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SEASONAL OCCURRENCE, BIOLOGY AND FEEDING BEHAVIOUR OF *EOCANTHECONA FURCELLATA* WOLF PREDATING MUGA SILKWORM *ANTHERAEA ASSAMENSIS* HELFER IN BRAHMAPUTRA VALLEY OF ASSAM, INDIA

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ABSTRACT

India produces all four types of commercially exploited silk viz., Mulberry, Eri, Tasar and Muga. Among these Tasar, Eri and Muga are non-mulberry silks and collectively known as Wild or Vanya Silks. Except Eri silkworm, Muga and Tasar are reared in open environment on its host plants. Muga is endemic to Assam and now its rearing practice is expanded to other states of North East India. Muga silkworm, *Antheraea assamensis* (Helfer) is polyphagus, multivoltine in nature. Their important food plants are Som (*Persea bombycina*) and Soalu (*Litsea monopetala*), which produces highly lustre golden silk of India. Most of the food plants of Muga silkworm are perennial tree and they are abundantly available in North Eastern region of India. As Muga silkworm is reared in open environment, challenging during rearing practices is due to various attacks from different insect predators. Among different insect predators of Muga silkworm, the most economical important predator is stink bug, *Eocanthecona furcellata* Wolf which cause extensive damage of crop during summer season. *E. furcellata* is commonly known as stink bug. The loss due to *E. furcellata* is alarmingly high in the preseed (Aherua and Jarua) and seed crops (Chotua and Bhodia) as compared to the commercial crops (Jethua and Kotia). The population dynamic of the predator has positive correlation with abiotic factors; their feeding behaviour is very tactical and skilful. Application of suitable Integrated Pest Management (IPM) is very crucial to manage the crop damage caused by *E. furcellata*.

Keywords : Vanya silks, Muga silkworm, insect predators, Som, Soalu, *Eocanthecona furcellata.*

Introduction

The North East region of India is characterized by sub-tropical to temperate type of climate and is internationally recognized as one of the biodiversity hotspots of the world for its rich in flora and fauna. It is a mega-biodiversity centre and distinguished as one of the ten distinct bio-geographic zones of the country andowing to its diverse geographical position, offers a tremendous complex variety of habitat and ecosystem. North East India is rich in seri-biodiversity being a natural abode for a number of sericigenous insects and their host plant genotypes. Muga, Eri, Oak tasar cultures, which are endemic prerogative and categorized under the *Vanya* (wild) silk moths.Muga silkworm is reared in outside environment and it is polyphagous in nature, feeding on wide range of host plants. Most of these food plants are perennial tree and available in wide range of geographical region of North east India. Among the numbers of food plants of Muga silkworm, Som (*Persea bombycina*) and Soalu (*Litsea monopetala*) are the primary host plants, Dighloti (*Litsea salicifolia*) and Mejankori (*Litsea cubeba*) are the secondary food plants. Other food plants viz., *Cinnamomum glaucescens*, *Actinodaphne obovata*, *Michelia champaca*, *Michelia oblonga*, *Ziziphus mauritiana*, *Zanthoxylum rhetsa*, *Celastrus hindsii* etc. are tertiary food plants. Muga silkworm is a very important bio-resource and it is found only in Assam and its neighbouring states. Muga silk occupies a prominent position in the cultural heritage and high aesthetic importance among the Assamese people and also has high economic importance. Muga silk production generates additional rural employment in the region. With the increasing of the importance of sustainable sericulture, the concept of management of pests and predators attacking Muga silkworm is very crucial. Insect pests and predators are major enemies of Muga silkworm. Predators like *E. furcellata* Wolf cause remarkable damage to silk industry. It is estimated that the loss due to parasites and predators is to an extent of 15-20% and varies from crop to crop (Singh and Maheshwari, 2002). These predators cause damage to Muga silkworm mainly during spring, summer and autumn season in day and night.

Materials and Methods

Field survey was conducted regularly at different locations of upper and lower Assam to study the population dynamic and seasonal occurrence of predator stink bug, *Eocanthecona furcellata* (Hemiptera : Pentatomidae) in Muga silkworm rearing farms at different locations of upper Assam namely CMER&TI rearing farms, GCC Chenijan, Lakwa, Perikata, Ponka and in lower Assam such as

Pailapool and Boko. From the survey, it was learnt that Stink bug, *E. furcellata* started its occurrence from the onset of spring, February to September. Peak period of its occurrence was found in the month of April and May of the year. Methods for monitoring stink bug species was conducted by examining larval dead, using a sweep net or beating branches of host plants or by constant visual observation in the rearing field. As the Muga host plants are tall trees, stink bug observation was conducted by using telescopic binocular. Stink bugs were collected from the field to study their life cycle, biology and feeding behavior. Close observations were made in the Muga rearing fields to learn their tactics and feeding behavior of the stink bugs. Stink bugs were collected using insect trapping net, counted their numbers and cultured in the lab to study life cycle and biology of the bugs. Field survey were conducted at regular intervals to find stink bug population during rearing period and weather status were recorded to study the correlation of abiotic factors and population dynamic of stink bug. Data analysis was performed using SPSS statistical software.

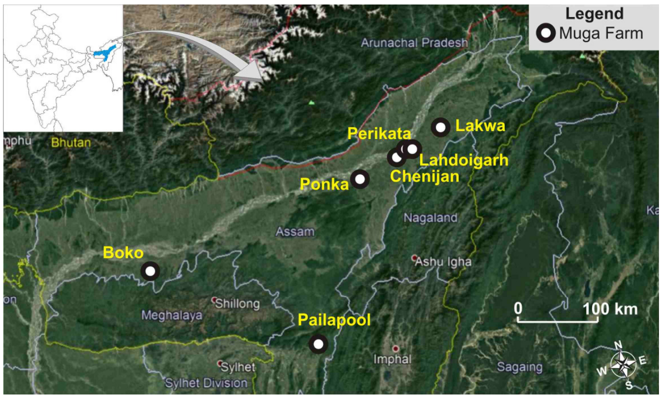

Fig. 1 : Survey and collection of Stink bug (*E. furcellata*) from different locations of Assam

Table 1: Survey and collection of stink bug, *E. furcellata* from different geographical locations of Assam

Name of location	Latitude	Longitude
CMERTI Farms	26°47'04.3"N	94°20'35.3"E
GCC Chenijan	26°46'18.3"N	94°16'36.9"E
Lakwa	26°59'52.5"N	94°47'46.6"E
Perikata	26°46'35.7"N	94°23'33.7"E
Ponka	26°35'01.0"N	93°46'26.8"E
Pailapool	24°50'04.7"N	93°01'39.7"E
Boko	25°59'25.8"N	91°15'14.3"E

Constant silent observations was required in the Muga rearing fields as the stink bug could hide under the leaves or branches of the host plants when sensing human approach in the rearing fields. Close observations were made in the Muga rearing fields in respect to their feeding behavior of the bugs. Stink bugs were collected using insect trapping net, counted their numbers, sexing of the adults was performed and cultured in the laboratory condition feeding wild caterpillars, maintaining temperature at 27^{o}C±2 and relative humidity 70-75% to study life cycle and biology of the stink bug.

Results and Discussion

There are reports that Muga silkworm is attacked by different insect pests from different parts of the country and other countries as well (Chaudhury, 1981; Thangavelu *et al.*, 1988; Singh & Das, 1996). *E. furcellata* is reported from Southeast Asia, Japan, India, and Taiwan, and has been preying on Lepidopteran, Coleopteran and Heteropteran insects (Ahmad, 1996; Chu, 1975; Chang, 2002; Jakhmola, 1983; Prasad *et al.*, 1983). This predator is regarded to be a generalist. It is a serious predator of Muga silkworm (Kumar and Rajkhowa, 2012). Predators cause damage to tasar larvae also during early instars. Due to these pests the production of tasar silk is affected considerably. *E. furcellata* (Hemiptera: Pentatomidae) is very serious predator which attacks the silkworm during young age rearing (Siddaiah and Devi, 2015). The predatory bug *E. furcellata* Wolff is found especially in cotton, chickpea and vegetable fields and has been found preying on larvae of leaf worm, spotted bollworm and American bollworm in Myanmar (Gillham, 1980; Yi and Kyi, 2000; Nyunt, 2001). Stink bug, *E. Furcellata* is very serious predator which attack the silkworm during young age rearing. The prevalence was more during II and III crop rearing than in I crop rearing season. It survives on other hosts during non-rearing season. Some of the pests/herbivoures of tasar host plant like larvae of vapourer tussock moths, semilooper, leaf hopper nymphs and boll headed caterpillar etc., serve as alternate (secondary) hosts to *E. furcellata* (Aruna and Devi, 2015). *E. furcellata* is commonly known as stink bug and it is considered as major pest of Muga silkworm. This stink bug has been reported as predator of Muga silkworm larvae causing considerable damage and loss to the silk industry in North Eastern India. From the field survey, it was revealed that stink bug generally attacks Muga silkworm at the height of 3 meter and above and both nymphal and adult stage cause damage to Muga silkworm. It has long and very strong proboscis. This Stink bug generally attack to first instar, second instar and third instar of silkworm.

Fig. 2: Stink bug, *E. Furcellata* attacking first and second instar Muga silkworm in the rearing fields.

Stink bug even attacked wild Muga cocoons piercing its proboscis into Muga pupae and sucked the haemolymph if silkworm larvae are not available in the rearing field. The feeding behavior of stink bug was found very tactical. Before attacking to Muga silkworm, the first strategy of stink bug was to approach to its prey (Muga silkworm) slowly and suddenly stabbed its proboscis into the Muga silkworm, causing injury and affecting the central nervous system. After then stink bug predator waited for sometimes till the silkworm got paralyzed or immovable. Later the stink bug approached to the injured Muga silkworm and took the chance to reinsert its proboscis for sucking haemolymph.

Life cycle of *E. furcellata*

Stink bug (*E. furcellata*) were collected from Muga rearing fields. Number of stink bugs collected from Muga rearing fields was counted after every collection and reared in laboratory condition. The life cycle of *E. furcellata* completed in 70-75 days including egg incubation period. Rearing of stink bug was taken place continuously for five generations. Stink bug, *E. furcellata* is multivoltine in nature. It has five nymphal instars, adult and egg stage. Both nymphal stage and adult stage of *E. furcellata* attacked to Muga silkworm.

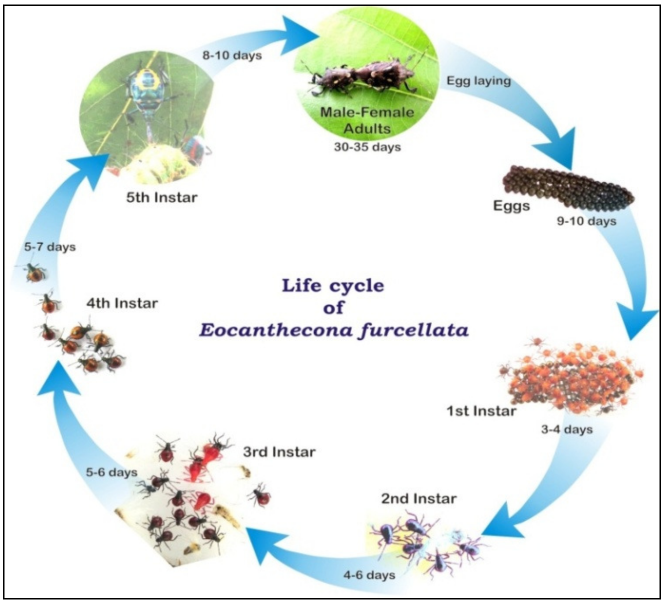

Fig. 3: Life cycle of stink bug, *E. furcellata*

Adults: Adults are dark brown in colour, which may vary based on different geographical region. The adults are dimorphic with thoracic markings. Female stink bug is broader in size as compared to male. Pronotal spines were seen only in adults. The life longevity of male and female stink bugs was noticed. Longevity of female stink bugs was found more than male. The average longevity of adult stink bug was found 30-35 days. After fifth instar, nymphal stage turns to adult stage. Later on, male and female adults started copulation after 3 days of moulting from fifth instar nymph. After copulation, first batch of viable eggs was laid by the female bugs after 3-4 days of mating. Female adults oviposited eggs in cluster, clued on the leaves. A matured female stink bug oviposited about 90 eggs on average and fertility is about 80-85%.

Eggs: Eggs were oviposited in cluster, clued either on the leaf or wall of the rearing container. The shape of stink bug eggs are round and size of eggs are about 1.0 mm long and 0.95 mm wide. In natural environment, stink bugs layed eggs on the leaves and shoots of plant. The colour of the eggs was brownish and shining in appearance. The incubation period of eggs is 9-10 days.

Nymphal stage: Nymphal and adult stage of stink bug are the feeding stage of stink bug. Freshly emerged nymphs were reddish in colour and gregarious. Later with the advancement of their growth, they moved separately in search of their prey. As the nymphs grew, blackish patches were developed on the mid dorsal and lateral part of the abdomen. There are five nymphal instars and total longevity of nymphal stages is about 30-35 days. Wing buds developed in last instar and the nymphs turned in to yellowish orange colour before moulting into adults.

Feeding behaviour of *E. furcellata*

E. furcellata, commonly known as stink bug is considered as major pest of Muga silkworm. This stink bug has been reported as predator of Muga silkworm larvae causing considerable damage and loss to the silk industry in North Eastern India. From the field survey, it was revealed that stink bug generally attacks Muga silkworm at the height of 3 meter and above and both nymphal and adult stage cause damage to silkworm. It has long and very strong proboscis. This Stink bug generally attack to first instar, second instar and third instar of silkworm. Stink bugs hardly attack fourth and fifth instars of Muga silkworm. If the silkworm larvae are not available in the rearing field, they attack even Muga cocoons piercing their long proboscis and suck the haemolymph from the pupa. In the field, the feeding behavior of this bug is very tactical and they have the habit of hiding when they perceive the signal of human or other animal approach. During attack, the first strategy is to approach its prey (silkworm) slowly and suddenly stab its proboscis into the body of the silkworm, causing injury and affecting the central nervous system. Later, the stink bug will again attacked the paralyzed Muga silkworm. After piercing its proboscis to Muga silkworm, the feeding process continues upto 20-30 minutes. A single predator can consume 100-150 larvae. The damage caused by this predator in Muga silkworm rearing is about 25% (Kumar and Rajkhowa, 2012). Most of the time, stink bug sucked haemolymph from pleural or ventral side of the silkworm.

In respect to the occurrence of bug predators, abiotic factors responsible for their population dynamic have been studied. It is found that seasonal occurrence of stink bugs were mainly in summer season, which means temperature is the main climatic factor responsible for the population resurgence of stink bug predator. The loss due to this bug predator alarmingly high in the summer crops *viz.*, pre-seed viz., Aherua and Jarua and seed crops viz., Chotua and Bhodia compared to the commercial crops viz., Jethua and Kotia (Singh *et al.*, 2019). Population of stink bug predator subsided with the onset of winter starting from November to February due to hibernation. Understanding their seasonal occurrence, proper identification of the stink bug attack in rearing fields, adoption of mechanical and cultural control practices are crucial to manage stink bug predators at farmer's level.

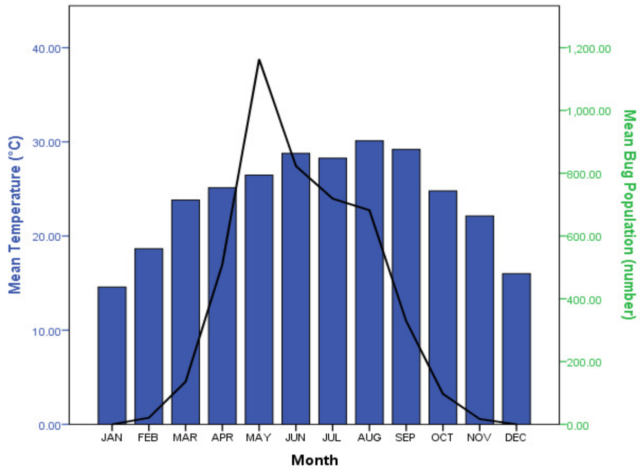

Fig.4: Occurrence of *E. furcellata* in respect to average temperature in 2018

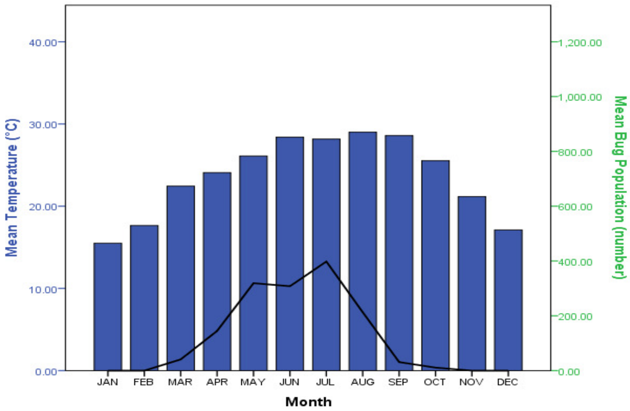

Fig. 5: Occurrence of *E. furcellata* in respect to average temperature in 2019

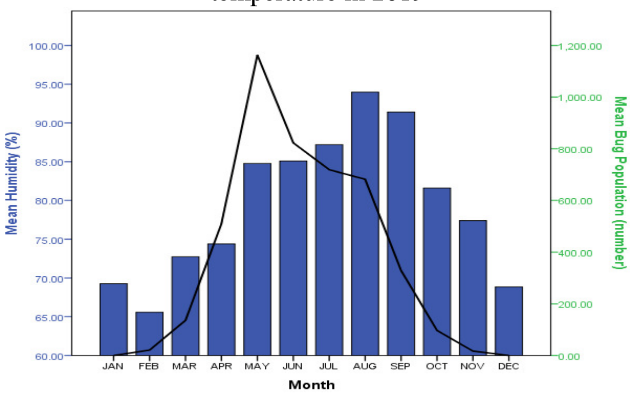

Fig. 6: Occurrence of *E. furcellata* in respect to relative humidity in 2018

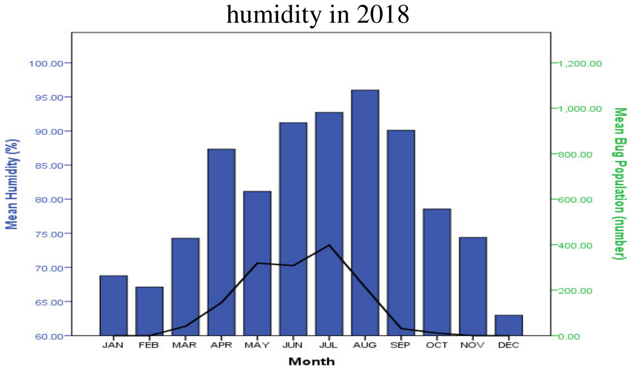

Fig. 7: Occurrence of *E. furcellata* in respect to relative humidity in 2019

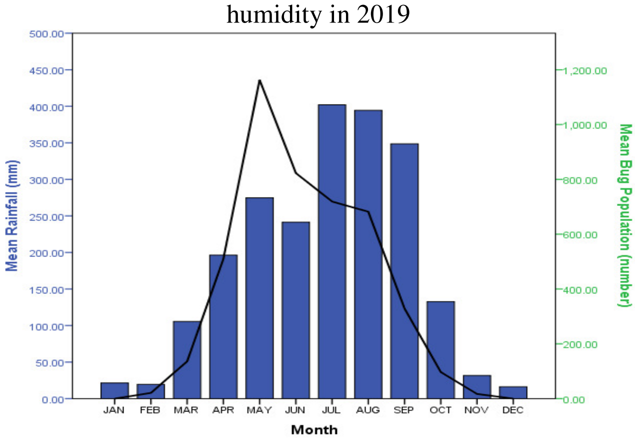

Fig. 8: Occurrence of *E. furcellata* in respect to related rainfall in 2018.

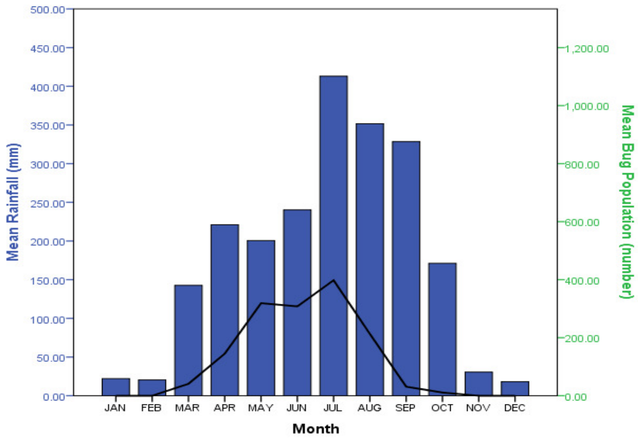

Fig. 9: Occurrence of *E. furcellata* in respect to related rainfall in 2019

From the above figures, it is revealed that temperature and humidity play important role in determining the seasonal occurrence of bug predator, *E. furcellata* in Muga ecosystem. Among the three abiotic parameters considered in the study to determine the population dynamic of stink bug predator, temperature plays major role in the development of their population. With the onset of spring season, occurrence of *E. furcellata* was visible in Muga rearing fields.

Maximum number of *E. furcellata* was found in May and its occurence was continued till August in 2018. However, in 2019, maximum number of *E. furcellata* was found in July and it was appearance was continued till October. From November onwards, when winter season switch on, *E. furcellata* population reduced and not appeared during whole winter season due to hibernation.

Occurrence of *E. furcellata* its correlation with climatic factors

It was hypothesized as found from several studies about trend of hemipteran population such as stink bug population may also highly dependent on climatic factors like humidity, temperature, rainfall *etc.* Under present study also temperature and rainfall was found to have highly positive correlation with bug population which was found significant at even 1 per cent level of significance in both of the data of bug collection in the year of year of, 2018 and 2019 (Table 2). The humidity also found to have similar relation but in lesser intensity as evident from r- value and its significance at 5 per cent level in both of the data collection year. The relationship of bug population with climatic condition correlates has been further elaborated in Table 3 and Table 4 through stepwise regression analysis. Though the population emergence in both year vary greatly (as presented in figures No. 9) but in both of the study year temperature was found to be more important climatic factor than other factors in deciding bug population emergence. Both of the year temperature solely contributed towards 65 per cent and 63.60 per cent variation in bug population. So, it can be considered that temperature is one of the major factor which control the stink bug emergence in Muga ecosystem.

Table 2: Correlation of Bug Population with Predictor variables

Climatic correlates (Predictor Variables)	2018		2019	
	Correlation coefficient	Significance (p value)	Correlation coefficient	Significance (p value)
Temperature	0.806**	0.002	0.798**	0.002
Humidity	0.664*	0.018	0.707*	0.010
Rainfall	0.772**	0.003	0.717**	0.009

***Correlation is significant at the 0.01 level (2-tailed)*
**Correlation is significant at the 0.05 level (2-tailed)*

Table 3: Regression analysis (Stepwise regression) of effect of predictor variables on dependent variable (stink bug population collected in 2018)

Estimation of effect size of predictor variables on bug population (Stepwise Regression Analysis) in 2018										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.806[a]	0.650	0.614	245.79	0.650	18.533	1	10	0.002	1.241

a. Predictors: (Constant), Temperature
b. Dependent Variable: Bug Population

Table 4: Regression analysis (Stepwise regression) of effect of predictor variables on dependent variable (stink bug population collected in 2019)

Estimation of effect size of predictor variables on bug population (Stepwise Regression Analysis) in 2019										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.798[a]	0.636	0.600	94.39454	0.636	17.506	1	10	0.002	1.236

a. Predictors: (Constant), Temperature
b. Dependent Variable: Bug Population

Conclusion

As Muga silkworm rearing is conducted in open environment, they are attacked by various insect pests and predators in the rearing fields. The yield of Mugaculture is constrained due to several natural abiotic and biotic vagaries. Among these factors, predation of Muga silkworm by insect predator, stink bug (*E. furcellata*) is very economically important that cause crop loss significantly during spring (Jethua; Commercial crop) and summer crops (Aherua; pre-seed), (Bhodia; seed). To take up management practices of this insect predator, foremost requirement is to study the population dynamic, biology and seasonal occurrence of *E. furcellata* in a particular agro-climatic condition. The seasonal occurrence of *E. furcellata* is very phenomenal during certain period of the year i.e. summer. The population development of *E. furcellata* is positively correlated with abiotic factors such as temperature, humidity. Understanding seasonal occurrence and proper identification of different stages of *E. furcellata* will help to control the insect predator at farmers level. Adoption of Integrated Pest Management practices, such as mechanical and cultural control are low cost effective methods to manage stink bug predator, *E. furcellata*.

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