Journal of Advances in Biology & Biotechnology

Volume 27, Issue 9, Page 237-246, 2024; Article no.JABB.121826
ISSN: 2394-1081

Influence of Biotic and Abiotic Factor on Incidence of *Glyphodes pyloalis* and its Natural Enemy's Population in Jorhat District, Assam, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jabb/2024/v27i91294

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/121826

Original Research Article

Received: 19/06/2024
Accepted: 21/08/2024
Published: 24/08/2024

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Cite as: *Brahma, Dipankar, Manjula Sultana, Roshmi Borah Dutta, Abhigyan Rajkhowa, Nilav Ranjan Bora, Jugabrat Sarma, and Rushali Chakraborty. 2024. "Influence of Biotic and Abiotic Factor on Incidence of Glyphodes Pyloalis and Its Natural Enemy's Population in Jorhat District, Assam, India". Journal of Advances in Biology & Biotechnology 27 (9):237-46. https://doi.org/10.9734/jabb/2024/v27i91294.*

ABSTRACT

The present study investigates the influence of biotic and abiotic factors on the population dynamics of *Glyphodes pyloalis*, a defoliating pest of mulberry plant in Jorhat district, Assam, India. The study, conducted from August 2021 to July 2022, examined the pest's interaction with weather parameters and natural enemies. The findings indicated that *G. pyloalis* populations peaked in spring and early summer, with the highest density (3.20 individuals per shoot) observed on May 15, 2022, under moderate temperatures and high humidity. In contrast, the lowest populations were observed in winter. The study identified *Apanteles obliquae*, *Chelonus carbonator*, Ichneumonid wasp and *Cheilomenes sexmaculata* as important natural enemies and showed significant positive correlations with *G. pyloalis* larvae. Regression analysis showed that evening temperature and relative humidity significantly influenced pest populations, while biotic factors, particularly parasitoids and predators, showed strong associations. These results highlight the importance of integrating biotic and abiotic factors in developing effective pest control strategies for mulberry ecosystems.

Keywords: Mulberry; Glyphodes pyloalis; weather parameters; natural enemies; pest management.

1. INTRODUCTION

There are many reasons why silk is a divine fabric; it absorbs well, has a natural lustre, is soft to the touch, lightweight, and is extremely durable. The silk industry has a large employment potential, is lucrative, and requires very little capital. The Indian people have long been associated with silk in their culture and way of life. India's silk trade and production dates back to the 15th century and is both successful and complicated [1]. It is estimated that a majority of sericulture workers are from economically backward groups, especially women. In the silk industry, India is a world leader due to its culture, traditional market, and large variety of silk clothing. India produces all five types of commercial silk - Mulberry, Tropical Tasar, Oak Tasar, Eri, and Muga. India ranks second in terms of raw silk production worldwide. Of the four types of silk produced in 2022-23, Mulberry produced 75.6% (27,654 MT), Eri 20.1% (7,349 MT), Tasar 3.6% (1,318 MT) and Muga 0.7% (261 MT) of all raw silk production of 36,582 MT [2].

Sericulture is the rearing of silkworms to produce silk, with mulberry leaves being the main source of food for the *Bombyx mori* L. silkworm [3]. Silkworms feeds on green leaves of the mulberry plant and turn them into beautiful silk. The success of sericulture and cocoon formation is highly influenced by leaf quality [4]. A variety of insects find endless food and shelter in the lush foliage of the evergreen perennial mulberry tree. Mulberries (Morus spp.) play a crucial role in the growth and development of silkworms (*Bombyx mori* L.), ultimately influencing the quality of silk produced. The nutritional composition of mulberry leaves, including factors such as leaf moisture, chlorophyll content, nitrogen, phosphorus, potassium and total sugars, has a direct impact on the health and parameters of the silkworm cocoon [5]. It was also known that the yield and quality of various plants or the harvest varies due to infestation with various pests and pathogens. Many insect problems have been associated with mulberry cultivation in India. Host plants of all kinds the silkworm is attacked by various pests and diseases, which ultimately leads to its reduction Yield and quality of leaves. A study found that silkworms that feed on pests attack the leaves do not have normal growth and ultimately result in inferior, therefore low income to farmers [6].

The insect pests that attack the mulberry plant are divided into sapsuckers, defoliators, borers and ground dwellers (termites) [7]. Among the pests, defoliators are considered the main pests because they cause significant damage to the mulberry plant. These defoliating pests cause approximately 12 to 25% loss of leaf yield, either through reduction of nutritional value or through defoliation. The consumption of low-quality leaves negatively impacts silkworm growth and ultimately the silk industry. Insect pests often hamper the production of mulberry leaves. Common insect pests that target mulberry plants include mulberry leaf roller, which folds and feeds on the leaves, and the mulberry thrips, which suck sap from the leaves causing them to curl and dry. Additionally, the mulberry tussock moth larvae feed voraciously on the foliage, leading to significant defoliation and reduced leaf quality [8]. *Glyphodes pyloalis*, commonly known as the mulberry pyralid, is a significant pest affecting mulberry cultivation. It is a defoliating pest of mulberry plants that also transmits germs to the Silkworms found in *Glyphodes pyloalis* [9]. It has been reported that *Glyphodes pyloalis* damages mulberry crops in many parts of the world, including northern Iran and China, with infestation rates reaching 73.03% in some areas [10]. The presence of pests on mulberry plants poses a major challenge and leads to the use of insecticide sprays, which can have a negative impact on the quality of mulberry leaves and therefore the silk produced. Today, there is more emphasis on organic sericulture, which can control pest populations with no or minimal use of pesticides. In order to achieve this goal, biological agents such as predators, parasitoids, and pathogens can be used, which are environmentally friendly and result in a healthy ecosystem for mulberry.

There are several reports on the population dynamics of defoliators depending on the meteorological factor. However, information on the population dynamics of pests and their natural enemies is almost lacking. Since an organism's population is regulated by both biotic and abiotic factors, it makes sense to include both biotic factors, particularly natural enemies, and abiotic factors to develop a regression model. Understanding temporal trends in the evolution of populations of pest species and their natural enemies is critical to developing rational management strategies. In this background, this study was conducted to investigate the influence of biotic and abiotic factors on the occurrence of *Glyphodes pyloalis* and its natural enemies in Jorhat district, Assam, India.

2. MATERIALS AND METHODS

The field study was conducted at the Regional Sericulture Research Station, Central Silk Board, Jamuguri, Jorhat, for ten months between August 2021 and July 2022 to study the influence of meteorological factors on the incidence of *Glyphodes pyloalis* and the natural enemy population. The variety of Mulberry plant used during research the period is Kanva-2 (K2).

A regular inspection method was used to sample the pest population (Sunil et al., 2013). Ten plants were randomly selected after 15 days interval, two from each of the four corners and the center of the experimental field, and inspections were conducted for the presence of insects on leaves, stems, and branches. An estimate of the population was made by counting the average number of insects per shoot, insects per leaf, and insects per plant. In addition, various predatory insects feeding on *Glyphodes pyloalis* were recorded and collected, and various larval stages of the pest were also collected in plastic containers. Field-collected specimens of adult parasitoids and predators were preserved and identified by the Entomology Department of AAU, Jorhat.

Data on various weather parameters, including maximum and minimum temperatures, morning and evening relative humidity, sunshine hours and rainfall, were collected at 15 days interval from the Meteorological Division of the Department of Meteorology, Assam Agricultural University, Jorhat. Statistical analysis was performed to correlate pest occurrence and severity with weather conditions. These data were analyzed using simple correlation and linear regression techniques.

3. RESULTS AND DISCUSSION

The Population trend of *Glyphodes pyloalis* and its major natural enemies are presented in Table 1. From the observed data, it is clear that there were fluctuations in the *Glyphodes pyloalis* population throughout the year, peaking at 3.20 individuals per shoot on May 31, 2022. The second peak was observed on September 15, 2021 with 1.80 individuals per shoot. The lowest numbers were recorded in late winter, with no individuals found on February 15th and 28th, 2022. There was a clear seasonal trend, with numbers decreasing from autumn to winter and increasing again in spring and early summer. The average frequency across all sampling dates was 1.05 individuals per shoot. The relative frequency percentage was 48.16%. The hymenopteran parasitoid and the coccinellid predator, namely *Apanteles obliquae*, *Chelonus carbonator*, Ichneumonid wasp and *Cheilomenes sexmaculata* have been recorded as potentially active natural enemies of *Glyphodes pyloalis*. Among four major natural enemies of *G. pyloalis, Apanteles obliquae* showed the highest relative abundance (31.97%) among the parasitoids, with the highest activity (1.00 parasitized larvae per plant) observed on May 31, 2022, coinciding with high abundance of *G. pyloalis*. *Chelonus carbonator*, the parasitic wasp and *Cheliomenes sexmaculata* (G+A) were also present at different levels throughout the year, with relative abundances of 14.75%, 12.29% and 13.11%, respectively. In order to determine the growth potential of any species under specific circumstances, population parameters are important. A new pest population's growth potential can be assessed by analyzing the population growth indices in response to selection and climatic conditions [11]. Understanding these population parameters is crucial for developing effective pest management strategies. By accurately assessing growth potential, we can predict outbreaks and implement timely control measures. This proactive approach helps minimize damage to crops and ecosystems, ensuring sustainable agricultural practices. In our study, the frequency of population development of natural enemies was found to be synchronized with the pest population.

Correlation coefficients between *Glyphodes pyloalis* and its natural enemies: The correlation coefficients between *Glyphodes pyloalis* larvae and their natural enemies were calculated and are presented in the Table 2. The results show significant positive correlations between the population of *G. pyloalis* larvae and its four natural enemies at a significance level of P = 0.05. *Apanteles obliquae* had the highest correlation with *G. pyloalis* larvae with a high r value of 0.80. This suggests a very strong positive relationship between the larval populations of *G. pyloalis* and *A. obliquae*, indicating that as the pest population increases, the population of this parasitoid also tends to increase proportionally.

Table 1. *Glyphodes pyloalis* and its major natural enemies during the year 2021-2022

Sampling Date	*Glyphodes pyloalis* (no./shoot)	*Apanteles obliquae* (no. of parasitized larva/ plant)	*Chelonus carbonator* (no. of parasitized larva/ plant)	Ichneumonid wasp (no. of parasitized larva/ plant)	*Cheilomenes sexmaculata* (G+A) (no./ plant)
15-Aug,2021	1.20	0.60	0.10	0.30	0.20
31-Aug	1.40	0.40	0.00	0.10	0.10
15-Sep	1.80	0.60	0.10	0.00	0.20
30-Sep	1.30	0.50	0.00	0.10	0.30
15-Oct	1.10	0.30	0.20	0.20	0.00
31-Oct	1.00	0.50	0.10	0.10	0.20
15-Nov	1.10	0.20	0.00	0.10	0.10
30-Nov	1.30	0.30	0.20	0.00	0.20
15-Dec	0.90	0.40	0.10	0.20	0.10
31-Dec	0.60	0.20	0.10	0.00	0.00
15-Jan,2022	0.10	0.00	0.00	0.00	0.00
31-Jan	0.10	0.00	0.00	0.00	0.00
15-Feb	0.00	0.00	0.00	0.00	0.00
28-Feb	0.00	0.00	0.00	0.00	0.00
15-Mar	1.10	0.30	0.20	0.10	0.10
31-Mar	0.80	0.40	0.10	0.30	0.30
15-Apr	1.30	0.60	0.30	0.40	0.30
30-Apr	1.40	0.50	0.20	0.20	0.20
15-May	3.20	0.70	0.40	0.50	0.50
31-May	2.10	1.00	0.60	0.40	0.20
15-Jun	0.90	0.50	0.40	0.20	0.30
30-Jun	0.80	0.50	0.30	0.10	0.10
15-Jul	0.90	0.50	0.30	0.20	0.20
31-Jul	1.00	0.40	0.50	0.10	0.30
Mean	1.05	0.39	0.18	0.15	0.16
Relative abundance %	48.16	31.97	14.75	12.29	13.11

Mean of 10 samples
G- Grub
A-Adult

Table 2. Relationship of *Glyphodes pyloalis* population with natural enemies

Glyphodes pyloalis	**Relationship**	***Apanteles obliquae***	***Chelonus carbonator***	***Ichneumonid wasp***	***Cheilomenes sexmaculata***
Larva	R	0.80*	0.52*	0.66*	0.71*

*(NS = Non-Significant; * = Significant at p=0.05)*

Cheilomenes sexmaculata showed the second strongest correlation (r = 0.71), followed by the parasitic wasp (r = 0.66). These moderately strong positive correlations suggest that as the larval population of *G. pyloalis* grows, the populations of these natural enemies also tend to increase, but not as much as that of *A. oblique*. The *Chelonus carbonator* had the lowest correlation among the four natural enemies, with an r value of 0.52. Although still significant, this moderate positive correlation suggests a less pronounced relationship between its population and that of *G. pyloalis* larvae compared to other natural enemies.

These significant positive correlations between the four natural enemies suggest synchronization between the pest and its natural enemy populations *Glyphodes pyloalis*, a major pest affecting mulberry plants in various regions such as Kashmir, Gujarat and China. Studies in Kashmir and Gujarat identified Hymenopteran parasitoids such as *Apanteles obliquae*, *Brachymeria* sp. and *Xanthopimpla* sp. as important larval parasitoids [12,13]. The present study showed that the population dynamics of *G. pyloalis* and its natural enemies exhibited seasonal trends, with generally higher numbers in spring and summer and lower numbers in winter. This relationship likely reflects the natural biological control that occurs in the ecosystem, where increasing pest populations make more resources (hosts or prey) available to their natural enemies, subsequently leading to an increase in their populations. This synchronization suggests a natural balance between the pest and its enemies that could be exploited for integrated pest management strategies.

Influence of weather parameter on *Glyphodes pyloalis* population: The occurrence of *Glyphodes pyloalis* was recorded from August 15, 2021 to July 31, 2022 in relation to various meteorological parameters. The *G. pyloalis* population fluctuated throughout the year, with peaks observed in spring and early summer. The highest population density (3.20 individuals per shoot) was recorded on May 15, 2022, coinciding with moderate temperatures (max. 28.40 °C, min. 23.00°C) and high relative humidity (98% in the morning, 93% at evening). and significant rainfall. (13.20mm). This peak was followed by another high count (2.10 individuals per shoot) on May 31, 2022 under similar weather conditions. The lowest populations were observed during the winter months, with no individuals recorded on February 15 and 28, 2022. These periods were characterized by lower temperatures (maximum 25.80°C, minimum 7.00°C on February 15) and lower relative humidity, particularly in the evenings. From March to May 2022 there was a gradual increase in population, which was accompanied by rising temperatures and generally higher humidity. Conversely, a population decline was observed from December 2021 to February 2022, which was accompanied by lower temperatures and lower humidity (Table 3).

Data suggests that *G. pyloalis* thrives in warm, moist conditions typical of late spring and early summer in this region. The combination of moderate temperatures (around 25-35 °C) and high humidity appears to be particularly favorable to population growth. Conversely, cooler and drier winter conditions appear to slow population growth.

Correlation coefficients between *Glyphodes pyloalis* and weather parameters: The *Glyphodes pyloalis* population showed significant positive correlations with temperature parameters. Specifically, there was a moderate positive correlation with maximum temperature (r = 0.44) and a stronger positive correlation with minimum temperature (r = 0.56). This suggests that warmer temperatures, particularly higher minimum temperatures, are associated with increased population growth of *G. pyloalis*. Relative humidity has different effects depending on the time of day. Morning relative humidity had a weak negative correlation (r = -0.14), while evening relative humidity had a moderate positive correlation (r = 0.48), which was statistically significant. This suggests that higher humidity in the evening may favour the accumulation of *G. pyloalis* populations. Precipitation, evaporation, and wind speed all showed weak positive correlations (r = 0.28, r =

Table 3. Weather parameters and *Glyphodes pyloalis* population growth during 2021-22

Sampling Date	*Glyphodes pyloalis* (no./ shoot)	Temperature (℃)		Relative Humidity (%)		Rainfall (mm)	Evaporation (mm)	WS (kmph)	HBSS (hr)
		Max.	Min.	Morning	Evening				
15-Aug,2021	1.20	31.40	25.50	95.00	75.00	1.40	2.60	4.60	2.50
31-Aug	1.40	33.20	23.90	92.00	75.00	0.00	2.90	2.50	5.40
15-Sep	1.80	36.60	25.90	92.00	64.00	0.00	4.20	1.80	8.90
30-Sep	1.30	31.60	23.70	95.00	68.00	0.00	1.90	1.80	7.30
15-Oct	1.10	35.50	24.90	97.00	65.00	0.00	3.00	1.30	8.20
31-Oct	1.00	31.20	19.20	98.00	62.00	0.00	2.30	1.10	8.50
15-Nov	1.10	29.10	14.90	98.00	57.00	0.00	1.80	1.10	8.30
30-Nov	1.30	27.00	10.90	100.00	46.00	0.00	1.40	1.30	8.30
15-Dec	0.90	25.60	10.40	97.00	55.00	0.00	1.90	1.20	8.20
31-Dec	0.60	24.40	10.10	100.00	53.00	0.00	1.00	1.40	7.30
15-Jan,2022	0.10	20.90	10.70	100.00	64.00	0.00	0.80	1.60	2.90
31-Jan	0.10	23.00	8.00	97.00	52.00	0.00	1.70	1.80	3.40
15-Feb	0.00	25.80	7.00	97.00	39.00	0.00	2.20	1.70	10.10
28-Feb	0.00	27.10	13.20	96.00	57.00	0.00	2.30	1.80	3.40
15-Mar	1.10	34.00	15.10	96.00	41.00	0.00	2.90	1.20	8.00
31-Mar	0.80	25.10	19.40	93.00	75.00	0.00	1.80	2.10	0.60
15-Apr	1.30	24.00	19.50	96.00	69.00	0.50	0.80	3.40	8.10
30-Apr	1.40	31.70	19.80	98.00	90.00	12.90	3.90	4.10	0.00
15-May	3.20	28.40	23.00	98.00	93.00	13.20	1.40	2.50	0.00
31-May	2.10	34.80	24.10	92.00	67.00	0.00	4.00	2.80	5.90
15-Jun	0.90	26.50	23.00	98.00	97.00	20.00	1.20	1.60	0.20
30-Jun	0.80	28.60	23.60	95.00	81.00	14.20	1.40	0.80	1.90
15-Jul	0.70	36.60	27.00	89.00	55.00	0.00	4.80	2.30	11.30
31-Jul	1.00	33.90	24.50	90.00	66.00	0.00	2.10	2.70	9.30

0.21, and r = 0.30, respectively) with pest population, but these correlations were not statistically significant. Bright sunshine hours had a very weak negative correlation (r = -0.12), which was also not significant.

During our study period, temperature, particularly minimum temperature, and evening relative humidity were found to be the most influential meteorological parameters affecting *G pyloalis* population dynamics. This finding is consistent with Borgohain et al, [14] who found that evening relative humidity and minimum temperature significantly affected *Glyphodes pyloalis* population levels. In a similar study, Ramegowda et al. [15] found that the number of rainy days and minimum temperature were negatively correlated with the abundance and severity of lesser mulberry pyralids (LMPs) (*G. pyloalis*). The significant influence of temperature on *G. pyloalis* population could be due to its influence on pest biology, distribution and abundance, as it is a crucial factor in pest population [16]. Weather plays a crucial role in influencing the occurrence and severity of pests and diseases in mulberry cultivation [17,18]. Studies have shown that the success of sericulture depends heavily on factors such as leaf quality, environmental conditions and pest control strategies [19].

Regression analysis of *Glyphodes pyloalis* population with abiotic and biotic factors during 2021- 22: Analysis of the larval population of *Glyphodes pyloalis* in relation to abiotic and biotic factors in 2021-2022 shows complex interactions, as evidenced by the multiple regression equation presented in Table 5. The model shows strong fit with a coefficient of determination (R^2) of 0.85, indicating that 85% of the variation in the larval population can be explained by the factors included. The regression equation suggests that the maximum temperature (X_1) has a positive influence on the larval population with a coefficient of 0.17. This fits with the general trend of insect populations responding positively to rising temperatures. The minimum temperature (X_2) shows a slightly negative relationship (-0.09), which is an interesting contrast to the positive effect of the maximum temperature. Relative humidity in both morning (X_3) and evening (X_4) appears to have minimal positive effects on the larval population, with coefficients of 0.04 and 0.02, respectively. This suggests that humidity plays a minor role in population dynamics. Precipitation (X_5) has a slightly negative impact (-0.03), while evaporation rate (X_6) has a stronger negative effect (-0.22). Wind speed (X_7) and daylight hours (X_8) both show slightly negative influences on the population.

Interestingly, biotic factors, particularly natural enemies, have different effects. *Apanteles obliquae* (X_9) and *Chelonus carbonator* (X_{10}) show positive associations with larval population (0.54 and 0.34, respectively), which may indicate a density-dependent relationship in which the number of these parasitoids increases as the host population increases. The parasitic wasp (X_{11}) and *Cheilomenes sexmaculata* (X_{12}) show strong positive correlations (1.15 and 1.84, respectively), suggesting that these predators may have the greatest influence on *G. pyloalis* population dynamics. The literature did not provide information to predict the occurrence of *G. pyloalis* based on expected weather conditions as well as natural enemies in the mulberry ecosystem. To develop a regression model that involves both biotic and abiotic factors, it is appropriate to encompass both biotic factors, particularly natural enemies, and abiotic factors. Due to the lack of such models, the biocontrol program in the mulberry ecosystem is lagging behind.

Table 4. Correlation factors between the population buildup of *Glyphodes pyloalis* with weather parameters during 2021-22

Weather parameters	Correlation coefficient
Max. Temperature (℃)	0.44*
Min. Temperature (℃)	0.56*
Relative Humidity (morning)	-0.14 NS
Relative Humidity (evening)	0.48*
Rainfall (mm)	0.28 NS
Evaporation (mm)	0.21 NS
Wind speed (kmph)	0.30 NS
Hours of Bright Sun Shine (hr)	-0.12 NS

*(NS = Non-Significant; * = Significant at p=0.05)*

Table 5. Relationship of *Glyphodes pyloalis* population with abiotic and biotic factors during 2021- 22

***Glyphodes pyloalis* population**	**R^2**	**Regression equation (Y)**
larva	0.85	$Y= -7.84 + 0.17X_1 – 0.09X_2 + 0.04X_3 + 0.02X_4 – 0.03X_5 – 0.22X_6 – 0.06X_7 -0.01X_8 + 1.54X_9 + 0.34X10 + 1.15X_{11} + 1.84X_{12}$

R^2 = Coefficient determination
X_1 = Max. temperature
X_2 = Min. temperature
X_3 = Relative humidity (Morning)
X_4 = Relative humidity (Evening)
X_5 = Total rainfall
X_6 = Evaporation rate
X_7 = Wind speed
X_8 = Bright sunshine hours
X_9=Apanteles obliquae
X_{10} = Chelonus carbonator
X_{11}= Ichneumonid wasp
X_{12}= Cheilomenes sexmaculata

Table 6. Relationship of natural enemies' population with abiotic and biotic factors during 2021- 22

Natural enemy population	**R^2**	**Regression equation (Y)**
Apanteles obliquae	0.83	$Y= 1.14 – 0.04X_1 + 0.03X_2 – 0.004X_3 – 0.005X_4 + 0.008X_5 + 0.09X_6 + 0.02X_7 + 0.01X_8 + 0.23X_9$
Chelonus carbonator	0.56	$Y= 2.76 – 0.007X_1 + 0.008X_2 – 0.02X_3 – 0.007X_4 + 0.02X_5 - 0.03X_6 + 0.04X_7 + 0.008X_8 + 0.11X_9$
Ichneumonid wasp	0.70	$Y= 0.82 – 0.04X_1 + 0.02X_2 – 0.001X_3 – 0.004X_4 + 0.003X_5 + 0.05X_6 + 0.04X_7 - 0.001X_8 + 0.14X_9$
Cheilomenes sexmaculata	0.75	$Y= 1.70 – 0.01X_1 + 0.007X_2 – 0.02X_3 – 0.001X_4 + 0.007X_5 - 0.03X_6 + 0.02X_7 + 0.006X_8 + 0.12X_9$

R^2 = Coefficient determination
X_1 = Maximum temperature
X_2 = Minimum temperature
X_3 = Relative humidity (Morning)
X_4 = Relative humidity (Evening)
X_5 = Total rainfall
X_6 = Evaporation rate
X_7 = Wind speed
X_8= Bright sunshine hour
X_9= Glyphodes pyloalis

In addition, Table 6 shows the results of a multiple regression analysis to determine the interaction effect of meteorological factors and *G. pyloalis* density on the constitution of a population of parasitoid and coccinellid Hymenoptera predators. All weather factors and the *Glyphodes pyloalis* population together resulted in an 83% change in the *Apanteles obliquae* population, a 56% change in the *Chelonus carbonator* population, a 70% change in the parasitic wasp population, and a 75% change in the population of *Cheilomenes sexmaculata*.

4. CONCLUSION

Hymenoptera parasitoids and coccinellid predators, namely *Apanteles obliquae*, *Chelonus carbonator*, parasitic wasp and *Cheilomenes sexmaculata*, have been recorded as potentially active natural enemies of *Glyphodes pyloalis*. The occurrence and peak activity of *Apanteles obliquae*, *Chelonus carbonator*, *Cheilomenes sexmaculata* and parasitic wasps were found to be synchronized with those of the *Glyphodes pyloalis* population. These four natural enemies showed a significant positive correlation with the *Glyphodes pyloalis* population. The increase in the number of natural enemies as the host/prey population increases reflects the stronger numerical response of predators. Maximum temperature, minimum temperature and relative humidity (evening) showed a significant positive correlation with *G. pyloalis* population, while precipitation, evaporation rate and wind speed showed a positive non-significant correlation. Relative humidity (morning) and daylight hours showed a non-significant negative correlation with *G. pyloalis* population. It can therefore be said that fluctuations in the population of *G. pyloalis* depend on both the population of natural enemies and meteorological factors. The population of *Apanteles obliquae* exhibited a substantial positive correlation with the maximum temperature, minimum temperature, relative humidity (evening), and wind speed. Significant positive correlations were found between the minimum temperature and precipitation and the population of *Chelonus carbonator*. There was a noteworthy positive correlation seen between the adult parasitic wasp population and the minimum temperature, wind speed, and the evening relative humidity. Minimum temperature and relative humidity (evening) showed a significant positive correlation with the *Cheilomenes sexmaculata* population. We can therefore conclude that certain meteorological factors play an important role in the availability of these natural enemies in the mulberry ecosystem. Meteorological parameters and natural enemies together accounted for 85% of the variation in the *Glyphodes pyloalis* population. All meteorological factors and the *Glyphodes pyloalis* population together explain 83% of the variation in the *Apanteles obliquae* population, 56% in the *Chelonus carbonator* population, 70% in the ichneumonid wasp population, and 75% in the *Cheilomenes sexmaculata* population.

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/121826