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SEASONAL ABUNDANCE AND NATURAL PARASITIZATION OF GALL FLY (*TRIOZA FLETCHERI MINOR* CRAWFORD) ON ARJUNA PLANTATION IN SEEMANCHAL REGION OF BIHAR INDIA

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ABSTRACT

The psyllid, *Trioza fletcheri* minor Crawford is one of the most significant gall-forming insect pests infesting the leaves of *Terminalia arjuna.* The non-chemical management of *T. fletcheri*, presents a significant challenge in Tasar culture due to the need to ensure the safety of the Tasar silkworm. The present study, conducted in the arjuna host plantation garden at the Advance Centre on Sericulture, Kishanganj, from February to July 2024, identified *T. fletcheri* as the primary pest of *T. arjuna*. The pest first emerged in early March and persisting until August, with a peak population of 162.60 flies per trap in early July (27th standard week). This coincided with the highest foliar damage (74.80%) in mid-July (28th standard week). Correlation analysis revealed significant positive associations between gall fly populations, foliar damage, and both minimum temperature (r = 0.716**) and relative humidity (r = 0.670**). Natural parasitization of *T. fletcheri* by chalcid wasps initiated in May, peaking at 48.38% in July (28th standard week), with parasitization positively correlated with gall fly population (r = 0.863**) and foliar damage (r = 0.883**). Parasitization was also significantly associated with relative humidity (r = 0.761**), while non-significant relationships were observed with maximum temperature, minimum temperature and rainfall. Biotic and abiotic factors collectively accounted for 85 percent (R^2) of the overall variation observed in the gall fly population. This study highlights the impact of weather conditions on pest and parasitization dynamics in *T. arjuna*.
***Keywords* :** Arjuna, Gall fly, Chalcid wasp, Parasitization, Weather parameters

Introduction

Silk, cherished for its association with peace, truth, and virtue, holds a prominent place in ceremonial rituals and festive celebrations around the globe, particularly in India. This luxurious fabric is not merely a textile but a symbol of cultural heritage and tradition. India has witnessed substantial growth in the production of all four major varieties of silk: Mulberry, Eri, Tasar, and Muga. The leading producers of mulberry silk include Karnataka, Andhra Pradesh, Tamil Nadu, Jammu and Kashmir, and West Bengal, while Jharkhand, Chhattisgarh, Odisha, and the Northeastern states are prominent in the production of non-mulberry silk. During the fiscal year 2023-2024, India's total raw silk production amounted to 38,913 metric tonnes, with mulberry silk comprising 76.82% of the total, Eri silk contributing 18.45%, and Tasar silk making up 4.08%, according to data from the Central Silk Board, Ministry of Textiles, Government of India (Anonymous, 2023).

Tasar silk is primarily reared by rural indigenous communities who rely on naturally occurring food plants for cultivation (Reddy *et al.*, 2011). As the second largest non-mulberry silk produced in India, Tasar sericulture is a vital livelihood for over 1.5 lakh tribal people across 15 states, with significant activity concentrated in nine states (Gedam *et al.*, 2023). Tasar silk, is produced by the Tasar silkworm, *Antheraea* *mylitta* Drury, a species native to India that primarily feeds on Asan and Arjun plants. The Tasar silk moth, native to tropical India, is widely distributed and exhibits polyphagous feeding habits. This insect species displays significant population variation, with up to 44 identified eco-races. It primarily feeds on Terminalia arjuna, Terminalia tomentosa, and Shorea robusta (Yadav *et al*., 2022). Terminalia arjuna, commonly known as the Arjun tree, holds great cultural and economic importance in India and serves as the main food source for Tasar silk moths (Chander, 2018).

Host plants play a vital role in the sericulture industry, as the availability of high-quality leaves is crucial for successful silkworm rearing. The number of rearing cycles per year and the production of disease-free silkworm eggs per batch are greatly influenced by the availability of host plant leaves in a given area. Effective agronomic practices are necessary for cultivating quality leaves. The feeding preferences and host plant selection of silkworms are largely affected by the presence and distribution of secondary metabolites within plants. Host plants significantly affect silkworm survival, food consumption rates, digestion, and nutrient assimilation. The quantity and quality of leaves consumed by silkworm larvae influence various factors, including growth rate, larval duration, survival rate, and reproductive potential. It has been found that the quality of leaves directly affects silkworm growth, development, and overall silk production (Das *et al*., 2020). The Tasar silk moth mainly feeds on Terminalia arjuna, Terminalia tomentosa, and Shorea robusta (Yadav *et al*., 2022). Apart from its mythological and cultural importance, the Arjun tree provides numerous ecological, and medicinal benefits (Biswas *et al*., 2011). *T. arjuna* has medicinal and sericultural value. Its bark is cardio-protective (Dwivedi and Chopra, 2014).

However, Tasar silk production faces challenges from various pests attacking host plants, leading to significant losses ranging from 15 % to 90 % (Ankita *et al*., 2018). *T. arjuna*, is susceptible to various insect pests, starting from nursery to late age, that impact its health and productivity (Singh and Bhargawa, 2023). Among these pests, the gall insect, *Trioza fletcheri* minor Crawford is particularly notable for its significant impact on leaf quality. This insect creates galls on the leaves, affecting the primary food source of the Tasar silkworm (Singh *et al*., 2018). Routine pest management in sericulture commonly involves the use of pesticides as a preventive measure, irrespective of pest incidence (Mandal *et al*., 2024). The non-chemical management of *T. fletcheri*, presents a significant challenge in Tasar culture due to the need to ensure the safety of the Tasar silkworm. Biological systems in IPM strive to control pests by manipulating the interactions among organisms present on food plants, often through natural methods without relying on chemical pesticides. Biological control is highly effective, offering long-term protection and being environmentally friendly, making it particularly suitable for sericulture in India. Considering these facts, the present study focuses on examining the occurrence of gall fly and its natural parasitization in *Terminalia arjuna* plantations in Seemanchal region of Bihar.

Materials and Methods

The present study was conducted from February to July 2024 at the Advanced Centre on Sericulture in Kishanganj (26°15'59.1"N and 88°01'49.3"E), Bihar, to investigate the prevalence of insect pests and their natural enemies on *Terminalia arjuna* (Acc. 102). Gall fly incidence was specifically tracked using eight yellow sticky traps, placed when plants had 4-6 leaves after pruning (Fig. 1). Weekly observations were recorded, with traps replaced every 15 days. Additionally, the percentage of gall fly induced foliar damage (Fig. 2) was assessed by examining five randomly selected branches weekly. To assess natural parasitization in gall flies, 20 infested leaves per plant were randomly collected, totaling 100 samples every fifteen days, and brought to the laboratory to observe parasitoid emergence (Fig. 3). A destructive sampling process involved opening all galls with a sharp needle to identify different parasitoids as per Reddy *et al*. (2021). Parasitization was calculated using the formula: Parasitism (%) = [(Number of adult parasitoids emerged / (Number of host adult insects + number of parasitoids emerged)) × 100], as outlined by Van Driesche (1983). Correlation studies were conducted with weather variables to evaluate the impact of abiotic factors on natural parasitism rates of gall flies. Weather parameters like temperature, humidity, and rainfall were recorded to analyze correlations with insect dynamics following Chakravarty and Agnihotri (2017). Also, the multiple regression analysis was performed to examine the relationship between gall fly populations and biotic and abiotic factors, using both dependent and independent variables.

Result and Discussion

Gall fly incidence

The gall fly (*Trioza fletcheri*) was the first pest to infest *Terminalia arjuna*, emerging in early March and persisting until August (Table 1 and Fig. 2). This insect was the most significant gall-former on *T. arjuna* leaves. The population of gall flies ranged from 0.00 to 162.60 per trap, peaking (162.60 flies/trap) in early July (27^{th} standard week), which coincided with the highest recorded foliar damage at 74.80% (28^{th} standard week). Further, to understand the influence of weather parameters on the incidence of *T. fletcheri*, a simple correlation analysis was conducted (Table 2). The correlation analysis revealed a significant positive relationship between the gall fly population and both minimum temperature (r = 0.716**) and relative humidity (r = 0.670**) at the 0.01 level of significance. Additionally, a non-significant positive association was noted with minimum temperature (r = 0.046) and rainfall (r = 0.412). Further the foliage damage due to gall fly infestation also exhibited significant positive correlation with minimum temperature (r = 0.889**) and relative humidity (r = 0.596**) at the 0.01 level of significance, and rainfall (r = 0.464*) at the 0.05 level of significance (Table 2). This suggests that higher minimum temperatures and increased humidity were strongly associated with increased gall fly activity, emphasizing the influence of these weather parameters on the pest's population dynamics and its potential impact on *T. arjuna*.

These findings align with the results of Gadad *et al.* (2020), who reported peak gall fly activity between the 28^{th} and 32^{nd} meteorological standard weeks. Similarly, Mukherjee et al. (2016, 2017) also identified *T. fletcheri* as a significant pest affecting the primary food plants of the Tasar silkworm, particularly *T. arjuna* and *Terminalia tomentosa*. The present findings are also corroborated by Singhvi *et al.* (2009), who studied the population dynamics of the gall-forming psyllid on *Terminalia* species under conditions in Maharashtra. They observed that psyllid infestation occurred year-round, with intensity varying throughout the year. The highest infestation rates (20.76-24.25%) were recorded during June and July, while the lowest (0.84-1.96%) occurred from October to December. The infestation declined sharply during winter and began to increase again from March to April. Similarly, Das *et al.* (1998) reported that *T. fletcheri* infestation peaks in August at 62.32% and in July at 57.84% in *T. arjuna* plantations. Their study highlighted that gall infestation is influenced by climatic factors. Specifically, an increase in mean minimum temperature and mean relative humidity was associated with higher infestation rates in *T. tomentosa*, while a rise in mean minimum temperature alone significantly increased infestation in *T. arjuna*. These findings further support the significant role of climatic conditions in determining the population dynamics of gall-forming psyllids on *Terminalia* species.

Natural parasitization of gall fly

The parasitization of gall flies by chalcid wasps began in the 19^{th} standard week, with an initial parasitization rate of 4.26%. This parasitization continued through the 31^{st} standard week, reaching a peak parasitization rate of 48.38% during the 28^{th} standard week (second week of July) (Table 1 and Fig. 4). High levels of parasitization were also recorded in the following weeks, with 30.60% in the 29th week, 32.84% in the 30^{th} week, and 31.42% in the 31st week. Moreover, a significant positive correlation was found between the natural parasitization of *T. fletcheri* by chalcid wasps and the pest population collected through traps (r = 0.863**) as well as the associated foliar damage in the host plant (r = 0.883**) at the 0.01 level of significance (Table 3). The correlation between parasitization and weather parameters revealed a highly significant positive association with relative humidity (r = 0.761**, p<0.01), while a non-significant negative relationship was observed with maximum temperature (r = -0.541). Additionally, a non-significant positive association was noted with minimum temperature (r = 0.095) and rainfall (r = 0.676).

To investigate the combined effect, a multiple linear regression equation was constructed, including all biotic and abiotic factors, regardless of their individual contributions (Table 4). Through regression analysis a multiple linear regression equation for estimation of gall fly population (Y) as -47.98 + 1.76 (X_1) + 3.09 (X_2) +1.64 (X_3) was constructed. The prediction of the gall fly population based on the prevalent biotic and abiotic factors could suitably be achieved to the maximum extent of 85 per cent by following the developed regression model.

To assess the combined impact, a multiple linear regression equation was developed, incorporating all biotic and abiotic factors, irrespective of their individual contributions (Table 4). The regression analysis led to the formulation of a multiple linear regression equation for predicting the gall fly population (Y) as: -47.98 + 1.76 (X1) + 3.09 (X2) + 1.64 (X3). The prediction of the gall fly population based on the prevalent biotic and abiotic factors could suitably be achieved to the maximum extent of 85 per cent by following the developed regression model.

These findings align with the earlier study by Singh *et al.* (1995), who identified two hymenopterous parasitoids, *Trechnites secundus* and *Aprostocetus niger*, which target the nymphal stage of *T. fletcheri*. They also explored the potential of these parasitoids as biological control agents against the gall-inducing insect, highlighting their role in managing pest populations and reducing damage to the host plants. In a more recent study, Reddy *et al*. (2021) investigated the natural enemies of the psyllid bug *T. fletcheri* and found that *Trechnites aligarhensis* was the predominant parasitoid attacking *T. fletcheri*. The study revealed a higher incidence of *T. fletcheri minor* on *T. arjuna* (22.98% of leaves affected) compared to *T. tomentosa* (12.59% of leaves affected), with the peak incidence of gall formation occurring in August and September. The parasitization rate by *T. aligarhensis* was also higher on *T. arjuna* (33.13%) compared to *T. tomentosa* (24.92%). Similarly, Muthukumar *et al*. (2017) reported that two parasitoids, *Aprostocetus diplosidis* and *Bracon* sp., were associated with parasitized maggots of gall midges. Natural parasitization by these parasitoids was high during April and May, exceeding 80%, while the incidence of gall damage in shoots was relatively low, averaging 32.28% during these months. However, in the present study, braconids were not found parasitizing gall flies.

Conclusion

This study highlights the significant impact of gall fly on foliage of *Terminalia arjuna*, a key host plant in Tasar sericulture. Gall fly infestation peaked in July, with a strong correlation to higher minimum temperatures and relative humidity, indicating the influence of climatic factors on pest dynamics. The natural parasitization by chalcid wasps effectively reduced the gall fly population, with parasitization rates peaking at 48.38% in mid-July. These findings emphasize the potential of biological control as an eco-friendly pest management strategy, reducing reliance on chemical pesticides and safeguarding the Tasar silkworm ecosystem.

Table 1: Incidence of gall fly and its natural parasitization (%) on *T. arjuna* during February to August, 2024

Month	Meteorological Standard Week	Gall fly infestation		Percent natural parasitization of gall fly due to chalcids
		Mean no. of flies per trap	Foliar damage (%)	
February	6	0.00	0.00	0.00
	7	0.00	0.00	0.00
	8	0.00	0.00	0.00
	9	0.00	0.00	0.00
March	10	0.00	0.00	0.00
	11	2.40	0.00	0.00
	12	5.20	1.60	0.00
	13	5.60	2.00	0.00
April	14	4.80	12.60	0.00
	15	19.60	11.00	0.00
	16	25.40	30.80	0.00
	17	47.00	35.60	0.00
May	18	40.40	38.20	0.00
	19	37.60	33.60	4.26
	20	38.00	41.60	9.72
	21	62.40	53.40	13.68
	22	56.80	50.80	19.29
June	23	74.20	52.60	25.35
	24	89.60	61.00	16.22
	25	92.00	60.80	18.25
	26	120.00	65.60	22.67
July	27	162.60	62.40	28.46
	28	142.00	74.80	36.54
	29	114.60	72.00	30.36
	30	86.20	69.60	32.84
August	31	74.00	70.40	31.42

Table 2: Correlation between weather parameters and gall fly population on *T. arjuna* during February to August, 2024

Insect	Weather parameters			
	Temperature (°C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
Gall fly	0.046	0.716**	0.670**	0.412
Foliar damage due to gall fly	0.179	0.889**	0.596**	0.464*

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Table 3: Correlation between abundance of chalcid wasps with weather parameters and pest insect populations on *T. arjuna* during February to August, 2024

Natural enemy	Weather parameters				Pest insect population
	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	
	Maximum	Minimum			
Chalcid wasp natural parasitization on gall fly (%)	-0.541	0.095	0.761**	0.676	0.863** (with gallfly population) 0.883** (with foliar damage due to gallfly)

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Table 4: Multiple regression of gall fly population with biotic and abiotic factors

Coefficients	Parameters	Error	T value	P value	F value	R^2	Adj -R^2
(Intercept)	-47.98	23.72	-2.02	0.05*	42.37**	0.85	0.83
X_1	1.76	0.57	3.05	0.005**			
X_2	3.09	1.17	2.64	0.01**			
X_3	1.64	0.72	2.27	0.03*			
Regression Equation	$Y= -47.98 + 1.76 (X_1) + 3.09 (X_2) +1.64 (X_3)$						

Y: Gall fly, X_1: Percent natural parasitization of gall fly by chalcids, X_2: Minimum temperature, X_3: Rainfall, ** Significant at 1% and *Significant at 5%

Fig. 1: Yellow sticky trap installed in arjuna field to monitor the gall fly population

Fig. 2: Gall fly infested *T. arjuna* leaves

Fig. 3: Rearing of gall-infested leaves of Arjuna in the laboratory for the observation of parasitoid emergence

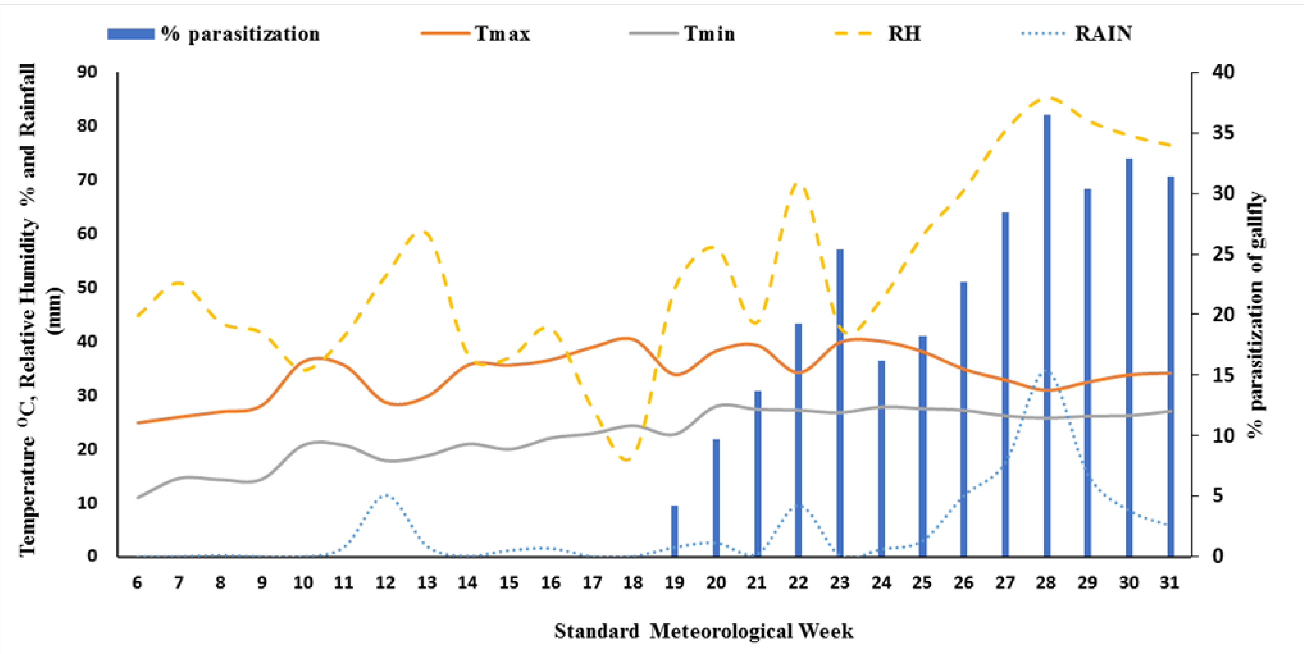

Fig. 4: Percent natural parasitisation of gall fly by chalcid wasp in *T. arjuna* during February-August, 2024

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