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Life Cycle and Population Dynamics of Amphutukoni Muga (*Cricula trifenestrata* Helfer)

Parashpriya Borah [a], Abhigyan Rajkhowa [a], Dipankar Brahma [b*], Dhanalakhi Gogoi [a], Th. A. Singha [a], Nanita Bora [a] and Nilav Ranjan Bora [b]

[a] *Department of Sericulture, Assam Agricultural University, 785013 Jorhat, Assam, India.*
[b] *Department of Sericulture, Forest College and Research Institute, TNAU, 641301 Mettupalayam, Tamil Nadu, India.*

Authors' contributions

This work was carried out in collaboration among all authors. Author DG did the conceptualization, formal analysis, resources, supervision. Author PB did the methodology, investigation. Author TAS did the software. Author NB did the validation. Authors AR and NRB did the data curation. Author DB did the writing—original draft preparation, review and editing. All authors read and approved the final manuscript.

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ABSTRACT

The study investigates the population dynamics and impact of the *Cricula trifenestrata* Helfer (Amphutukoni Muga) on the Som plant (*Persea bombycina* King.) in Jorhat district, Assam, India. Muga silk, known for its unique golden luster, is endemic to Assam's sericulture industry. However, infestations by *C. trifenestrata* threaten its silk production. Field observations from March 2020 to

**Corresponding author: Email: dipankarbrahma121@gmail.com;*

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March 2021 found that the pest population peaked in January 2021, with significant leaf defoliation, particularly of terminal branches, rendering the plants unsuitable for Muga silkworm rearing. The mean infestation rate escalated from July 2020 (20.00 ± 0.00%) to January 2021 (85.00 ± 7.07%), with a corresponding increase in damage extent from 15.25 ± 2.47 pests per plant to 68.36 ± 2.42 pests per plant. Cocoon formation predominantly occurred in January, with the highest count being 21.48 ± 10.27 cocoons. This study underscores the necessity for timely management of this pest to mitigate the loss due to *C. trifenestrata* infestation. Understanding the relationship between pest population dynamics and meteorological factors is essential for developing integrated pest management strategies.

Keywords: Cricula trifenestrata; Muga silk production; pest infestation; Som plant; integrated pest management.

1. INTRODUCTION

The sericulture industry in Assam is deeply rooted in local traditions and customs. Due to region's favorable climate, Assam produces the four commercially used types of silk viz., Muga, Eri, Oak and Tasar, which are endemic prerogatives and falls under the category Vanya silk (wild) [1]. Among these, Muga silk holds a special place as it is unique to India. This rare fiber has a captivating natural golden color, giving it a lustrous appearance and making it highly coveted and expensive. The production of this golden silk is exclusive to the North-East region, particularly the Brahmaputra valley, adding to its prestige and value. The Muga silkworm, growth and development are influenced by abiotic factors such as temperature, humidity, precipitation and light. However, the practices of rearing outdoors expose these valuable insects to a multitude of organisms. Environmental fluctuations throughout the year can lead to outbreaks of disease and insect pest infestation and thus affects productivity [2].

Muga silkworm feeds polyphagously particularly on Som (*Persea bombycina* King. syn. *Machilus bombycina*) and Soalu (*Litsea polyantha* Kost. syn. *Litsea monopetala*). However, this silkworm also feed on some secondary host plants like Dighloti (*Litsea salicifolia*) and Mejankori (*Litsea cubeba*). Most of the Muga silkworm's food plants are perennial tree in nature and available in a wide range geographical region in Northeast India [3]. One of the main factors causing yield loss in silk production is infestation of insect pest of host plants for silkworms. The host plants of the Muga silkworm are attacked by many types of harmful insects. An important step has been taken by Choudhury (1982) and Thangavelu (1988) to record pests and the type of damage caused by Muga food plant pests [4]. Among the many harmful insects that attack the Som plant are wild saturniids. This includes the silkmoth *Cricula trifenestrata* Helfer (Saturniidae: Lepidoptera), locally also called “Amphutukoni Muga”. It is considered one of an important defoliator and habitat from lowlands to high plateaus at over 2000 m altitude in Meghalaya, Assam, Tripura and West Bengal [5]. *Cricula trifenestrata* is polyphagous and is usually seen on the wing around August, with a possible second brood during August to September. The *Cricula* silkworm goes through several phases throughout its life. It starts with the eggs that female butterflies lay. When the eggs hatch, small larvae (caterpillars) emerge and begin feeding on the leaves [6]. The caterpillars eat the entire leaf blade, with the exception of the midrib, appears strangely broom-like preventing the muga silkworm from being raised successfully [7]. As the larva grows, it eventually wraps a cocoon around itself for protection. In this cocoon the larva transforms into a pupa. After a while, the adult insect emerges from the cocoon. The adult butterflies then mate and the cycle begins again when the female lays new eggs. Although *C. trifenestrata* is considered a serious pest of the Som plant, however, there is little information available about *C. trifenestrata* in the state of Assam. Timely control of this pest before reaching the economic threshold level (ETL) is the need of the hour to save muga silk production in the Assam. Considering these facts, the present study was conducted to study the type of damage, occurrence and population growth of *Cricula trifenestrata* on the Som plant and its relationship with meteorological factors.

2. MATERIALS AND METHODS

2.1 Study Sites

The field studies were conducted in the Som plantation located in different farms within Jorhat

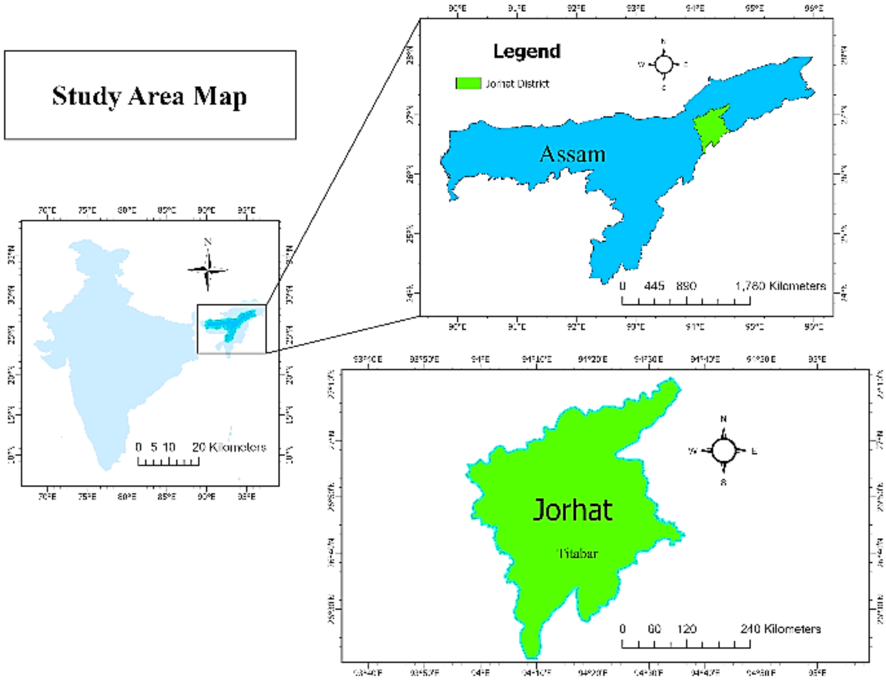

Fig. 1. Study area map of Jorhat district

Fig. 2. Field Laboratory of CMER&TI, Titabar (a), Tamulbari Farm, Titabar (b)

district (26°44'N and 94°10'E) (Fig. 1). Observations were made at 15-day intervals from March 2020 to March 2021 at different Som plantation of Jorhat district and neighbouring areas, resulting in two observations per month (Fig. 2). The average of these two monthly observations was used for the final assessment.

2.2 Life Cycle

2.2.1 Nature of damage

The nature of damage of the pest was studied and recorded carefully on randomly selected 10 Som plants at 15 days interval from the different muga plantation farm of Jorhat district and neighbouring areas.

2.2.2 Population build up

The population build up by the pest was recorded by counting the number of insects present on four branches per plant from 10 randomly selected plants. Four infested branches from each plant from each direction would be selected and the number of insect (*Cricula trifenestrata* Helfer) present in each branch were counted.

2.2.3 Mean rate of infestation (%)

For this observation 10 plants were randomly selected and the number of Amphutukoni Muga infested plants were counted. The observation was assessed at 15 days intervals and the percentage was worked out for every month. The mean rate of infestation (%) was calculated by the following formula:

$$\text{Mean rate of infestation (\%)} = \frac{\text{No. of infested plant}}{10} x\ 100$$

2.2.4 Extent of damage

For the observation of extent of damage, 10 plants were randomly selected and in each plant four branches were selected from four directions. The total number of larvae present per branch were counted and average number of larvae per plant was worked out. Extent of damage was calculated by the following formula:

$$\text{Extent of damage per plant} = \text{Average insect per branch x Total number of branch per plant}$$

2.2.5 Nature of cocoon formation

The total number of cocoon formation per clusters were observed on four branches from each direction per plant from 10 randomly selected plants in field condition and recorded.

2.2.6 Meteorological observation

During the experiment all data on meteorological factors viz., temperature (maximum and minimum), total rainfall, number of rainy days, relative humidity (morning and evening), wind speed and bright sunshine hours were recorded for the entire period of the study from the Department of Agrometeorology, Assam Agricultural University, Jorhat to determine their influence on pest infestation.

2.3 Statistical Analysis

A simple correlation analysis was made between the mean population and mean rate of infestation by Amphutukoni Muga with independent variables to find out the influence of weather factors on the population and its damage caused by its infestation. For Correlation studies, monthly average values of the environmental factors were taken into consideration to know their influence on pest population and intensity of damage during the present investigation. Simple regression line was plotted to know the impact of independent variables on the dependent variable. Multiple regression line was fitted to know the combined effect of variables on the dependent variable using IBM SPSS Statistics version 23 software.

3. RESULTS

3.1 Nature of Damage

The larval stage of *Cricula trifenestrata* was observed to be the most damaging to Som plants during the study. The larvae voraciously fed on the leaves, devouring the entire leaf blade and leaving only the midrib, causing complete defoliation and giving the plant a broom-like appearance. The female moth laid eggs on the upper portion of the leaves, mostly at night. After hatching, the newly emerged larvae consumed the egg shells and were light yellow in color with a black head. The yellow color darkened by the end of the first instar, and the early instar larvae preferred to feed on tender and soft leaves of terminal branches.

The full-grown larvae were bright reddish-black in color with yellow dotted spots around the tubercles, and their heads were brick red (Fig. 3). The mature larvae preferred to eat mature and coarse leaves of Som plants, devouring the entire leaf surface except the midrib. The caterpillars caused direct damage to the Som plant by leaving the mature and coarse leaves of lateral branches to form cocoons, resulting in total leaf yield loss. The infested plants were found unsuitable for rearing muga silkworms.

3.2 Population Build Up

The presence of the pest *Cricula trifenestrata* was observed consistently throughout the year. A graphical representation shows the relationship between population build-up and weather parameters from March 2020 to March 2021 (Fig. 4). The pest population (number of insects per branch) was at its lowest in July (8.75±0.35). Leaf infestation gradually increased from August onwards, with values of 10.75±0.35, 14.60±1.69, 14.16±0.23, 19.89±0.74, 30.06±9.10, and peaking at 32.97±1.91 in January. Population levels rose during autumn and winter, reaching a peak in January. In February, there was a slight decrease to 29.91±2.24. The highest population density of the pest was observed in January. In January, the average temperatures were 23.50°C and 10.40°C (maximum and minimum) with an evening relative humidity of 62.87%. The lowest population build-up was recorded in July, with average temperatures of 31.5°C and 25°C (maximum and minimum).

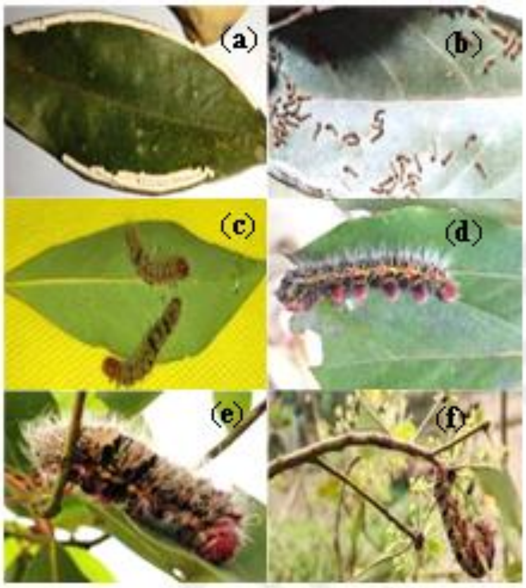

Fig. 3. Eggs of *Cricula trifenestrata* (a), 1st instar larva (b), 2nd instar larva (c), 3rd instar larva (d), 4th instar larva (e), 5th instar larva (f)

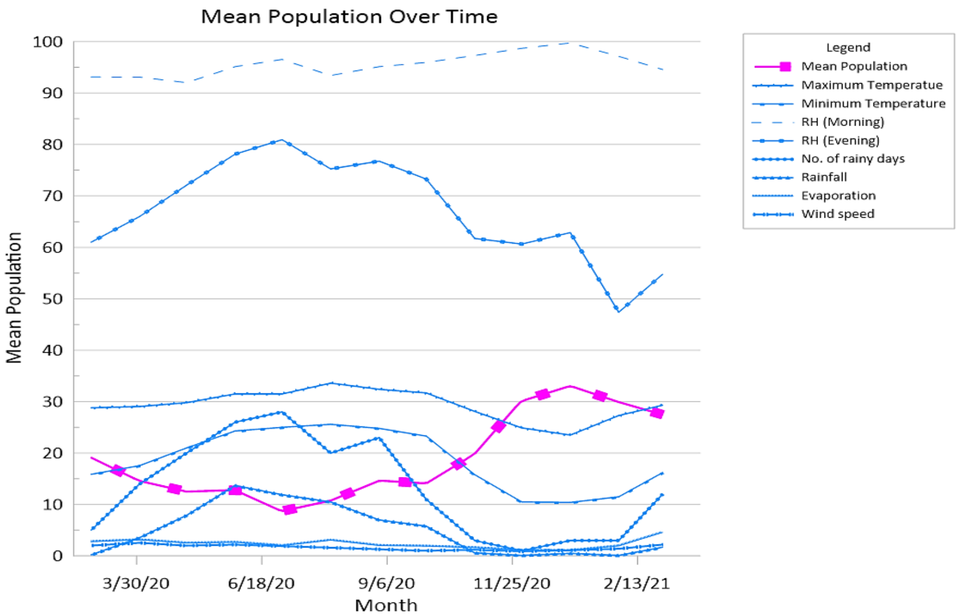

Fig. 4. Mean population of *Cricula trifenestrata* over time

3.3 Mean Rate of Infestation (%) and Extent of Damage (%)

The study found that the lowest infestation rate was observed in July 2020 (20.00 ± 0.00%). Infestation rates increased from August 2020 (25.00 ± 7.07%) to September 2020 (50.00 ± 0.00%), which was double the rate of August. The infestation rate continued to rise in the subsequent months: October 2020 (65.00 ± 7.07%), November 2020 (75.00 ± 7.07%), December 2020 (80.00 ± 14.14%), and January 2021 (85.00 ± 7.07%). The highest mean rate of infestation was observed in January 2021. However, the population slightly decreased in February 2021 (60.00 ± 0.00%) and March 2021 (45.00 ± 7.07%). The variation in mean rate of infestation in December 2020 and January 2021 was attributed to different weather parameters, which directly affected the mean rate of population. The lowest extent of damage was observed in July 2020 (15.25 ± 2.47 pests per plant), followed by a gradual increase in subsequent months. The highest extent of damage was recorded in January 2021 (68.36 ± 2.42 pests per plant). Notably, the extent of damage remained high in December 2020 (61.82 ± 18.22 pests per plant), January 2021 (68.36 ± 2.42 pests per plant), and February 2021 (66.03 ± 4.47 pests per plant). The extent of damage rate declined from May 2020 (20.71 ± 2.17 pests per plant) to August 2020 (20.06 ± 0.43 pests per plant), with the lowest rate observed in July 2020 (15.25 ± 2.47 pests per plant) (Table 1) (Fig. 5).

Table 1. Mean rate of infestation and extent of damage by *Cricula trifenestrata*

Month	Infested Plants (No.)	Mean Rate of Infestation (%)	Extent of Damage (%)
March 2020	4.50 ± 0.70	45.00 ± 7.07	34.65 ± 0.13
April 2020	5.00 ± 1.00	50.00 ± 14.14	20.71 ± 2.17
May 2020	3.00 ± 1.40	30.00 ± 14.14	23.94 ± 3.04
June 2020	4.00 ± 1.40	40.00 ± 14.14	24.51 ± 2.34
July 2020	2.50 ± 0.70	25.00 ± 7.07	28.19 ± 2.62
August 2020	2.50 ± 0.70	25.00 ± 7.07	28.00 ± 0.43
September 2020	5.00 ± 0.00	55.00 ± 0.00	30.00 ± 0.00
October 2020	6.50 ± 0.70	65.00 ± 7.07	30.43 ± 0.21
November 2020	7.50 ± 0.70	75.00 ± 7.07	42.89 ± 2.63
December 2020	8.00 ± 1.40	80.00 ± 14.14	48.00 ± 9.00
January 2021	8.50 ± 0.70	85.00 ± 7.07	54.00 ± 9.00
February 2021	6.00 ± 0.00	60.00 ± 0.00	60.00 ± 0.00
March 2021	4.50 ± 0.70	45.00 ± 7.07	66.03 ± 4.47

Data based on 10 plants

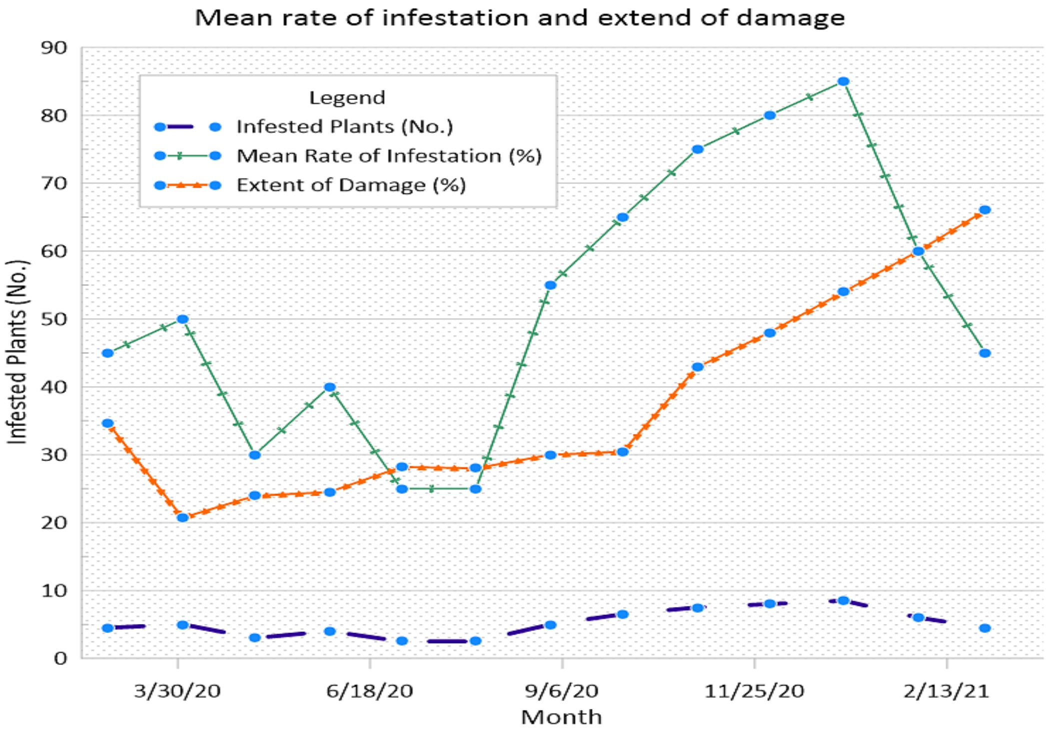

Fig. 5. Mean rate of infestation and extent of damage of *Cricula trifenestrata*

Table 2. Mean number of cocoons observed per month during the experimental period

Month	Mean Population (No.)	Mean No. of Cocoons (Mean)	Mean No. of Cocoon Clusters (Mean)	No. of Single Cocoons (No.)
March 2020	12.10±1.59	5±3	1±1	10
April 2020	14.50±1.35	4±1	0±0	4
May 2020	12.60±1.69	2±1	0±0	6
June 2020	8.75±5.05	2.80±5.07	1.00±3.42	7
July 2020	12.75±13.36	7.25±13.08	2.50±11.18	2
August 2020	14.60±16.29	13.00±15.62	0.00±15.84	0
September 2020	14.60±1.69	13.00±6.22	3.90±1.84	14
October 2020	14.16±0.23	0.00	0.00	0
November 2020	19.89±0.74	13.30±3.60	5.41±3.05	20
December 2020	30.06±9.10	0.00	0.00	0
January 2021	32.97±1.91	21.48±10.27	6.41±1.36	21
February 2021	29.91±2.24	6.00±6.36	2.00±1.89	4
March 2021	27.47±1.02	6.22±2.79	1.85±0.49	8
Total	19.12±1.59	9.92±3.28	2.13±0.88	10

Data based on 10 plants

Fig. 6. Nature of cocoon formation of *Cricula trifenestrata* on Som plant (a-d)

3.4 Nature of Cocoon Formation

After releasing their final excreta, the larvae moved back and forth to find a suitable group of leaves for cocooning. The study revealed that they first formed a weak hammock-like structure with a weak peduncle, then crawled under the hammock and began spinning the cocoon. The cocoons of *Cricula trifenestrata* were found in clusters, typically consisting of 2 to 7 or more cocoons. The cocoons were perforated in nature and had a bright golden yellow color (Fig. 6). During the study, the highest number of cocoons was observed in January 2021 (21.48 ± 10.27), followed by November 2020 (13.30 ± 3.60). No cocoon formation was found in May, July, October, and December 2020. The highest number of clusters was observed in January (6.41 ± 1.36) (Table 2).

3.5 External Morphology of *Cricula trifenestrata* Pupa and Moth

The pupa of *Cricula trifenestrata* was dark brown in color with a hard, sclerotized, and smooth integument. The sex differentiation in both male and female pupae was prominent. The male pupa was smaller in size compared to the female pupa. There was a dot-like structure on the 9thabdominal segment in the male pupa, while a clear, fine longitudinal line was visible on the 8thabdominal segment of the female pupa (Fig. 7).

The male *Cricula trifenestrata* moth was bright yellowish to brown in color, while the female moth was reddish-brown. The wings of the female moth were longer than those of the male moth. In the present investigation, it was clearly visible that the female moth had three dot-like transparent windows in its forewing, while the male moth had only two dot-like transparent windows, which were smaller in size compared to those of the female.

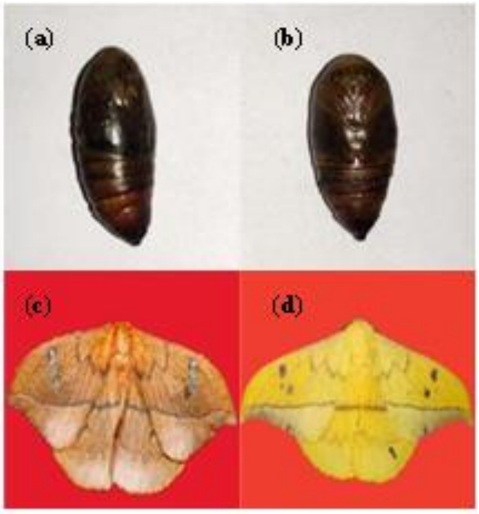

Fig. 7. Female pupa (a), Male pupa (b), Female moth (c), Male moth (d) of *Cricula trifenestrata*

4. DISCUSSION

The study addresses the incidence and population dynamics of the leaf defoliator *Cricula trifenestrata* Helfer on the Som plant, *Persea bombycina* King, in Jorhat, Assam. The study found that *Cricula trifenestrata* is a significant pest, capable of causing severe defoliation, which adversely affects the primary food plant of the Muga silkworm, *Antheraea assamensis*.

Larvae fed on *Persea bombycina* exhibit higher protein and lipid content, indicating it as a superior host plant [8]. The nature of damage caused by *Cricula trifenestrata* is extensive, with the caterpillars consuming entire leaf blades and leaving only the mid-rib, leading to significant defoliation. *Cricula trifenestrata* takes 61–125 days to complete its life cycle, with significant defoliation occurring in the 4th and 5th instars [9]. The larvae pass through 5 instars and complete 4 generations per year [10]. Early instar caterpillars primarily target tender leaves on terminal branches, while later instars consume more mature leaves, which negatively impacts the potential leaf yield for the muga silkworm. Notably *Cricula trifenestrata* affects crops like cashew and cardamom, causing significant damage. In cashew plants, the infestation by *Cricula trifenestrata* larvae was positively correlated with the number of flowers and seeds [11]. In Sikkim, infestations on cardamom have been documented [12].

The study's examination of the pest's population dynamics from March 2020 to March 2021 indicates that *Cricula trifenestrata* remains active throughout the year, with population fluctuations influenced by seasonal climatic conditions. The lowest pest population was recorded in July 2020, while the highest was observed in January 2021. Similarly high levels of infestation in *Persea bombycina* were noted from September to January [7].

Correlation studies between meteorological factors and the intensity of *Cricula trifenestrata* infestation reveal that temperature (both maximum and minimum), evening relative humidity, total rainfall, number of rainy days, evaporation, and wind speed are negatively correlated with pest intensity. In contrast, morning relative humidity and bright sunshine hours show no significant influence. Notably, morning relative humidity and bright sunshine hours positively correlate with pest population buildup, which supports the hypothesis that increased humidity and sunshine favor their population growth. Among various weather factors, minimum temperature emerged as the most dominant factor affecting *Cricula trifenestrata* population, with a high negative correlation.

Multiple regression analysis underscores that approximately 93.40% of the variation in *Cricula trifenestrata* population is attributable to the combined effect of different meteorological parameters, highlighting the significant influence of climatic factors on pest dynamics.

The incidence data indicate that *Cricula trifenestrata* is active year-round, with peak infestation periods observed from November 2020 to January 2021. The higher infestation rates during the Katia (October-November) and Jarua (December-January) crops correlate with increased damage potential, adversely affecting the quality and yield of muga silk.

The cocoon formation behavior observed in this study shows that mature larvae form weak hammock-like structures by pulling leaves together before spinning their cocoons. The cocoons, found in clusters with weak peduncles, consist of 2 to 7 cocoons and have a distinctive bright golden-yellow color as first described by Walker in 1855 and further defined by Capt. Jenkins and Helfer. The moth is notable for its three window-like structures on the forewing [5].

Maintaining the health of *Persea bombycina* is critical as it directly affects muga silkworm rearing. Beside *Persea bombycine,* the wide range of host plants makes *C. trifenestrata* a favorable candidate for wild silkworm cultivation. Its silk cocoons can be used in handicrafts, contributing to local economies [13]. Future research could further explore the suitable host plant for *C. trifenestrata* and economic utilization from this wild silkworm while, Effective strategies need to balance pest suppression without harming the muga silkworms.

5. CONCLUSION

The study found the larval stage of *Cricula trifenestrata* as the most detrimental phase for Som plants, leading to significant defoliation and leaf yield loss. The larvae exhibit a preference for tender leaves during early instars and transition to mature leaves as they grow, systematically denuding the plants. The infestation observed is consistent throughout the year, with notable population peaks during autumn and winter, particularly in January.

This corresponds to fluctuations in temperature and humidity and illustrates the impact of the environment on pest dynamics. Additionally, the extent of pest damage and infestation rates correlate with seasonal changes and peak in the colder months. The study also emphasizes the clustered cocoon behavior of pests and the distinctive morphological features of pupae and moths, which facilitate species identification and understanding of the life cycle of *Cricula trifenestrata*.

6. FUTURE SCOPE

The information obtained from the study will help on developing integrated pest management strategies tailored to the *Cricula trifenestrata*. The future study should focus on biological control methods that use natural predators and parasitoids to reduce larval populations. Studies examining the genetic predisposition of Som plants to pest resistance could produce varieties with increased resistance. Furthermore, an in-depth analysis of pest response to climate variability will be crucial, particularly in the context of global climate change.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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