



Record of seven new host-plants for *Phycodes radiata* Ochseneheimer (Lepidoptera: Brachodidae)

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Abstract

The fig leaf roller moth, *Phycodes radiata* is a sporadic and polyphagous pest known to infect various *Ficus* plants of the family Moraceae, causing significant foliar damage worldwide. The present study documents the discovery of seven new host plants for *P. radiata* through field surveys and laboratory investigations in urban and rural areas of western Uttar Pradesh, Haryana and Punjab states of India respectively. In the present study, *Ficus retusa*, *F. mysorensis*, *F. microcarpa*, *F. palmeri*, *F. rumphii*, *F. krisnae*, and *F. infectoria* were reported to be the new host plants for *Phycodes radiata* from Bulandshahr, Saharanpur, Meerut, Hapur, Muzaffar Nagar, and Baraut districts of western Uttar Pradesh, Haryana, and Punjab states of Northern India. *P. radiata* is a regular pest of these host plants that is active from January to November. The larvae tie the leaf lamina with silk thread and roll the leaves to feed inside. Maximum infestation and damage were recorded on *F. retusa* in all the study areas. Our findings expand the known host range of this pest and highlight the importance of continued monitoring and research to mitigate its impact on *Ficus* plants.

Keywords: Fig leaf roller, *Ficus retusa*, *F. mysorensis*, *F. microcarpa*, *F. palmeri*, *F. rumphii*, *F. krisnae*, *F. infectoria*, Host plants

Introduction

The fig leaf roller moth, *Phycodes radiata*, is a moth that belongs to the order Lepidoptera and the family Brachodidae. It was described by Ochseneheimer in 1808. Brachodidae is a family of day-flier moths, commonly known as little bear moths, which includes about 135 species distributed around the world (Edwards *et al.* 1999) [4]. *P. radiata* is found in Pakistan, Afghanistan, Nepal, India, Sri Lanka, China, and Iran (Kallies, 2004; Kallies *et al.*, 2010, Hamzeh *et al.*, 2010) [8, 9]. It is a sporadic, minor, and polyphagous pest of *Ficus* plants in the family Moraceae. Larvae of *P. radiata* are defoliators that fold the leaves and feed within it. In India, *Phycodes radiata* has been reported on several *Ficus* plants of the Moraceae family by Fletcher (1917, 1919), Beeson (1941), Wadhi & Batra (1964), Nair *et al.* (1976), Kumar and Ramamurthy (2010) [10], and Dhobi *et al.* (2021), but in present study it has been recorded simultaneously on seven new host plants of the family Moraceae. *Ficus krishnae* is known as Makhan katori and Krishna fig in Hindi; however Krishna butter cup in English because of its cup-shaped leaves (Balamurugan *et al.*, 2012) [2]. *F. krishnae* has traditional medicinal values for the treatment of various ailments such as cancer, leprosy, diabetes, skin diseases, anaemia, paralysis, ulcers, and liver diseases (Kumar *et al.* 2021) [11]. *F. microcarpa* is a sacred plant with spiritual significance and both medicinal and non-medicinal values. It has antibacterial, anticancer and antioxidant properties. *F. microcarpa* is used as traditional folk medicine to treat various diseases and disorders (Chan *et al.*, 2017) [5]. *Ficus infectoria*, known as Phikan or white Fig belongs to the family Moraceae. It is an important medicinal plant that is widely spread throughout the world. Aqueous preparations of *Ficus infectoria* fruits have high antioxidant and anti-inflammatory activities

(Mir, *et al.*, 2022) [13]. *Ficus mysorensis* is a species of fig tree native to India. The colourful bright orange-red fruit is used in India in winemaking and for jelly. In southern India, where it is native, it possesses religious significance. *Ficus rumphii* is a deciduous tree that has long been used to treat CNS disorders, diuresis, and hypothermia (Gupta, *et al.*, 2006) [6]. Extracts of leaves, bark, and root of *Ficus rumphii* exhibits anti-inflammatory activity (Singh *et al.*, 2021) [12]. *Ficus palmeri*, also called "Rock Fig," is a tree that grows in Central Mexico. It is tough and can survive in places where it doesn't rain a lot. *Ficus retusa/panda* is a large and extensively growing tree that belongs to family Moraceae. This tree has both medicinal and ornamental values (Semwal *et al.*, 2013) [14]. Although, *Ficus* plant spp. has medicinal and spiritual values. Despite this, they also serve as food plants for various insects. The present study aims to record the new host plants for *Phycodes radiata*.

Materials and Methods

Field survey for *Phycodes radiata*'s host-plants

The field survey was conducted in urban and rural areas of district Bulandshahr, Saharanpur, Meerut, Muzaffarnagar, Baraut, Yamuna Nagar and Chandigarh, where the *Ficus* plants were available abundantly. *Phycodes radiata* larvae were found to infest the foliage of the seven *Ficus* plants spp.: *Ficus retusa*, *Ficus mysorensis*, *Ficus microcarpa*, *Ficus palmeri*, *Ficus rumphii*, *Ficus krisnae*, and *F. infectoria*. To determine the host-plants for *P. radiata*, direct observations were made from 2021 to 2024 on the *Ficus* plants and documented using a camera. Immature stages of *P. radiata* were found to feed and infest on the leaves of seven *Ficus* spp. The host-plant species were identified with the help of plant taxonomist. Time of sampling and location were also recorded as supporting data.

Feeding test of *P. radiata* larvae

Except the infestation and damage of *P. radiata* larvae in natural conditions, the larvae were also tested to eat the leaves of the seven *Ficus* plants (*Ficus retusa*, *Ficus mysorensis*, *Ficus microcarpa*, *Ficus palmeri*, *Ficus rumphii*, *Ficus krisnae*, and *F. infectoria*) in laboratory at Department of Zoology, Maharaj Singh College, Saharanpur, Uttar Pradesh, India. The larvae were allowed to feed on the leaves of these plants for twenty-four hours, to conclude that these are the host-plants.

Field observations and data collection

The field observations were taken monthly throughout the year (January to December) on ten host plants of each *Ficus* spp. to record the seasonal abundance, percentage of infestation, mode of feeding, and damage to the leaves of *P. radiata* larvae on *Ficus retusa*, *Ficus mysorensis*, *Ficus microcarpa*, *Ficus palmeri*, *Ficus rumphii*, *Ficus krisnae*, and *F. infectoria*. The population of larvae was observed monthly and counted as number of larvae per ten host plants. The data were compiled using M.S. excel.

Results and Discussion

The results obtained in this study showed that the *Phycodes radiata* is a regular pest of (*Ficus retusa*, *Ficus mysorensis*,

Ficus microcarpa, *Ficus palmeri*, *Ficus rumphii*, *Ficus krisnae*, and *F. infectoria*) in district Bulandshahr, Hapur, Meerut, Muzaffarnagar, Saharanpur, and Baraut of western Uttar Pradesh, Yamuna Nagar and Chandigarh of Haryana and Punjab. The host plant of *P. radiata* from Moraceae family indicated that this pest is polyphagous herbivore insect in Northern India that attacks only on the *Ficus* plants. Occurrence of *P. radiata* on various host plant species is important for studying the biology and ecology of this pest which is the basis for integrated pest control.

Previously recorded hosts plants for *Phycodes radiata*

To our knowledge, the previously recorded host-plants for *P. radiata* from the family Moraceae are : *F. religiosa*, *F. urceolaris*, *F. carica*, *F. glomerata*, *F. racemosa*, *F. sur*, *F. benghalensis*, *F. benamina*, *F. benamina* L. var. *nuda*(Miq.), *F. tsiela*, *F. heterophylla*, *F. palmate*, *F. indica*, *Mimusop selengi*L, *Xanthium*, and *Paulownia* spp. from India, Sri Lanka, East Africa, and oriental region (Bajwa and Gull, 2000).

Present record

In present study it has been recorded on the following new host plants of the Moraceae family from different parts of India. Detailed information is given in table-2.

Table 1: List of seven new host plants for *Phycodes radiata* from the Moraceae family recorded from Bulandshahr, Hapur, Meerut, Muzaffarnagar, Baraut, and Saharanpur districts of western Uttar Pradesh, and Yamuna Nagar and Chandigarh of Haryana and Punjab, India

Lepidoptera family	Lepidoptera name	Host plant family	Name of the new host plants		Locations in U.P., India
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus retusa</i>	(Fig-2)	Bulandshahr
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus retusa</i>	(Fig-2)	Hapur
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus retusa</i>	(Fig-2)	Meerut
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus retusa</i>	(Fig-2)	Muzaffarnagar
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus retusa</i>	(Fig-2)	Baraut
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus retusa</i>	(Fig-2)	Saharanpur
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus retusa</i>	(Fig-2)	Chandigarh
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus retusa</i>	(Fig-2)	Yamuna Nagar
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus mysorensis</i>	(Fig-3)	Saharanpur
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus microcarpa</i>	(Fig-4)	Saharanpur
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus microcarpa</i>	(Fig-4)	Hapur
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus microcarpa</i>	(Fig-4)	Chandigarh
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus microcarpa</i>	(Fig-4)	Meerut
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus microcarpa</i>	(Fig-4)	Yamuna Nagar
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus microcarpa</i>	(Fig-4)	Muzaffar Nagar
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus microcarpa</i>	(Fig-4)	Baraut
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus microcarpa</i>	(Fig-4)	Bulandshahr
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus palmeri</i>	(Fig-5)	Saharanpur
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus krisnae</i>	(Fig-6)	Saharanpur
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus rumphi</i>	(Fig-7)	Saharanpur
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus infectoria</i>	(Fig-8)	Saharanpur
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus infectoria</i>	(Fig-8)	Nagar
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus infectoria</i>	(Fig-8)	Bulandshahr
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus infectoria</i>	(Fig-8)	Hapur
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus infectoria</i>	(Fig-8)	Yamuna Nagar
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus infectoria</i>	(Fig-8)	Chandigarh
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus infectoria</i>	(Fig-8)	Muzaffar Nagar
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus infectoria</i>	(Fig-8)	Baraut
Brachodidae	Phycodes radiata	Moraceae	<i>Ficus infectoria</i>	(Fig-8)	Meerut

Table 2: Seasonal population of *P. radiata* larvae on seven new host plants

Number of fig leaf roller larvae per ten host plants during the year-2022										
Months	<i>Ficus retusa</i>	<i>Ficus mysorensis</i>	<i>Ficus microcarpa</i>	<i>Ficus palmeri</i>	<i>Ficus rumphii</i>	<i>Ficus krisnae</i>	<i>Ficus infectoria</i>	Av. temp. (°C)	Rainfall (in mm)	Relative humidity (in %)
January	6±0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.53±0.91		54.75±7.58
February	8±0.42	0.00	0.00	0.00	0.00	0.00	0.00	24.12±0.69	101.51	66.45 ±6.92
March	28±0.67	20±0.89	22±0.94	26±0.91	22±0.98	28±0.77	15±0.94	29.44±0.96		51.36±5.23
April	30±0.69	22±0.74	25±0.97	29±0.74	24±0.71	30±0.81	17±0.96	37.21±0.91		26.36 ±7.31
May	32±0.73	25±0.75	28±0.86	32±0.78	25±0.89	33±0.99	20±0.94	40.29±0.85	25.61	16.79±6.75
June	30±0.89	22±0.78	30±0.98	25±0.76	22±0.74	27±0.98	18±0.76	41.45±0.88		22.85±8.36
July	33±0.87	26±0.99	33±0.99	34±0.98	29±0.93	38±0.99	25±0.78	35.94±0.82		59.95±7.35
August	35±0.92	29±0.89	35±0.98	36±0.88	32±0.97	34±0.98	27±0.81	32.85±0.82	262.275	71.36±6.86
September	24±0.85	14±0.76	23±0.96	27±0.78	23±0.99	26±0.79	16±0.98	30.15±0.81		74.78±4.96
October	12±0.78	7±0.69	11±0.97	11±0.89	8±0.78	10±0.87	6±0.63	29.86±0.88		61.35±6.42
November	7±0.78	3±0.63	5±0.82	4±0.69	3±0.70	5±0.72	3±0.95	26.12±0.95	25	47.95±5.85
December	4±0.97	0.00	0.00	0.00	0.00	0.00	0.00	13.21±0.79		51.95±8.55
Number of fig leaf roller larvae per ten host plants during the year-2023										
January	5±0.89	0.00	0.00	0.00	0.00	0.00	0.00	12.61±1.52		64.28±7.13
February	7±0.58	0.00	0.00	0.00	0.00	0.00	0.00	17.29±2.89	87.97	59.74±5.15
March	24±0.76	19±0.91	27±0.97	24±0.94	20±0.99	23±0.79	10±0.98	23.99±2.98		54.86±8.45
April	26±0.81	21±0.78	30±0.91	26±0.78	21±0.78	28±0.84	13±0.99	32.99±2.96		27.21±5.54
May	28±0.78	23±0.79	32±0.88	30±0.84	23±0.91	30±0.94	17±0.96	38.65±2.82	39.97	21.41±6.95
June	26±0.91	20±0.84	23±0.95	22±0.89	20±0.77	25±0.94	12±0.89	34.23±2.84		31.33±7.45
July	30±0.89	24±0.79	36±0.97	31±0.97	27±0.98	35±0.97	23±0.74	37.69±3.39		51.52±8.58
August	32±0.98	27±0.98	38±0.91	34±0.84	30±0.99	30±0.94	25±0.85	32.43±2.85	242.139	72.41±6.78
September	22±0.89	18±0.79	28±0.97	21±0.79	20±0.89	24±0.84	20±0.99	31.96±2.86		60.38±8.15
October	9±0.85	6±0.81	7±0.89	8±0.91	5±0.81	7±0.91	5±0.78	27.91±1.96		58.74±8.45
November	6±0.94	3±0.71	4±0.87	2±0.95	3±0.71	4±0.76	3±0.00	23.86±2.77	14.24	32.74±7.45
December	3±0.99	0.00	0.00	0.00	0.00	0.00	0.00	17.25±4.21		35.26±4.96
Number of fig leaf roller larvae per ten host plants during the year-2024										
January	7±0.82	0.00	0.00	0.00	0.00	0.00	0.00	11.69±1.22		67.87±8.35
February	9±0.53	0.00	0.00	0.00	0.00	0.00	0.00	18.88±2.35	20.28	60.21±5.25
March	26±0.69	22±0.91	35±0.98	29±0.95	27±0.89	25±0.84	18±0.98	22.84±2.62		56.41±8.40
April	30±0.72	26±0.89	39±0.99	32±0.78	30±0.87	27±0.82	21±0.91	31.79±2.14		27.82±5.32
May	32±0.81	28±0.79	41±0.89	37±0.85	35±0.91	30±0.95	24±0.97	34.42±2.95	80.84	23.98±8.55
June	30±0.91	26±0.84	34±0.89	27±0.79	30±0.95	25±0.97	20±0.78	38.25±3.85		30.12±9.85
July	34±0.89	29±0.98	44±0.98	38±0.89	36±0.98	31±0.89	26±0.86	35.25±3.34		54.32±8.25
August	38±0.94	31±0.98	47±0.98	41±0.95	39±0.89	35±0.79	30±0.88	31.75±2.39	273.89	71.51±6.32
September	28±0.87	14±0.78	35±0.94	31±0.89	29±0.95	26±0.87	24±0.88	27.85±1.39		63.35±6.85
October	14±0.86	7±0.86	20±0.89	15±0.93	14±0.88	12±0.94	9±0.79	24.87±1.59		57.21±7.55
November	8±0.81	4±0.79	10±0.88	7±0.86	6±0.78	6±0.98	4±0.98	21.26±2.89	22.80	34.18±5.45
December	4±0.97	0.00	0.00	0.00	0.00	0.00	0.00	14.86±3.19		30.28±7.58



Fig: (1) Egg (2) Larva of *Phycodes radiata* feeding on the leaf of *Ficus panda* (3) *Ficus mysorensis* (4) *Ficus microcarpa* (5) *Ficus palmeri* (6) *Ficus Krisnae* (7) *Ficus ramphii* (8) *Ficus infectoria* (Photo courtesy: Dr. Om Datta, Head of Zoology Department, Maharaj Singh College, Saharanpur)

Seasonal occurrence of *Phycodes radiata* larvae

Phycodes radiata is a seasonally active polyphagous pest. The female moth laid elongated and brown eggs singly on the new flush of the leaves. The eggs hatched after an incubation period of 6.80 ± 0.70 days. The newly hatched larvae are yellowish brown and become darker later. The larvae of *P. radiata* were recorded to be available from January to December, on *Ficus retusa* being the most abundant from March to August, which declined significantly from September to December. On *F. mysorensis* and *F. infectoria*, the larvae of *P. radiata* were observed from March to September, while on *F. microcarpa*, *F. palmeri*, *F. rumphii*, and *F. krisnae*, they were recorded to be available from March to November. The maximum population of larvae was recorded from April to August and declined gradually from September to December. The larval population was observed to be nil on *F. microcarpa*, *F. palmeri*, *F. rumphii*, *F. mysorensis*, *F. infectoria*, and *F. krisnae* in the months of January and February. The lowest population was observed from September to November on all seven host plants. No larvae were found in the month of December except on *F. ritusa* (Table-2).

Feeding behavior in early and late instars

The early instars are gregarious and prefer to feed on the upper and lower surfaces of young leaves inside the silken web and consume the entire tissue of the leaf margin and leaf tip in a 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 first instars are gregarious and feed on the lower surface of leaves, primarily targeting mesophyll tissue. The second instar feeds on the upper and lower surfaces of the leaves within the silken webs, as well as the mesophyll and lower epidermis, leaving the dorsal epidermis unharmed. The later larval instars, viz., the third, fourth, and fifth, feed solitary on the dorsal surface of the leaves and spin a silken thread to fold the leaf lamina and make a silken web to feed within the leafy tunnel. Infested leaves turned yellow, dried out, and faded away over time.

Feeding behavior in adults of *P. radiata*

The adult moths of *Phycodes radiata* are diurnal and found sucking nectar on the flowers of bitter gourds and bottle gourds of the family Cucurbitaceae. (Kumar and Ramamurthy, 2010) [10] also observed the adults feeding on the flowers of the bitter gourd and bottle gourd.

Defence behaviour in the larvae of *P. radiata* from natural enemies

The labial glands of most Lepidopteran larvae release fibrous proteins that are collectively known as silk. The larvae of *P. radiata* also release silk, which is used to spin a web of silken thread for shelter, feeding, pupation, and protection from natural enemies. All stages of larvae produce silken thread from their spinneret gland. Moreover, upon being disturbed, the larvae also show wriggling movements and release a greenish-yellowish fluid from the mouth to warn the predators. The

wriggling movement also helps the larvae escape the egg deposition of certain parasitoid wasps.

Discussion

However, host plant records for *P. radiata* are already documented from *Ficus* genus of the family Moraceae. Here we present the record of *Phycodes radiata* associated with seven new host plants of *Ficus* genus (Moraceae) from Bulandshahr, Saharanpur, Hapur, Meerut, Baghpat, Muzaffarnagar, and Baraut districts of western Uttar Pradesh, Haryana and Punjab states of India. To the best of our knowledge and review of literature, *Ficus retusa*, *F. microcarpa*, *F. mysorensis*, *F. palmeri*, *F. rumphii*, *F. krisnae*, and *F. infectoria* are the new host plants for *Phycodes radiata* that have been first time identified and recorded. Host plants are those plants that support the life cycle of another organism by acting as a food source, habitat, breeding site, or place. Herbivorous insects' fecundity is largely determined by the quality of their host plants. The quality of the host plant, including its defence metabolites, carbon, and nitrogen content, directly influences the potential and actual fecundity of herbivores (Awmack and Leather, 2002) [3].

A phytophagous (herbivorous) insect needs to find a host plant in order to meet its nutritional needs and locate an appropriate place to lay its eggs. Even though the host plants are frequently hidden among a variety of other plants, insects are still able to find them (Bruce *et al.*, 2005) [16]. The host plants play an important role in the survival of immature and adult stages of the insects.

The report of seven new host plants for *P. radiata* underscores the broad host range and adaptability of this pathogen. These findings have implications for management strategies of this pest, as the inclusion of these new host plants in surveillance and control programs will be necessary to effectively manage *P. radiata* infestations. Further research is warranted to elucidate the mechanisms underlying host specificity and pathogenecity of *P. radiata* on these newly identified hosts.

Conclusion

In conclusion *Phycodes radiata* is a considerable polyphagous and sporadic pest of the *Ficus* species of the Moraceae family which cause significant damage to the foliages of the host plants *F. retusa*, *F. mysorensis*, *F. microcarpa*, *F. palmeri*, *F. rumphii*, *F. krisnae*, and *F. infectoria*. The field observations revealed that *P. radiata* attacks on these ornamental and medicinal plants grown in gardens, horticulture gardens, educational institutes, forests, and roadside plantations in urban and rural areas of northern India. Our study expands the known host range of *P. radiata* to include seven new plant species. These findings contribute to our understanding of the epidemiology and ecology of this pest and emphasize the importance of continued surveillance and research efforts to mitigate its impact on *Ficus* plants.

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