned plantation.

Keywords: Gall fly, yellow sticky trap, metrological standard weeks, pruned, pollarded and plant spacing

Introduction
Terminalia arjuna is the primary host plant of the Tropical Tasar silkworm *Antheraea mylitta* Drury in commercial sericulture. Silkworms feed on leaves during their entire larval period and utilize the leaf metabolites for the biosynthesis of silk. It is therefore clear that host plant plays a dominant role in cocoon production as a source of nutrition to the silkworms. However, foliage is prone to depredation by disease causing organism such as pathogens and pests. Among the several pests known to attack Tasar plants *Trioza fletcheri* Minor (Hemiptera-Psyllidae) has attained a serious status [1].

Trioza fletcheri is a subtropical plant louse, induces leaf galls on at least five species of *Terminalia* in the Indian subcontinent. Unlike a majority of gall-inducing psylloids that are generally host and site specific [2], *T. fletcheri* is known not only from the leaf galls of *T. tomentosa* and *T. arjuna*, but also from those of *T. catappa* Linn., *T. paniculata* Roth, and *T. tomentosa* X *T. arjuna* hybrids [3]. *T. fletcheri* completes its life cycle in 34 days, and the cecidogenetic process lasts 20-22 days, correlating with the developmental phases of the nymphal instars. Nymphal I instar initiate galls by settling on stomatal apertures of the host leaf, and the host plant responds by producing a covering growth enclosing the nymphal instars. Karyological study of the triozids raised independently from galls shows that the same species induces galls on both *tomentosa* and *arjuna*. In spite of that, probably due to genetic and physiological variation in host plants, subtle differences in the expression of mature gall form and production of trichomatous covering growth during early stages of cecidogenesis are evident. Largely, morphogenetic and metabolic responses within growing gall systems are identical. Shorter egg pedicels of *T. fletcheri* appear to be an evolutionary adaptation to the host plants of mesic distribution. Apart from direct damage it also causes the stress to plant

indirectly by reducing in photosynthesis rate, respiration rate and stomatal conductance [4]. Presently chemical management practice is the only option against this pest and this method is feasible for forest plantation but not for the plantation used for tasar culture. Since the use of insecticides is not commonly recommended in the tasar culture considering the safety of the silkworm. Due this barrier there is a need to find out the other alternative management options which are safer to the silkworms. Hence, the present investigation was undertaken to evaluate the effectiveness of yellow sticky traps in monitoring and mass trapping of gall flies, to understand the seasonal flight activity and to know the influence of plant spacing on *T. fletcheri* infesting *T. arjuna*.

Material and methods

The present study was conducted at Central Tasar Research and Training Institute, Ranchi, between March to September 2019. Commercially available yellow sticky traps were purchased from Rev Agro Services, Nashik, Maharashtra and used during the experiment. Size of the sticky card used for the assessment was 150 x 200 mm. Adult trapping study was conducted at three spacing *viz.*, 4′ x 4′, 6′ x 6′ and 10′ x 10′ ft plant spacing to know the flight activity and abundance of gall fly at different plant spacing. Similar observation was also recorded between the pruned and pollarded plantation at 4′ x 4′ spacing to know the influence of pruning and pollarding on the gall fly incidence. At each spacing yellow sticky traps were placed on three plants with one trap per tree when plants produced 4-6 leaves after pruning/pollarding. Sticky traps were tied to the stick with holes punched near the upper edge of each trap and it was installed at 4 to 4.5 m above the ground near the outer side of the canopy (Fig. 1). After the installation observation on number of gall insects trapped in each traps were recorded at weekly interval. During the study traps were replaced at every 15 days to avoid the miscounting and confusion in recording the data, since it has been observed that most of the trap surface was covered with gall flies and few other insects after 15 days of traps installment.

Fig 1: Experimental View depicting the trap installation and trap catches of gall fly adults

Result and Discussion

Results of sticky trap catches revealed that gall fly catch was ranged from 01 to 171.67 in 4′ x 4′ (Pruned), 1.67 to 146.33 in 4′ x 4′ (Pollarded), 6.33 to 175.67 in 6′ x 6′ and 2.0 to 134.33 gall flies/ week in 10′ x 10′ spacing. Among the different weeks of observations, in case of 4′ x 4′ plant spacing (pruned) highest gall fly incidence was recorded at 29th (171.67 gall flies/week/trap) meteorological standard week (MSW) which was followed by 31st and 28th MSW with 126.33 and 123.33 gall flies/week respectively. Whereas lowest gall fly incidence was recorded during 38th MSW (1.00 gall flies/week) and 37th MSW (2.67 gall flies/week). During remaining weeks of observation it was found that gall fly incidence was fluctuating between 14.67 to 109.67 gall flies/week (Table 1).

In comparison to 4′ x 4′ pruned plantations similar observations were made on gall flies incidence in 4′ x 4′ spacing pollarded plantation. Results on the activity of gall flies in this plantation showed comparatively higher gall fly activity. Across the different meteorological standard weeks in 4′ x 4′ pollarded plantation maximum gall fly activity was recorded at 31st MSW with 146.33 gall flies/week, 29th MSW (145.67 gall flies/week) and 32nd MSW (145.00 gall flies/week) and also during 17th and 19th MSW activity of gall fly found higher with 135.67 and 125.33 gall flies/week correspondingly. Whereas lowest population of gall flies were

recorded at the end of the season at 38th MSW with 1.67 galls weekly. While on remaining weeks fluctuating population was observed and it was ranged between 7.33 to 111.67 gall flies per week (Table 1).

Similar observations were made at 6′ x 6′ spacing plantation and it has been observed lowest mean gall fly activity (53.68 gall flies/week) among the different spacing's considered during the study period. However, overall observation throughout the different meteorological standard weeks revealed that weekly mean gall flies trapped was ranged from 6.33 to 175.67 gall flies per week. Between the different weeks of observation peak occurrence of gall fly was recorded at 29th and 30th MSW with 175.67 and 142.00 gall flies per week respectively. Whereas, lowest incidence was observed at 38th (6.33) and 37th (10.33) MSW. On remaining weeks moderate and fluctuating trend of incidence was observed (Table 1).

Likewise in another recommended plant spacing 10 x 10 ft, seasonal abundance of gall fly was ranged from 2.00 to 134.33 gall insect/week. Between the different weeks of observation peak period of occurrence was during 28th (134.33 gall flies/week) and 29nd (106.67 gall flies/week) MSW. Lowest gall fly incidence was observed during 38th and 39th MSW, whereas remaining weeks recorded middling gall fly incidence (Table 1).

Overall incidence of gall fly across the different weeks of observation found fluctuating in all the plant spacing's of *T. arjun.* However peak flight activity among the different plant spacings was observed between 28 to 32 MSW (Fig. 2). Increased activity of gall fly between 28-32 MSW might be due to the favorable weather conditions like optimum temperature, rainfall and relative humidity during this period. Since The population of *T. fletcheri* correlates significantly with temperature, relative humidity and rainfall [5] [6] [7] [8] [9]. On the contrary, availability of young and good quality foliage due to the rainfall during this period might have also enhanced the activity of *T. fletcheri*. Since biology of psyllids generally linked to young flush leaves of its host plants, as young flush is required for both oviposition and nymphal development [10]. Another possible reason might be high level of leaf volatiles from young foliage generally attracts the psyllids for oviposition [11]. Similarly due to the availability of more succulent young foliage during this period might have lead to augmented activity of *T. fletcheri* in *T. arjuna.*

With respect to influence of plant spacing on the incidence of *T. fletcheri* 4′ x 4′ (Pollarded) spacing plantations recorded highest gall fly incidence of 76.28 gall flies/week/trap which was followed by 4′ x 4′ (Pruned) plantation with 62.42 gall flies/week/trap. Whereas, comparatively lower gall fly incidence was recorded in 6′ x 6′ m and 10′ x 10′ plant spacing with 53.68 and 55.98 gall flies/week/trap (Fig. 3). Variation in the gall fly incidence between the different plant spacing might be due to the prevailing microclimate. Since many studies have shown that the orchards with closer spacing and varieties of dense foliage/inflorescence attract high pest population [12] [13].

During the present study we have also made the observation on effect of pruning and pollarding on gall fly incidence. Results shown that pollarded plants (76.28 gall flies/week/trap) were more preferred by the gall flies compared to pruned plants (62.42 gall flies/week/trap). Variation in the gall incidence between the spacing might be due to the existing microclimate, plant canopy size and availability of succulent foliage. However there are no relevant literatures available hence these results cannot be discussed further.

Present study also gives the clarity over usage of yellow sticky traps for monitoring and mass trapping of *T. fletcheri* in *T. arjuna*. During the study it has been observed that yellow sticky cards were efficient in attracting and trapping of large number of gall fly adults. Hence yellow sticky traps can be used against psyllids for mass trapping because psyllids are diurnal insects which respond positively to light reflectance patterns of its host plant and specifically to the reflectance of young expanding flush shoots [14], [15]. In light of the absence of any effective odorant for field population studies, yellow or lime-green sticky cards are currently the gold standard and most common method used for monitoring *of* psyllids like *Diaphorina citri* [16]. Among the different colored sticky traps yellow sticky traps are effective in trapping the eucalyptus gall wasp, *Leptocybe invasa* [17]. In similar way yellow sticky traps can be used in the tasar sericulture for monitoring and mass trapping of *T. fletcheri* infesting tasar silkworm food plant *T. arjuna.*

Table 1: Mean number of gall flies (*Trioza fletcheri*) trapped at weekly interval across the different plant spacing's of *Terminelia arjuna*

	Plant spacing (Ft)			
Meteorological standard week (MSW)	**4′ x 4′ (Pollarded)**	**4′ x 4′ (Pruned)**	**6′ x 6′ (Pruned)**	**10′ x 10′ (Pruned)**
13 (March 28)	17.00	46.00	25.33	29.44
14 (April 4)	24.67	47.33	28.66	33.56
15 (April 11)	40.67	72.00	42.55	51.74
16 (April 18)	55.33	40.33	37.22	44.30
17(April 25)	125.33	37.33	40.67	67.33
18 (May 2)	57.00	93.33	37.33	72.33
19 (May 9)	135.67	71.00	70.33	53.33
20 (May 16)	84.67	62.00	68.67	71.67
21 (May 23)	53.67	38.00	25.00	67.33
22 (May 30)	42.67	36.00	42.67	75.00
23 (June 6)	113.33	50.67	32.00	53.00
24(June 13)	102.33	55.67	45.33	66.67
25 (June 20)	88.33	57.67	47.51	75.33
26 (June 27)	74.33	89.33	46.44	72.67
27 (July 4)	97.67	73.33	46.12	61.67
28 (July11)	79.33	123.33	42.90	134.33
29 (July 18)	145.67	171.67	175.67	106.67
30 (July 25)	111.67	109.67	142.00	86.67
31 (Aug 1)	146.33	126.33	97.67	69.67

32 (Aug 8)	145.00	91.67	90.67	53.33
33 (Aug 16)	111.00	62.67	82.33	44.33
34 (Aug 22)	67.67	29.67	53.00	29.00
35 (Aug 29)	34.00	19.67	32.00	13.00
36 (Sept 5)	21.00	14.67	27.00	12.00
37 (Sept 12)	7.33	2.67	10.33	9.00
38 (Sept 20)	1.67	1.00	6.33	2.00
Range	1.67-146.33	1.00-171.67	6.33-175.67	2.00-134.33
Mean	76.28	62.42	53.68	55.98

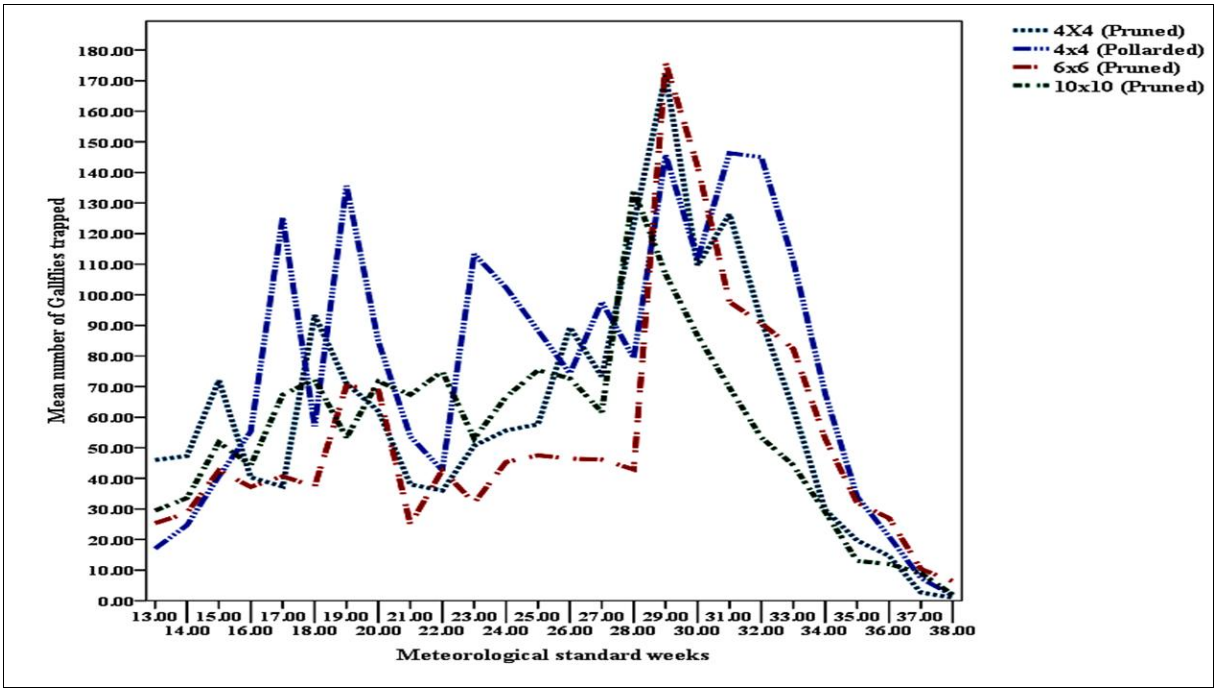

Fig 2: Seasonal flight activity of gall fly (*Trioza fletcheri*) across different plant spacing

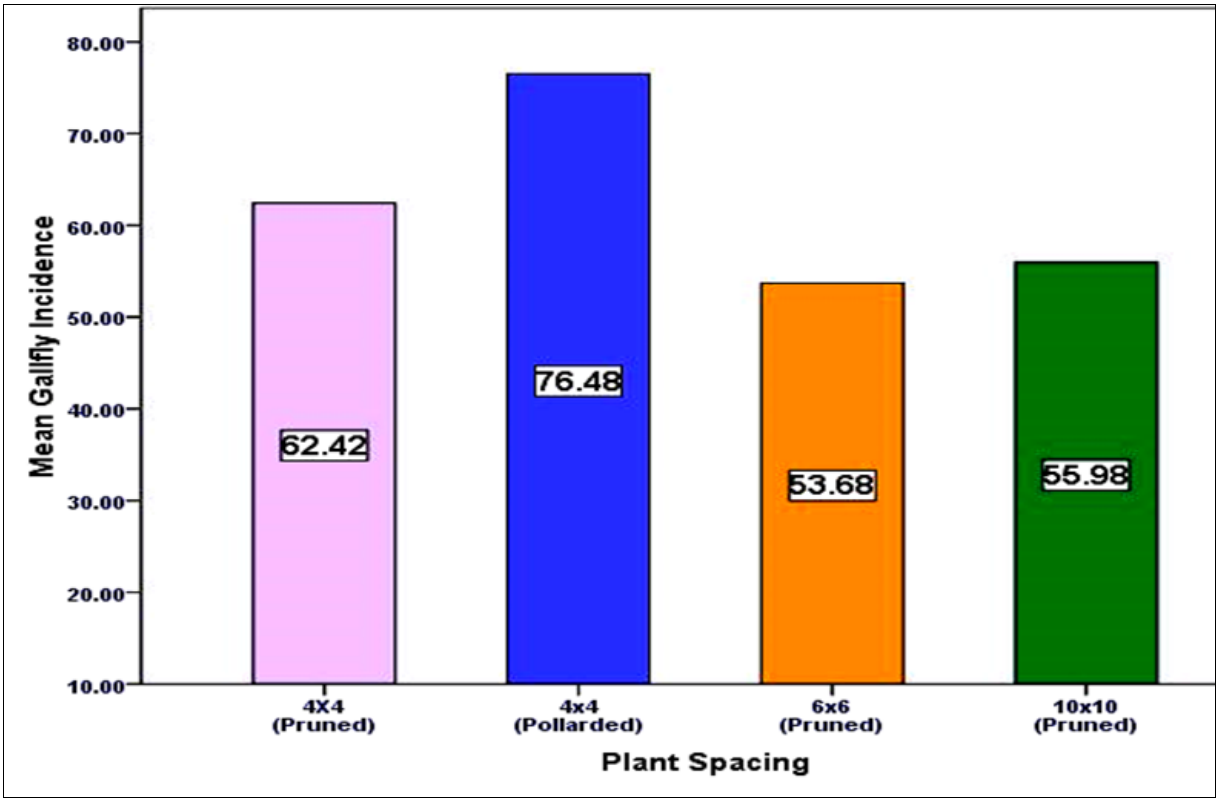

Fig 3: Seasonal mean number of *Trioza fletcheri* trapped on yellow sticky traps placed at different plant spacing of *Terminelia arjuna* across the metrological standard weeks

Conclusion

The study has come out with the finding that, maximum flight activity of the *T. fletcheri* in *T. arjuna* plantation is between 28-32 metrological standard weeks (July-Aug). During the study it was also observed that plant spacing, pruning and pollarding have the influence on the extent of gall fly incidence in *T. arjuna* plantation. In addition to these results present study also concludes that yellow sticky traps were effective in attracting and trapping of adults of *T. fletcheri.* Hence, considering the fact that Non-chemical management of gall fly infesting tasar silkworm food plants is one of the challenging tasks in view of the safety of the silkworm. So that yellow sticky traps can be effectively utilized for monitoring and mass trapping of the gall fly infesting the tasar silkworm food plants. Monitoring of the gall fly is critical for control decision making. Some of the control/management practices like collection and burning of infested branches, spraying of botanical insecticides, and low persistent insecticides can be timely initiated based on the monitoring of the gall fly. Apart from these mass trapping of the gall flies through yellow sticky traps also helps to manage this pest by reducing the population buildup.

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