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Diurnal activity and seasonal incidence of mirid bug, *Nesidiocoris tenuis* (Reuter), on bottle gourd and its natural enemies in relation to weather parameters

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ABSTRACT: Bottle gourd, *Lagenaria siceraria* (Molina) Standley, is an important cucurbit crop often affected by insect pests. A field study was conducted during *Kharif,* 2024 at Horticulture Farm, Sri Karan Narendra College of Agriculture, Jobner, Jaipur, to assess the diurnal activity and seasonal incidence of the mirid bug, *Nesidiocoris tenuis* (Reuter), a major emerging pest of bottle gourd, and its natural enemies. The mirid bug, *N. tenuis,* exhibited clear diurnal activity, with the maximum abundance at noon, followed by afternoon and early morning and declining activity towards evening. Infestation on leaves began in the 33rd Standard Meteorological Week (SMW) (0.72 bugs/ five leaves per plant) and peaked in the 39th SMW (23.76 mirid bugs/five leaves per plant). Populations on flowers and fruits appeared during the 36th and 37th SMW and reached peaks in the 40th SMW (11.28 mirid bugs/ five flowers per plant) and in the 41st SMW (19.60 mirid bugs/ five fruits per plant), respectively. Natural enemies, mainly coccinellids and spiders, appeared from the 34th SMW, with peak populations of 3.76 and 5.72 per plant, respectively. Mirid bug incidence showed a significant positive correlation with maximum temperature and sunshine hours ($p<0.05$), while fruit infestation was negatively correlated with rainfall. The regression analysis indicated that abiotic factors explained 88.3- 93.3% of mirid bug population variability, highlighting maximum temperature as the most influential factor. The present study findings provide a basis for forecasting and sustainable management of *N. tenuis* in bottle gourd.

Keywords: Diurnal activity, correlation, mirid bug, natural enemies, regression, weather parameters.

INTRODUCTION

Bottle gourd, *Lagenaria siceraria* (Molina) Standley, is an important cucurbitaceous vegetable crop widely cultivated in tropical and sub-tropical regions of the world (Halder *et al.,* 2021; Behera *et al.,* 2023). The crop is valued for its nutritional and medicinal properties. The fruits are a good source of vitamin C, essential minerals such as iron, phosphorus, potassium and magnesium, and contain high levels of choline, which plays an important role in brain function and metabolism (Rahman, 2003; Milind and Satvir, 2011). In addition, bottle gourd has been reported to possess several pharmacological properties including anti-hyperlipidemic, anti-inflammatory, antioxidant, anti-inflammatory, immuno-modulatory, hepatoprotective, and cardioprotective activities (Milind and Satvir, 2011; Minocha *et al.,* 2015; Mahapatra *et al.,* 2023).

In India, bottle gourd occupies an area of approximately 200 thousand hectares, with an annual production of about 3.369 million metric tonnes (Anonymous, 2022–23a). Major bottle gourd-producing states include Uttar Pradesh, Rajasthan, Haryana, Gujarat, Punjab, Bihar, West Bengal, Madhya Pradesh, Karnataka, Assam and Maharashtra. In Rajasthan, the crop is grown mainly in Jaipur, Alwar, Sawai Madhopur, Sirohi, Tonk, Bikaner, Dausa, Jodhpur and Kota districts, covering about 3.79 thousand hectares with a total production of 25.76 thousand metric tonnes and an average productivity of 6.80 t ha^{-1} (Anonymous, 2022-23b).

The productivity of the bottle gourd is constrained by several biotic and abiotic factors, among which insect pests constitute a major limitation (Haldhar and Maheshwari, 2018; Halder *et al.,* 2021; Yadav *et al.,* 2024). Bottle gourd is infested by a diverse complex of insect pests throughout its growth period, including the red pumpkin beetle (*Aulacophora foveicollis* Lucas), melon fruit fly (*Zeugodacus cucurbitae* Coquillett), hadda beetle (*Henosepilachna vigintioctopunctata* Fabricius), aphid (*Aphis gossypii* Glover), whitefly (*Bemisia tabaci*

Gennadius), leaf miner (*Liriomyza trifolii* Burgess), jassid (*Amrasca biguttula biguttula* Ishida), bottle gourd plume moth (*Sphenarches caffer* (Zeller)), pumpkin caterpillar (*Diaphania indica* (Saunders)), and mirid bugs such as *Nesidiocoris tenuis* (Reuter), *Nesidiocoris cruentatus* (Ballard), and *Metacanthus pulchellus* Dallas (Bhowmik and Saha, 2017; Halder *et al.,* 2017; Haldhar and Maheshwari, 2018; Halder *et al.,* 2021; Patra *et al.,* 2022; Raghavendra *et al.,* 2022; Parkash *et al.,* 2023; Divekar *et al.,* 2024). Among these, mirid bug *N. tenuis* (Reuter) (Hemiptera: Miridae) has recently emerged as an important pest of bottle gourd in several regions of India. Severe infestations were recorded during the *Kharif* season of 2023 in Rajasthan, resulting in significant yield losses and reduction in fruit quality. Previous studies have reported that infestation of *N. tenuis* can cause substantial crop losses, with 70-80 % fruit damage and about 30 % of shoots under severe conditions (Halder *et al.,* 2021). Similarly, Raghavendra *et al.* (2022) reported fruit damage ranging from 61.90 to 73.68 % due to this pest. Both nymphs and adults of *N. tenuis* feed tender plant tissues by piercing and sucking plant sap, resulting in small punctures on leaves surrounded by irregular chlorotic areas. On young fruits, feeding results in brown puncture marks accompanied by sap or resin exudation, which later develops into reddish-brown spots or blister-like lesions. These symptoms lead to blemished fruits with reduced market value, as consumers prefer smooth, light green, and unblemished fruits (Halder *et al.,* 2017; Halder *et al.,* 2021; Raghavendra *et al.,* 2022). However, *N. tenuis* is a zoophytophagous, capable of feeding on both plant tissues and small arthropods, including lepidopteran larvae and soft-bodied pests.

Understanding the population dynamics and diurnal activity patterns of this emerging pest is essential for developing timely and effective management strategies. Weather parameters such as temperature, relative humidity and rainfall are known to influence the seasonal abundance and activity of insect pests. Although some studies have documented the seasonal occurrence of *N. tenuis* on cucurbit crops (Bhatt and Patel, 2018; Halder *et al.,* 2017; Halder *et al.,* 2021; Raghavendra *et al.,* 2022), detailed information on its seasonal incidence and diurnal activity in relation to weather parameters under the semi-arid agro-climatic conditions of Rajasthan is limited. We hypothesized that the seasonal incidence and diurnal activity of *N. tenuis* on bottle gourd are strongly influenced by crop phenology and prevailing weather conditions in semi-arid ecosystems. Therefore, the present study was conducted to investigate the diurnal activity and seasonal incidence of *N. tenuis* on bottle gourd and to analyse its relationship with key weather parameters. The findings are expected to provide baseline information for the development of region-specific and timely pest management strategies.

MATERIALS AND METHODS

Experimental site and crop establishment

A field experiment was conducted *Kharif*, 2024, at the Horticultural farm, Sri Karan Narendra College of Agriculture, Jobner, Jaipur, Rajasthan, India (26° 05' N, 75° 28' E) to study the diurnal activity and seasonal incidence of the mirid bug, *N. tenuis*, on bottle gourd, *Lagenaria siceraria*. The bottle gourd variety 'Pusa Naveen' was sown during the second week of July 2024. The experiment consisted of five plots, each measuring 2.0 m x 5.0 m. The crop was planted at a spacing of 2.5 m between rows and 0.5 m between plants. Five plants were randomly selected and tagged in each plot for regular observations. Recommended agronomic practices were followed for crop production, except that no plant protection measures were applied to allow natural infestation of insect pests and associated natural enemies.

Insect identification and sampling procedure

Insect specimens collected from the infested field were identified as *Nesidiocoris tenuis* (Reuter) by the ICAR–National Bureau of Agricultural Insect Resources, Bengaluru, India. The population of mirid bugs (both nymph and adult) was recorded at weekly intervals from leaves, flowers and fruits of the tagged plants. For assessing diurnal activity, observations were recorded from five leaves per plant and five fruits per plot at four intervals: 07:00 h (morning), 12:00 h (noon), 15:00 h (afternoon) and 19:00 h (evening). Seasonal incidence of the mirid bug was monitored using the same sampling procedure, with the addition of five flowers randomly selected per plant. The population of natural enemies, particularly ladybird beetles (Coccinellidae) and spiders (Araneae) was recorded from tagged plants during each observation period.

Statistical analysis

The data on mirid bug population and natural enemies were analyzed to determine their relationship with prevailing weather parameters using correlation and regression analysis. Statistical analyses were performed using Microsoft Excel.

RESULTS AND DISCUSSION

Diurnal activity of mirid bug

The present investigation was conducted to assess the diurnal activity and seasonal incidence of mirid bug, *N. tenuis,* and its natural enemies on bottle gourd, *L. siceraria,* under prevailing climatic conditions during *Kharif* 2024. The results indicated that the mirid bug population persisted throughout both the vegetative and reproductive stages of the crop, indicating its continuous association with bottle gourd during the cropping period. Diurnal variations in mirid bug activity were recorded on both leaves and fruits. Infestation on leaves began during 33rd standard meteorological week (SMW) with a low population, which gradually increased and reached a peak during the 38th SMW. Throughout the observation period, mirid bug activity on leaves was consistently highest at noon, followed by afternoon, early morning and evening. The maximum population (27.40 bugs/ five leaves per plant) was recorded at noon. Similarly, the mean population density was highest during noon hours (13.48 ± 2.79) and lowest during evening hours (6.46 ± 1.64) (Fig. 1). The present findings corroborate earlier reports on the pest status and population dynamics of *N. tenuis* on cucurbitaceous crops. Raghavendra *et al.* (2022) reported that *N. tenuis* is a serious pest of bottle gourd, with the highest population density on tender vine tips, followed by fruits and leaves, and two distinct population peaks during the 21st and 24th SMW. Although the timing of peak activity differed slightly, the progressive increase and subsequent decline in pest population observed in the present study followed a similar seasonal trend.

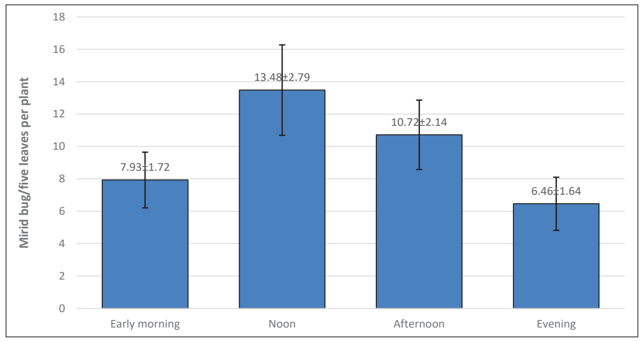

Fig. 1. Diurnal activity of mirid bug, *N. tenuis* on bottle gourd leaves

A similar diurnal pattern was recorded on fruits. Mirid bug infestation commenced during the 36th SMW and continued until the 44th SMW, with peak infestation observed during 41st SMW. The highest population (21.20 bugs/ five fruits per plot) was recorded during noon hours, followed by afternoon, early morning and evening observations. Mean population density on fruits was also highest at noon (10.78 ± 2.38 bugs/ five fruits per plot) and lowest during evening hours (6.80±1.89). These results clearly indicate that mirid bug activity is strongly influenced by the time of day, with peak activity occurring during mid-day hours (Fig. 2).

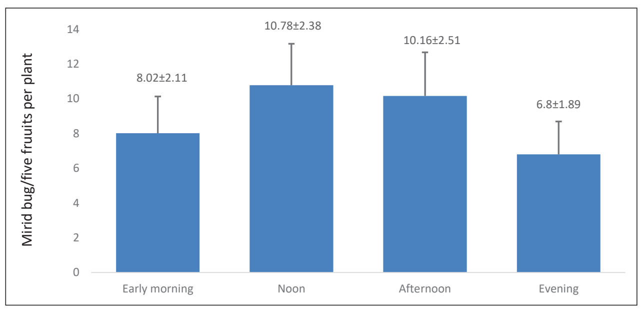

Fig. 2. Diurnal activity of mirid bug, *N. tenuis* on bottle gourd fruits

Table 1: Seasonal incidence of mirid bug, *N. tenuis* and their natural enemies on bottle gourd

SMW	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Sunshine hours	*N. tenuis* population/ plant		*N. tenuis* population five fruits/ plot	Natural enemies population/ plant	
	Max.	Min.	Mor.	Eve.			Leaves	Flowers	Fruits	Coccinellids	Spiders
33	31.41	24.84	96	83	26.4	1.28	0.72	0.00	0.00	0.00	0.00
34	33.11	22.72	95	79	34.8	2.50	3.36	0.00	0.00	0.12	0.20
35	33.91	24.54	93	79	45.2	5.01	11.40	0.00	0.00	0.36	0.80
36	32.54	24.24	96	82	93.7	4.08	10.84	0.96	0.00	1.04	1.12
37	32.81	24.18	94	80	18.3	4.35	15.92	2.52	4.20	0.92	2.32

38	32.67	23.54	93	71	19.3	3.24	17.64	4.52	8.40	1.60	2.96
39	35.42	24.37	86	63	0	8.42	23.76	9.68	15.20	2.88	5.72
40	36.40	22.52	79	55	0	8.51	22.68	11.28	17.20	3.76	4.24
41	36.94	20.71	62	41	0	8.41	20.72	8.16	19.60	2.72	3.28
42	36.58	17.21	63	33	0	7.91	18.16	5.64	14.40	1.68	2.40
43	35.04	17.45	61	35	0	7.08	7.28	1.88	6.80	0.52	1.12
44	33.24	13.9	65	29	0	7.88	3.92	0.00	1.20	0.08	0.52

Table 2: Correlation between mirid bug and natural enemies population with weather parameters

Weather parameters	Mirid bug population on			Natural enemies population	
	Leaves	**Flowers**	**Fruits**	**Coccinellids**	**Spiders**
Max. Tem. (°C)	0.682*	0.763**	0.871**	0.728**	0.620*
Min. Tem. (°C)	0.186^{NS}	0.070^{NS}	-0.136^{NS}	0.140^{NS}	0.184^{NS}
Mor. RH (%)	-0.171^{NS}	-0.308^{NS}	-0.540^{NS}	-0.236^{NS}	-0.151^{NS}
Eve. RH (%)	-0.168^{NS}	-0.311^{NS}	-0.515^{NS}	-0.233^{NS}	-0.178^{NS}
Rainfall (mm)	-0.325^{NS}	-0.520^{NS}	-0.636*	-0.376^{NS}	-0.442^{NS}
Sunshine hours	0.595*	0.664*	0.733**	0.630*	0.601*
Coccinellids	0.910**	0.982**	0.903**		
Spiders	0.933**	0.934**	0.841**		

* Correlation coefficient significant at the 0.05 level
** Correlation coefficient significant at the 0.01 level
NS, Non-significant

Population dynamics of mirid bug, *N. tenuis* on leaves, flowers and fruits of bottle gourd

Seasonal incidence of *N. tenuis* on leaves revealed that the pest first appeared during 33th SMW with a population of 0.72 bug per plant. The population increased steadily and reached a peak during the 39th SMW (fourth week of September) with 23.76 bugs per plant. Thereafter, the population declined gradually and reached a minimum level of 3.92 bugs per plant during the 44th SMW (Table 1). Correlation analysis indicated a significant positive association of mirid bug population with maximum temperature (r=0.682, $p<0.05$) and sunshine hours (r=0.595, $p<0.05$). A non-significant positive correlation was observed with minimum temperature, whereas non-significant negative correlations were recorded with morning relative humidity, evening relative humidity and rainfall (Table 2). The multiple regression analysis revealed that abiotic factors explained 82.8% of the variation in the mirid bug population, while stepwise regression indicated that maximum temperature alone contributed 46.5% to the observed variation (Table 3 and 4). The increasing pest importance of *N. tenuis* has also been documented by Halder *et al.* (2021), who reported its continuous occurrence from the 17th to 52nd SMW on bottle gourd in Varanasi, Uttar Pradesh, causing severe crop damage, including 70–80% fruit infestation and nearly 30% shoot damage.

The incidence of mirid bug on flowers began during the first week of September with a population of 0.96 bug per five flowers per plant. The population increased gradually and reached to its peak during the first week of October (40th SMW) with 11.28 bugs per plant. Subsequently, the infestation declined and reached the lowest population level (1.88 bugs per plant) during 43rd SMW (Table 1). Correlation analysis revealed a significant positive relationship between mirid bug population and maximum temperature (r = 0.763, $p < 0.01$) as well as sunshine hours (r = 0.664, $p < 0.05$). Other

Table 3: Multiple regression analysis between mirid bug and natural enemies with weather parameters

Insect-Pest (s)		Regression equation (Y=a+bX)	R^2 Value
Mirid bug on	Leaves	Y=-131.29[a]* + (1.91)$T_{Max.}$+ (2.88)$T_{Min.}$ +(0.79)RH1+ (-0.87)RH2 + (0.02)RF + (0.85)SS	0.828
	Flowers	Y=-69.76[a] + (0.97)$T_{Max.}$+ (1.76)$T_{Min.}$ +(0.44)RH1+ (-0.56)RH2 + (-0.01)RF + (0.05)SS	0.918
	Fruits	Y=-109.36[a] + (2.13)$T_{Max.}$+ (3.12)$T_{Min.}$ +(0.44) RH1+ (-0.91) RH2 + (-0.02)RF + (-0.82)SS	0.933
Coccinellids		Y=-21.84[a] + (0.29)$T_{Max.}$+ (0.56)$T_{Min.}$ +(0.14) RH1+ (-0.18)RH2 + (0.01)RF + (0.05)SS	0.883
Spiders		Y=-21.34[a] + (0.05)$T_{Max.}$+ (0.82)$T_{Min.}$ +(0.21) RH1+ (-0.25) RH2 + (-0.01)RF + (0.29)SS	0.917

a, Constant; T_{max}: Temperature maximum; T_{min}: Temperature minimum; RF: Rainfall, RH1: Morning relative humidity; RH2: Evening relative humidity; SS: Sunshine hours

Table 4: Stepwise regression analysis between mirid bug and natural enemies with weather parameters

Insect-Pest (s)		Regression equation (Y=a+bX)	R^2 Value
Mirid bug on	Leaves	Y=-87.49[a] + (2.94)$T_{Max.}$	0.465
	Flowers	Y=-54.33[a] + (1.70)$T_{Max.}$	0.582
	Fruits	Y=-114.57[a] + (3.57)$T_{Max.}$	0.758
Coccinellids		Y=-15.54[a] + (0.49)$T_{Max.}$	0.728
Spiders		Y=-18.21[a] + (0.59)$T_{Max.}$	0.384

weather parameters showed non-significant correlations (Table2). Multiple regression analysis indicated that weather factors together explained 90.8% of the variability in the mirid bug population, with maximum temperature alone accounting for 58.2% of the variation (Table 3 and 4). Seasonal incidence patterns observed in the present study are also consistent with those reported by Sharath *et al.* (2021), who recorded mirid bug activity on snake gourd from the 36th to 46th SMW with peak populations around the 40th SMW. Similarly, Mishra *et al.* (2015) reported the onset of mirid bug infestation during the 2nd SMW and a peak population of 0.52 bugs per plant during the 35th SMW, along with a significant positive correlation with temperature, supporting the temperature-dependent population build-up observed in the present investigation.

Infestation of *N. tenuis* on fruits was first observed during the 37th SMW with a population of 4.20 bugs per five fruits per plot (Table 1). The population increased progressively and reached its maximum during the 41st SMW with 19.60 bugs per plot. Thereafter, the population declined gradually and reached its lowest level during the 44th SMW (1.20 bugs per plot). Correlation analysis revealed a significant positive association between mirid bug population and maximum temperature (r = 0.871, $p < 0.01$) as well as sunshine hours (r = 0.733, $p < 0.01$), whereas rainfall showed a significant negative correlation (r = −0.636, $p < 0.05$). Other weather parameters exhibited non-significant correlations (Table 2). Multiple regression analysis indicated that weather variables together accounted for 93.30% of the variation in mirid bug population, with maximum temperature alone contributing 75.80% of the variation (Table 3 and 4). Comparable population dynamics have also been reported on other host crops. Bhagyasree *et al.* (2023) on tomato and Kumar and Sharma (2023) on sesame observed peak *N. tenuis* populations between the 38th and 40th SMW followed by a gradual decline. In agreement with the present findings, Halder *et al.* (2017) reported a significant positive relationship between temperature and mirid bug population, while relative humidity, wind velocity and rainfall showed negative but non-significant associations. However, Kumar and Sharma (2023) observed a positive association with morning relative humidity and a negative relationship with maximum temperature, suggesting that pest–weather interactions may vary depending on crop species, prey availability and prevailing agro-climatic conditions.

CONCLUSION

Nesidiocoris tenuis has emerged as an important pest of bottle gourd under field conditions. The pest exhibited a distinct seasonal incidence pattern, with peak populations occurring on leaves during the 39th SMW, followed by flowers in the 40th SMW and fruits in the 41st SMW, indicating a progressive shift in infestation across plant parts as the crop advanced in growth. Among the abiotic factors, maximum temperature and sunshine hours significantly influenced the population build-up of *N. tenuis*, whereas the remaining weather parameters showed no significant effect. The positive association of coccinellids and spiders with mirid bug populations suggests their potential role in the natural regulation of the pest. These findings improve our understanding of the seasonal dynamics of *N. tenuis* and provide a basis for developing timely and eco-friendly pest management strategies in bottle gourd cultivation.

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AUTHOR CONTRIBUTION STATEMENT

All authors have contributed significantly to the conception, execution, analysis and preparation of the manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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