

Seasonal occurrence and damage caused by *Phycodes radiata* Ochseneimer (Lepidoptera, Brachodidae) on *Ficus* spp. in Uttar Pradesh, India

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ABSTRACT: A field study was conducted from 2019 to 2021 in the Saharanpur district of Uttar Pradesh to record the seasonal occurrence, infestation, and damage of the fig leaf roller, *Phycodes radiata* Ochseneimer (Lepidoptera, Brachodidae), simultaneously on four species host plants, *Ficus benjamina* L., *F. benghalensis* L., *F. glomerata* L. and *F. religiosa* Linn. During the three years, the peak density of *P. radiata* larvae was observed from March to August that declined gradually till December. Maximum larval population, infestation and damage were recorded on *F. religiosa* followed by *F. benjamina*, *F. glomerata*, and the lowest on *F. benghalensis*. The incidence of *P. radiata* larvae was observed on *F. benjamina* even in the month of January, while it was nil on other three host plants.

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KEY WORDS: *Ficus benjamina*, *F. benghalensis*, *F. glomerata*, *F. religiosa*, fig leaf roller

The fig leaf roller *Phycodes radiata* Ochseneimer (Lepidoptera, Brachodidae) was described by Ochseneimer in 1808 and has been considered as a sporadic pest of *Ficus* species (Moraceae). Its occurrence has been recorded in Pakistan, Afghanistan, Nepal, Sri Lanka, Myanmar, and parts of India, China, and Iran (Fletcher, 1917, 1919; Beeson, 1941; Wadhi and Batra, 1964; Nair et al., 1976; Kumar and Ramamurthy, 2010; Kallies, 2004; Kallies et al., 2011; Karim et al., 2010; Dhabi et al., 2021). Bajwa and Gul (2000) reported it on *Paulownia* sp. from Pakistan. The fig leaf roller is a pest of *Ficus* spp., whose larvae fold the leaf lamina with the help of silken thread and construct a leaf tunnel to feed inside. The larvae feed from the upper epidermis, parenchyma, and mesophyll

tissues of the leaves (Karim et al., 2010; Dhabi et al., 2021). *Ficus benjamina* L., *F. benghalensis* L., *F. glomerata* L. and *F. religiosa* Linn. have various medicinal as well as spiritual values in the Indian culture. These plants are attacked by a number of insect pests and *P. radiata* is one of them. In the present study, seasonal abundance, infestation and damage by *P. radiata* has been studied simultaneously on the afore said plants in Saharanpur of western Uttar Pradesh.

A monthly survey of the gardens, roadside plantations, and residential areas was conducted for three consecutive years from 2019-2021 in Saharanpur district, U.P., India to record the seasonal abundance of *P. radiata* on *F. benjamina*, *F. benghalensis*, *F. religiosa* and *F. glomerata*.

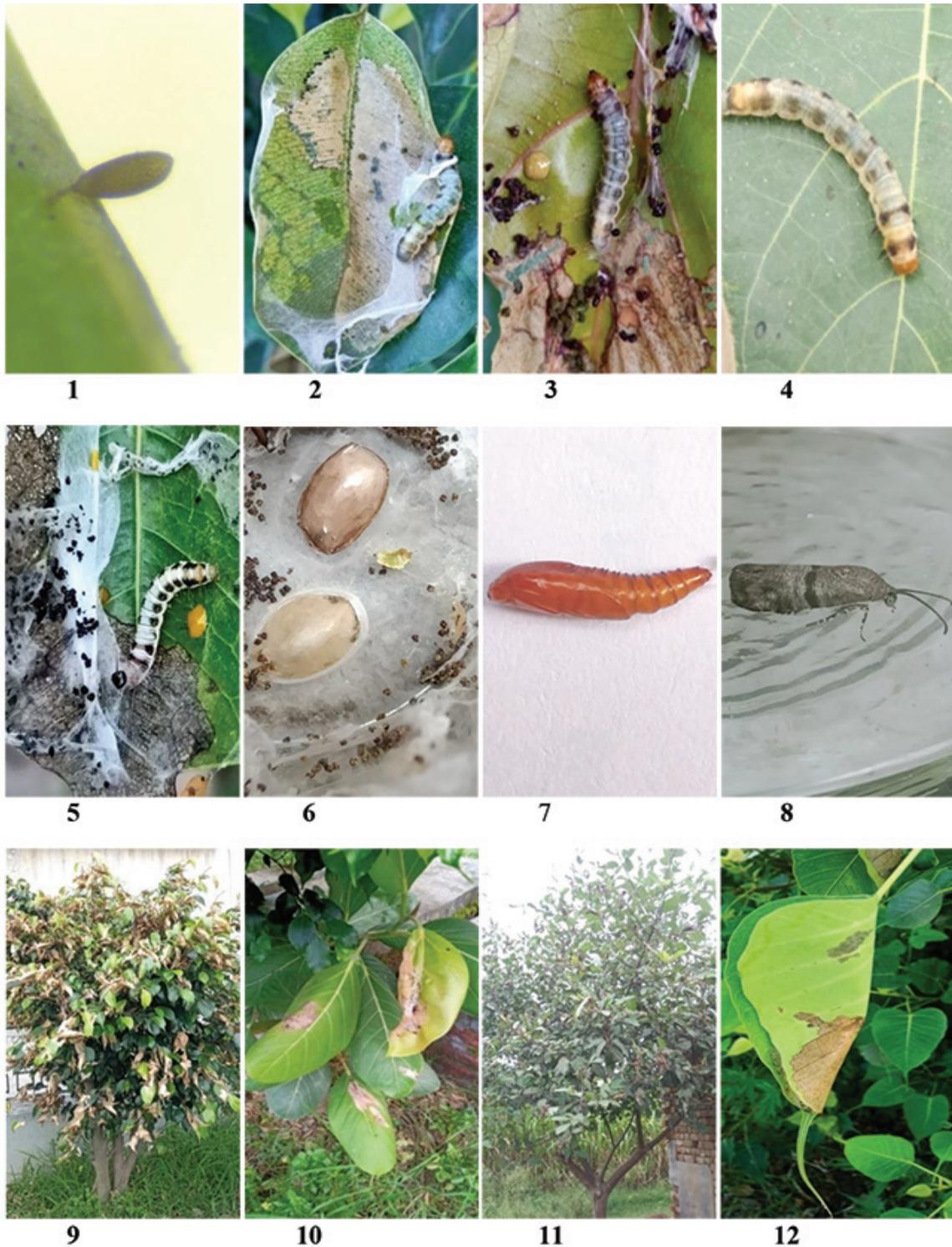
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The host plants of 5–10 years of age were selected for the study, and observations were taken monthly. The larvae were sampled and counted by visual observation as well as by removing the infested leaves from each host plant. In the case of large trees such as *F. religiosa* and *F. benghalensis*, the observations were taken randomly in the east, west, north, and south directions of the trees. Ten host plants were selected for recording observations on seasonal population, percentage of infestation, and damage per leaf. The percentage of infestation on each host plant was recorded by counting the infested leaves out of the total leaves on a plant, while the damage per leaf was recorded by observing the total leaf area eaten by the larvae. The observations were taken for three years on the same host plants to confirm the results. The seasonal population, seasonal occurrence, percentage of infestation, mode of feeding and damage per leaf of *P. radiata* larvae were recorded on each host plant in the field. Photographs of the eggs, larvae, pupae, adults, and damage on the host plants were taken with the help of a Dewinter stereoscopic zoom microscope and digital camera. Mean values and standard errors of the collected data were calculated and compiled using Microsoft Excel. The daily meteorological data like temperatures (°C), rainfall, and relative humidity (RH) were taken from HRI and Training Center, Saharanpur.

Seasonal abundance of *P. radiata*: Occurrence of *P. radiata* on four host plants was recorded from January to December during the year 2019, 2020, and 2021. In 2019, population of *P. radiata* larvae was recorded to be high on *F. benjamina* from March to August, which declined significantly from September to December. On *F. benghalensis* the larval population was comparatively lower than *F. benjamina*, *F. glomerata* and *F. religiosa* from March to August that declined gradually from September to December. In *F. glomerata* the number of larvae recorded was lower than *F. religiosa*. The larval population was observed to be nil on three host plants, *i.e.*, *F. benghalensis*, *F. glomerata* and *F. religiosa* in the month of January and February. The lowest population was observed

from September to December on all the four host plants (Table 1).

During 2020, the larval population was recorded to be reduced to some extent in comparison to 2019, but the peak population was recorded from March to August on all the four host plants. The lowest population was observed from September to December, and no larvae were found from January to February on *F. benghalensis*, *F. glomerata* and *F. religiosa* (Table 1). In 2021, the larval population increased on the all the four host plants in comparison to 2020. The maximum number of larvae was recorded on *F. religiosa* followed by *F. benjamina* and *F. glomerata*. No larvae were found on *F. benghalensis*, *F. glomerata* and *F. religiosa* from January to February except on *F. benjamina*. The minimum number of larvae was observed on *F. benghalensis* as compared to other three host plants. In 2021, the population observed generally lowest during the months of January, February, September, October, November and December on *F. benjamina* and the maximum was recorded from March to September. In the months of January and February, the larval population of *P. radiata* was recorded to be the lowest on *F. benjamina*, and nil on *F. benghalensis*, *F. glomerata* and *F. religiosa*. Along with temperature, rainfall and relative humidity the tender leaves are also an important factor for population buildup of any insect, which are required for egg laying females and feeding for immature stages. *Ficus benjamina* is an evergreen plant and tender leaves are almost available throughout the year, while in case of *F. glomerata*, *F. benghalensis* and *F. religiosa* the tender leaves appeared in the end of March and remain till the end of December. In January and February no tender leaves were found on *F. glomerata*, *F. benghalensis* and *F. religiosa*, hence, the population of *P. radiata* observed nil during these two months. Although, temperature, humidity and rainfall also play an important role in the rise and fall of insect population. Maximum temperature is favorably and strongly associated to population abundance, but the rainfall is adversely connected to insect population reduction (Table 1).



Figs. 1- Egg, 2, 3, 4 - Final instar larva feeding on *Ficus benjamina*, *F. benghalensis* and *F. glomerata*;
 Figs. 5 - Final instar larva feeding on *F. religiosa* leaf, 6 – Cocoon, 7 – Pupa, 8 - Adult of *Phycodes radiata*;
 Figs. 9, 10, 11, 12 - Infested leaves of *F. benjamina*, *F. benghalensis*, *F. glomerata* and *F. religiosa* respectively

Table 1. Seasonal population of *Phycodes radiata* larvae on *Ficus* spp. (2019-2021)

Month	Number of larvae per 10 host plants – 2019				Mean temp. (°C)	Rainfall (mm)	Relative humidity (%)
	<i>F. benjamina</i>	<i>F. benghalensis</i>	<i>F. glomerata</i>	<i>F. religiosa</i>			
January	2.11±1.02	0.00	0.00	0.00	11.5±0.89	104.77	55.90 ±8.54
February	1.57±1.01	0.00	0.00	0.00	25.1±0.68		69.35 ±8.91
March	39.80±1.28	30.20±1.25	36.80 ±1.10	40.20±1.12	31.4±0.91		53.25 ±13.16
April	40.50±1.30	33.50±1.40	38.50± 1.25	40.35±1.13	38.3±0.94	29.40	26.36 ±10.23
May	35.50±1.90	28.20±1.50	37.40±1.12	38.65±1.24	41.4±0.89		19.25±7.41
June	32.50±1.10	23.30±1.45	35.60±1.34	36.47±1.40	42.3±0.98		24.81±10.45
July	36.40±2.15	27.50±1.35	30.70±1.19	35.50±1.30	37.2±0.79	290.286	60.40±13.15
August	39.60±1.95	25.40±1.10	32.59±1.50	37.80±1.24	34.3±0.86		73.25±5.95
September	25.57±2.54	20.50±1.11	20.20±1.25	24.50±1.11	33.1±0.84		76.33±5.64
October	8.0±2.30	4.11±2.45	9.21±1.30	9.11±1.60	31.2±0.98	29	62.15±7.40
November	5.0±1.02	2.31±1.01	5.10±0.02	6.21±0.02	28.1±0.97		49.61±6.02
December	1.12±0.09	2.21 ±0.02	4.10±1.01	4.50±1.05	14.2±0.79		54.45±9.45
During the year-2020							
January	1.91±1.22	0.00	0.00	0.00	14.70±1.24	88.99	69.38±12.04
February	1.55±1.11	0.00	0.00	0.00	18.79±2.85		60.68±6.13
March	34.70±1.29	28.10±1.15	35.50 ±1.15	39.60±1.25	22.96±2.92		55.96±12.35
April	38.25±1.25	30.40±1.35	37.30± 1.27	38.95±1.30	31.7±2.40	38.77	28.16±6.25
May	33.40±1.82	25.22±1.40	35.50±1.16	37.85±1.28	37.06±2.97		22.70±9.45
June	30.31±1.15	20.20±1.31	33.90±1.24	35.90±1.45	38.23±2.84		33.13±8.89
July	35.51±2.20	22.40±1.25	29.30±1.39	33.40±1.35	35.29±3.12	249.143	52.32±11.38
August	38.82±1.87	23.50±1.15	31.69±1.41	38.70±1.28	31.32±2.18		74.32±9.33
September	27.59±2.51	17.40±1.20	22.25±1.35	23.60±1.15	31.40±1.10		62.28±9.26
October	7.21±2.25	3.10±1.16	7.80±1.25	8.19±1.50	29.67±1.46	13.06	60.83±9.30
November	3.51±1.11	2.80±1.11	5.60±1.30	7.29±1.12	22.96±2.55		34.64±8.52
December	1.10±0.08	1.08 ±0.02	5.10±1.01	6.50±1.02	18.70±3.05		39.16±6.56
During the year-2020							
January	1.75±1.02	0.00	0.00	0.00	13.60±1.22	18.23	68.77±12.40
February	1.87±1.01	0.00	0.00	0.00	19.78±2.35		61.10±6.11
March	39.91±1.21	31.16±1.28	37.10 ±1.17	40.35±1.15	23.94±2.62		56.41±12.40
April	40.25±1.20	30.40±1.45	38.50±1.22	39.98±1.27	30.71±2.12		29.90±6.27

May	36.56±1.96	25.70±1.41	37.39±1.12	37.89±1.27	36.32±2.86	78.94	23.90±9.63
June	34.53±1.15	23.30±1.45	35.80±1.44	35.84±1.34	39.35±2.25		32.22±7.79
July	37.30±2.19	25.80±1.35	28.79±1.18	36.89±1.35	34.15±3.34	283.88	53.56±11.21
August	38.70±1.82	26.30±1.15	30.69±1.42	38.83±1.28	30.41±2.31		72.90±8.42
September	23.42±2.44	19.56±1.13	22.21±1.15	24.24±1.13	28.50±1.32		61.25±8.29
October	6.71±2.21	3.11±1.05	8.91±1.25	9.15±1.21	26.47±1.55	22.80	59.81±8.45
November	5.5±1.12	2.31±1.01	5.35±0.02	6.15±1.02	23.36±2.86		35.68±7.55
December	2.15±1.19	2.21 ±0.02	4.70±1.01	4.73±1.06	15.56±3.15		40.18±7.58

Mode of feeding in early and late instar larvae and damage to the host plants:

The early instars are gregarious and preferred to feed on upper and lower surface of the young leaves inside the silken web and generally consume the entire tissue of leaf margin and leaf tip in circular way leaving a hole on the tip. Sometimes, they consume the half leaf from the tip side and fold the leaf lamina together to form a tunnel. Generally, a single larva was observed in a silken web. The second instar consumes the dorsal and ventral surfaces of the leaves, whereas the third, fourth, and fifth instars (Figs. 2-5) are solitary and forage on the dorsal side of leaves and spin a silken thread to fold the leaf lamina, and form a silken web for feeding within it. The infested leaves turned yellow, dried out, and faded away. During first year, 90 per cent infestation was recorded on an individual host plant of *F. benjamina* (Fig. 9) with 95 per cent damage per leaf. Maximum infestation was observed on *F. religiosa* (95±1.05% with 70.±0.955 % damage per leaf), followed by *F. benjamina* (90±1.20% infestation having 95±0.89% leaf damage) and *F. glomerata* (80±1.15% infestation with 85±0.99 % damage per leaf). The lowest was recorded on *F. benghalensis* (30±1.14% with 20±0.79% damage per leaf). The larva used silken web to bind the 2-15 infested leaves into a cluster that lasted on the host plant for a long period before falling off. Whereas, the host plant *F. religiosa* (Fig.12) was found to be heavily infected with 95 per cent infestation per plant and 70 per cent damage per leaf. The leaf lamina was completely folded and fastened by the larva. In most cases, 2-4 folded

and unfolded leaves were found interwoven together in a silken web. *Ficus benghalensis* (Fig. 10) had the lowest infestation among the four host plants, with a 30 per cent infestation and 20 percent damage per leaf, while the larvae infested *F. glomerata* (Fig. 11) up to 80 and caused 85 percent damage per leaf, and tied 2-6 leaves together in a silken web. Singh and Kaur (2017) also reported 70-80 per cent leaf damage on fig plants caused by *P. minor* and *P. radiata* in Punjab from July to September, while, Verma and Dogra (1984) reported it 15-20 per cent damage from Solan (HP).

During second year, the percent of infestation and damaged reduced to some extent and observed to be as (87±1.10, 90±0.84); (27±1.14, 18±0.75); (78±1.15, 80±0.94); and (90±1.05, 68±0.90) respectively on all four host plants. During 3rd year the percent of infestation and damage was recorded as (93±1.23, 97±0.91); (34±1.25, 24±0.92); (84±1.21, 87±0.93) and (97±1.12, 75±0.98) on *F. benjamina*, *F. benghalensis*, *F. glomerata* and *F. religiosa*, respectively. The adult moths (Fig. 8) of *P. radiata* are diurnal and generally found sucking nectar on the flowers of bitter gourd and bottle gourd of family Cucurbitaceae. Similar findings were also reported by Kumar and Ramamurthy (2010).

The larvae of *P. radiata* spin a web of silken thread for shelter, feeding, pupation, and protection from natural enemies. The larvae prepare a brown cocoon for pupation (Fig. 6). The silken thread is produced by the spinneret gland of the larvae. Moreover, on being disturbed, the larvae also show

wriggling movements and release a greenish or yellowish fluid (Figs. 3, 4) from its mouth to warn the predators. Wriggling movement could also help the larvae to escape from egg deposition of certain parasitoid wasps.

The study concludes that fig leaf roller *P. radiata* is a sporadic and considerable pest of *Ficus benjamina*, *F. benghalensis*, *F. glomerata* and *F. religiosa* in Saharanpur district. The activity of *P. radiata* commenced from first week of March and recorded maximum up to August on all four host plants. The population was recorded on peak in the last week of each month. During the three years, the maximum population of larvae was recorded on *F. religiosa*, *F. benjamina* and *F. glomerata*, while the minimum was observed on *F. benghalensis*. The maximum percent of infestation and damage per leaf was recorded on *F. religiosa* and the lowest on *F. benghalensis*. The larvae were found throughout the year on all four host plants except in January and February on *F. benghalensis*, *F. glomerata* and *F. religiosa*.

ACKNOWLEDGEMENTS

Thanks are due to Dr. S.C. Dhiman, (Former Professor and Head, Department of Zoology, Maharaj Singh College, Saharanpur) for scientific discussion during the study, Dr. Amit Dhiman (Asstt. Professor, Department of Botany, Purnamal Degree College, Gangoh, Saharanpur) for helping in the identification of the host plants, and Joint Director, HRI and Training Center, Saharanpur, for providing meteorological data.

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