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Correlation and regression studies on incidence of leaf roller, *Diaphania pulverulentalis* (Hampson). (Lepidoptera: Pyralidae) in mulberry

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Abstract
The quality mulberry leaf and subsequent quality silk production is greatly hampered due to the incidence of defoliating insect pests. The maximum population buildup of the pest was recorded during September – October, 2017 with the incidence range of 35.67 to 40.12 per cent and July to September, 2018 (39.86 to 30.36 per cent). Further, the study revealed that, there was a linear relationship of the pest incidence with decreasing temperature and increasing relative humidity, under Chintamani conditions. Correlation analysis revealed that, there was a significant negative correlation between pest incidence with maximum temperature. All the other abiotic and biotic stress factors had a positive correlation with incidence of the leaf roller. However, multiple regression analysis revealed that none of these abiotic and biotic factors significantly influenced the population of leaf roller, *D. pulverulentalis* (Hampson) in mulberry.

Keywords: Regression studies, incidence, leaf roller, *Diaphania pulverulentalis*

Introduction
Sericulture is an integral part of the agrarian economy of India. It helps to improve the livelihood and socio-economic conditions of the farming community. At present about 86.04 lakh persons are employed in this sector and it is estimated that, an acre of irrigated mulberry provides employment throughout the year with an average net returns of around Rs 60,000 per year, which is significantly higher than the income from other crops (Kshama Giridhar *et al*. 2008) [5] India ranks second amongst silk producing countries next to China and contribute about 12 per cent of the global raw silk production with total raw silk production of 31, 906 MT and foreign exchange earnings of Rs. 1649.48 crores per annum. Mulberry (*Morus* sp.) is the sole food plant for sisslkworm, *Bombyx mori* L. and is a native of Himalayas. Currently it is being cultivated in more than 32 countries all over the world and in India the area under mulberry cultivation is 2, 23,926 acres (Anon., 2018) [1]. The production and productivity of mulberry is influenced by several factors. Which hinder the productivity as well as quality of silk cocoons and among them the incidence of pests and diseases are major biotic factors. In sericulture ecosystem, around 300 insect and non-insect pest species have been reported to be infesting the mulberry crop (Biradar, 1989) [3] of which, the defoliators are considered to be major, as they cause extensive damage to the mulberry. These defoliating pests cause around 12 to 25 per cent leaf yield loss either by depletion in nutritive value or through defoliation (Rajadurai *et al*. 1999) [9]. The mulberry leaf yield loss in Mysuru and Chamarajanagar districts due to *Diaphania pulverulentalis* (Hampson) was upto 30 per cent (Sengupata *et al*. 1990) [11]. Hence, mulberry leaf roller is considered as major insect pest of mulberry.
In Karnataka, the incidence of *D. pulverulentalis* (Hampson) on mulberry ranged from 0 to 100 per cent, being severe in winter months (October to February) and reduced to 0 to 30 per cent in summer months (March to June) and yield loss is around 30 per cent in Koppa, Mandya, Mysuru and Kanakapura Taluks (Siddegowda *et al*. 1995 [12] Rahmathulla *et al*., 2015) [8] The infestation and population build-up of a pest is influenced by weather parameters in addition to weather parameters; several natural enemies hinder the population buildup of leaf roller in the mulberry eco-system. Thirty seven parasitoids and six predators are known to naturally regulate the leaf roller at different life stages (Manjunath Gowda *et al*. 2005) [6] and ten entomopathogenic fungi were found to be minimize the incidence of leaf roller

(Srinivasa Gowda, 2000) [13] From this study an attempt has been made to understand the influence of abiotic and biotic factors on population dynamics of leaf roller throughout the year in Karnataka viz., Chikaballapur.

Material and Methods

The population dynamics was monitored at fortnightly intervals, by 'fixed plot method' as suggested by Govindaiah and Devaiah (1995) [4] in two locations *viz.*, Chintamani of Chikkaballapura district, the potential sericulture areas of Karnataka. In each place, V_1 mulberry garden was selected, with similar cropping pattern and divided into five micro plots measuring two sq. mt, fixed in the four corners and one in the centre of the garden. Totally 75 plants were randomly selected for recording the pest population (15 plants/micro plot). At the same time the population of the predators associated with in mulberry ecosystem were also recorded. Fifteen plants were chosen randomly from each of five micro plots and labelled. The number of leaf roller larvae present on the infested leaves of each plant was counted. Similarly, predatory population associated with mulberry ecosystem was counted and the intensity of pest attack was calculated by using the following formula.

$$\text{Pest (P) or natural enemies (NE) population number / plant} = \frac{P1 + P2 + \ldots\ldots P10}{\text{Total number of plants observed}}$$

Where P_1 to P_{10} and NE_1 to NE_{10} indicate the number of larvae/caterpillars and natural enemies present on the observed plants in sequential manner, respectively. Similarly pest incidence calculated by

$$\text{Percentage of pest incidence (PPI)} = \frac{\text{Number of infested plant}}{\text{Total number of plants observed}} \times 100$$

To determine the effect of weather parameters on the seasonal dynamics of leaf roller on mulberry, meteorological data of Chintamani area were utilized. Weather data (max. & min. temperatures, morning & afternoon relative humidities and rainfall), activity/abundance of predators and leaf roller population (as dependent factors) were subjected to correlation and multiple linear regression analysis to determine the overall influence of these factors (From September 2017 to February 2019) on the activity of leaf roller during the cropping period.

Results and Discussion

Population dynamics of mulberry leaf roller at Chintamani,

The observation during September 2017 to February 2019 regarding the population dynamics of leaf roller indicated that, during 2017, the incidence of leaf roller during September was 35.67 per cent, with pest population of 2.92 per single plant. And a remarkable increase in the pest incidence and peak leaf roller population was noticed in the month of October with 40.12 per cent, with a mean pest population of 2.80 per plant. Pest Infestation gradually declined over a period of time, this continued upto April-2018 1.58 per cent with pest population of 0.24 numbers per plant this might due to continuous dry spell during summer season. During January 2018, the pest incidence and pest population was 3.60 per cent and 0.32 per plant respectively and subsequently in the month of February iah2018 no pest incidence was observed (Fig.1) (Table 1).

Table 1: Mulberry leaf roller *D. pulverulentalis* infestation as influenced by abiotic factors at Chintamani

Year	Months	Meanpest incidence (%)*	Mean pest population (Number/Single plant)	Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm)
				Max.	Min.	Morning	Evening	
2017	September	35.67	2.92	29.58	19.92	73.80	70.50	194.60
	October	40.12	2.80	28.93	19.30	79.65	75.48	211.30
	November	18.36	1.40	27.59	16.75	77.07	74.30	16.80
	December	11.20	0.80	27.65	15.29	75.32	69.16	06.80
2018	January	03.60	0.32	28.85	15.01	74.00	59.03	00.00
	February	00.00	0.00	30.57	15.91	62.18	52.54	12.00
	March	00.00	0.00	33.65	17.91	51.32	40.35	00.00
	April	01.58	0.24	34.76	19.28	57.30	47.00	02.60
	May	21.35	0.80	37.37	20.55	62.16	55.77	123.80
	June	27.36	1.04	31.69	19.59	62.50	56.83	84.30
	July	39.86	3.0	30.52	18.68	77.61	67.74	132.80
	August	37.36	3.16	30.64	19.43	75.55	72.55	96.30
	September	30.36	2.40	31.14	19.93	71.03	66.93	81.80
	October	24.89	1.80	30.82	19.75	68.87	65.39	71.80
	November	13.20	0.76	29.43	18.49	67.90	63.00	12.90
	December	06.20	0.48	28.93	18.16	75.00	63.94	00.60
2019	January	08.80	0.60	29.00	16.28	68.74	54.55	12.08
	February	00.00	0.00	31.57	18.43	66.07	55.89	00.00

* Mean value from 2 fortnight observation.

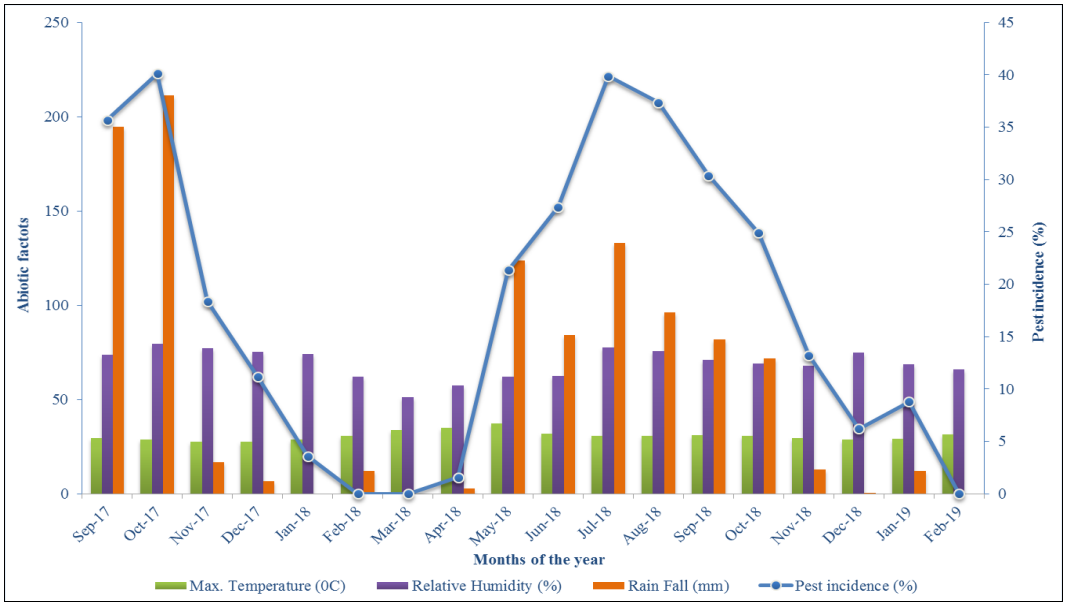

Fig 1: Incidence of mulberry leaf roller, *D. pulverulentalis* in relation to abiotic factors at Chintamani

Table 2: Mulberry leaf roller, *D. pulverulentalis* infestation in relation to predatory fauna at Chintamani

Year	Months	Mean pest incidence (%)*	Mean pest population (Number/ single plants)	Cryptolaemus montrouzieri (Number/ 75 plants)	Cheilomenes sexmaculata (Number/ 75 plants)	Spiders (Unidentified) (Number/ 75 plants)	Preying Mantids (Number/ 75 plants)
2017	September	35.67	2.92	04.00	19.00	1.00	11.00
	October	40.12	3.36	05.00	25.00	4.00	05.00
	November	18.36	1.40	00.00	09.00	00.00	09.00
	December	11.2	0.80	00.00	05.00	00.00	00.00
2018	January	03.60	00.32	00.00	03.00	00.00	03.00
	February	00.00	00.00	01.00	00.00	00.00	00.00
	March	00.00	00.00	02.00	02.00	00.00	03.00
	April	01.58	00.12	03.00	00.00	00.00	00.00
	May	18.30	0.80	01.00	07.00	00.00	02.00
	June	27.36	1.04	02.00	05.00	00.00	06.00
	July	39.86	3.12	05.00	24.00	3.00	08.00
	August	37.36	3.16	02.00	18.00	00.00	02.00
	September	30.36	2.40	04.00	19.00	00.00	06.00
	October	22.00	1.80	00.00	11.00	00.00	02.00
	November	10.32	0.76	03.00	05.00	00.00	03.00
2019	December	06.20	0.48	00.00	03.00	00.00	00.00
	January	08.80	0.14	05.00	02.00	00.00	00.00
	February	00.00	0.00	03.00	00.00	00.00	00.00

* Mean value from 2 fortnight observation.

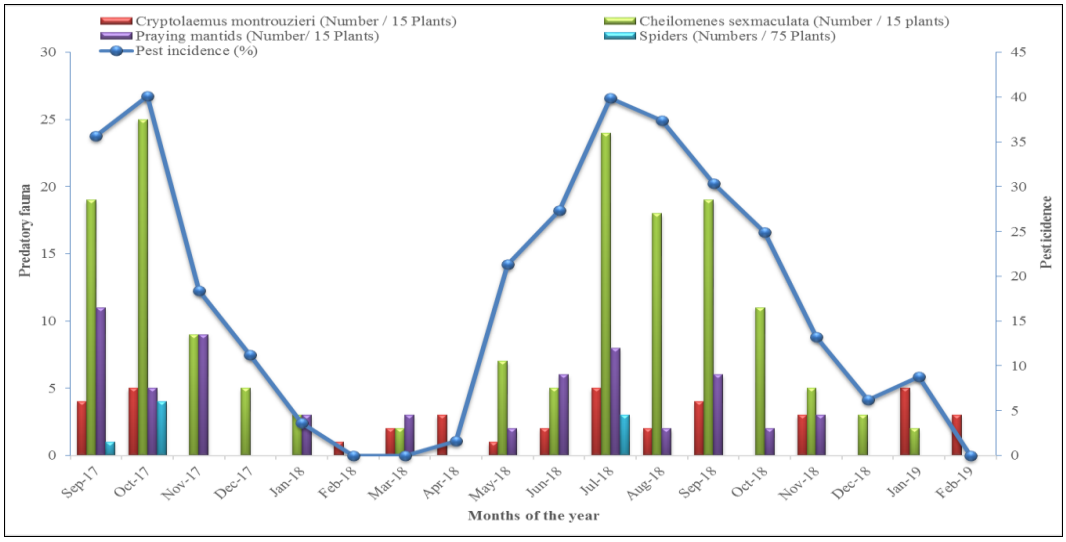

Fig 2: Incidence of mulberry leaf roller, *D. pulverulentalis* in relation to Predatory fauna at Chintamani

Plate 1: Incidence of Leaf roller *D. pulverulentalis* on mulberry

Table 3: Correlation and Regression analysis of *D. pulverulentalis* population with abiotic and biotic factors during 2017-19 at Chintamani.

Variables	Correlation	Multiple Regression
X_1 - Max Temperature	-0.449	-1.728
X_2 - Min Temperature	0.541*	1.321
X_3 - Morning Relative humidity (%)	0.530*	-0.284
X_4 - Evening Relative humidity (%)	0.749**	0.383
X_5 - Rain fall (mm)	0.844**	0.076
X_6 - Cryptolaemus montrouzieri	0.412	0.130
X_7 - Cheilomenes sexmaculata	0.981**	2.560
X_8 - Preying Mantids (Unidentified)	0.873**	0.119
X_9 - Spiders (Unidentified)	0.326	-2.766

**. Significant at 0.01 level.
*. Significant at 0.05 level.

Again an increase in the incidence was recorded during May (21.35 %) with a pest population of 0.80 per plant which could be attributed to onset of south west monsoon that led to increase in the atmospheric humidity, which was significantly positively correlated with pest incidence. Further leaf roller population went on increasing from June to September (30.36 %) with increasing larval population (2.40 per single plant) and peak infestation was recorded in the month of July (39.86 %) with a mean larval population of 3.0 per plant.

With onset of winter during 2017 and decline in rainfall, the incidence level further decreased from the month of October to December and this trend continued upto the beginning of 2019 and recorded minimum infestation and larval population during January (8.8 % and 0.60 per single plant respectively) and during February 2019 the pest incidence was absent (Fig.1) (Table 1).

Multiple regression model for leaf roller incidence with abiotic and biotic factors

Y (Leaf roller incidence) = 28.70 - 1.728 X_1 + 1.321X_2 - 0.284 X_3 + 0.383 X_4 + 0.076 X_5 + 0.130 X_6 + 2.560 X_7 + 0.119X_8 -2.766 X_9 ; $R^2 = 0.81R^2$.

The leaf roller population showed great variations in accordance with weather factors and predatory fauna observed during the study period. A negative correlation was observed between the population of leaf roller and maximum temperature (r = - 0.449), similar observations were also reported earlier by Rahmathulla *et al.* (2011) [7]. The correlation coefficient data indicated that, the pest population recorded very low or nil, when the temperatures rise during January to April. However, a significant positive correlation was recorded between the pest population and minimum temperature (r = 0.541*), morning relative humidity (r = 0.530*), evening relative humidity (r = 0.749*) and rain fall (r = 0.844*) (Table 3). This might be due to good rain fall during the months of June–October which leads to decrease the max temperature and increased relative humidity. This probably created a favourable micro - climate for growth and development of leaf roller due to increased availability of more nutritious and succulent leaves which favoured the population build-up of the pest and its predators as reported by Velavan *et al.* (2001) [14] and Samuthiravelu, *et al.* (2003) [10]. Peak leaf roller infestation occurs both during southwest and northeast monsoon periods and showed that rainfall and relative humidity were conducive for the multiplication of the pest (Bai and Marimadaiah, 2002) [2] The present study clearly revealed that, there is a linear relationship between decreasing temperature and increasing relative humidity coinciding with increased pest population under Chintamani conditions.

The correlation study indicated that, population build-up of leaf roller was positively correlated with population of predatory fauna. Among the predators, the population of *C. sexmaculata* (r = 0.981**) and mantids (r = 873**) were significantly positively correlated with an increase in the pest population (Table 2 and 3) (Fig.2). *C. montrouzieri* incidence was noticed even during the study period even though it is not a predator of leaf roller but its presence may be due to pest complex. However, multiple regression analysis revealed that none of these abiotic and biotic factors significantly influenced the population of leaf roller *D. pulverulentalis* activity under Chintamani conditions

Conclusion

During the study period of 2017-19, the overall influence of different weather parameters across Chintamani. Chikkaballapura district of Karnataka indicated significant (negative) influence of maximum temperature and positive influence of minimum temperature, morning relative humidity, evening relative humidity, rain fall and predators (coccinellids, mantids, & spiders) on the abundance as well as the activity of leaf roller. Abundance of pest was noticed especially in winter season *i.e.*, September – October, 2017 and rainy season *i.e*., June to August, 2018 and this clearly indicated that, the population dynamics of leaf roller was positively correlated with minimum temperature, rainfall and relative humidity both during rainy and winter seasons in Chintamani area of Chikkaballapura.

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