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Prevalence of leaf eating larval stages of major insect pests of Lepidoptera in black gram

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Abstract
Continuous monitoring of insect pest populations in crops is critical to avoiding the losses due to pest damage. During August to November in 2016 and 2017, a field experiment was done to assess the extent of damage caused by the larval stages of Lepidopteran insect pest on black gram. This study used a random block design and three replications to determine the prevalence of a number of prominent insect pests of this order in the black gram crop. The leaf weber (*Omiodes indicata* Fab.), pod borer (*Maruca testulalis* Geyer), bihar hairy caterpillar (*Spilosoma obliqua* Walker) and the blue butterfly (*Lampides boeticus* L.) were the most common lepidopterans discovered in the field. Their larval stages were mostly leaf feeders, inflicting damage to the black gram crop at various phases of maturation. Relationship between climatic conditions and insect abundance was measured using Karl Pearson's coefficient of correlation; nevertheless, the results were inconsequential.

Keywords: Bihar hairy caterpillar, Black gram, blue butterfly, leaf weber, spotted pod borer

1. Introduction
Among the several forms of pulses, black gram (*Vigna mungo* L.) plays an important role in people's cuisines, particularly in Assam and North-East India. The leguminosae family and subfamily papilionaceae include black gram (Verdcourt, 1970) [27]. Pest problems cause the loss of 2.5 to 3.0 million tonnes of pulses each year (Rabindra *et al*., 2004) [14]. In India, 18 to 20 different insect pests attack the black gram (Singh and Singh, 1977) [20]. Assam and North-East India's agro-climatic conditions fluctuate within a beneficial range for insect pest growth and reproduction (Thakur and Firake, 2015) [24]. Many insects in the order Lepidoptera are also detrimental to economic crops, lowering output. Because lepidopteran larvae rely on plants for nourishment, they have an impact on plant output. These pests inflict harm at various phases of crop growth and under diverse weather circumstances. Berani *et al*. (2017) [1] discovered two lepidopteran insects in his experiment on black gram: the Bihar hairy caterpillar (*Spilosoma obliqua* Walker) and the pod borer (*Maruca testulalis* Geyer). People of our experimental area and in other places have adopted a traditional agricultural technique that has been passed down from generation to generation to address the problem of insect infestations. For example, sequential cropping is a cropping strategy in which farmers cultivate two to three short-term crops in succession. Indigenous soil health care practises are applied in this manner without official knowledge, and soil fertility and productivity enhanced as a result. Farmers in Assam's Kamrup (Rural) district have been seen sowing black gram seeds on paddy nursery fields just days before transplanting rice plants. The pest complex composition of black gram grown in paddy nursery fields may differ from other similar cultivations. As a result, understanding the qualitative and quantitative makeup of insect pests, as well as their impact on black gram, is crucial. Regardless of the approach employed to control or manage insect pests, timely surveying and monitoring is always advantageous to improved management. The current experiment was designed to examine the population fluctuations of the major lepidopteron insect pest that infests black gram.

2. Materials and Methods
2.1 Site of experiment: The Kamrup district, one of the 35 districts that make up the state, is located in the Brahmaputra valley. From August through November of 2016 and 2017, our experimental facility was located in the Hajo revenue circle of this area (26.3303^0 N,

91.5148^0 E). The climate in this region is humid subtropical, with considerable summer rainfall, uncomfortable winters, and high humidity. Paddy is the predominant crop in this region, with three major varieties: winter (Sali), autumn (Ahu), and summer (Rabi). During the Kharif season, additional crops such as Arahar and black gram are planted (Source: Kamrup Rural Department of Agriculture). As key elements of this project, a survey and observational study of insects from the order lepidoptera that cause damage to black gram were undertaken, with three replications, to determine their qualitative and quantitative parameters, nature of damages, and seasonal incidences. The experimental area shows a mixed and sequential cropping of a native black gram variety "Saonia mah" on paddy nursery fields. We chose this plot for our experiment since no fertiliser, pesticides, or irrigation was employed to promote crop growth. An elevated bund of roughly 0.6 m separated two locations in the paddy nursery, and the experiment was set up in three replications with identical spacing between plots. The paddy nursery field covered an area of 668.5 square metres (7200 square feet). Within the field, three plots were established, and each was monitored regularly.

2.2 Method of observation: Southwood and Handerson's (2000) [23] approaches were utilised to observe insects and ecological characteristics. Observations were done between 6 and 8 a.m., when insects are least active. The visual counting approach was employed on 5 randomly selected plants in each replication to count the insect pest population, particularly in larval stages in the "Z" sample pattern. To avoid edge effects, a few steps were taken from the plot boundary into the field before sampling the first plant. To keep track of insect numbers, a field data sheet template was created. Observation began on September 4, 2016, in the 35th standard week, and on September 10, 2017, in the 36th standard week. Overall, data was taken from three plots after two weeks of seeding at regular intervals during each standard week from September to November in 2016 and 2017. The pest status of the insect was classified as high, medium or low according to the "Pest Risk Analysis (PRA) Training, Participant Manual" (FAO, 2007) [6]. When an insect is present for a period of days, it is considered a major pest, and treatment is required, resulting in financial losses. Minor pest, when insects cause pest incidence to occur for a short period of time with little need for treatment and no significant economic losses. Damage caused by lepidopteran insect pests was also observed by examining the pods, stems, and leaves. The results of population fluctuation were associated with abiotic variables. To investigate the instantaneous effect of weather parameters such as temperature (minimum and maximum), relative humidity (minimum and maximum), on the population succession of insect pests, the correlation coefficient value was calculated using standard statistical procedures.

2.3 Statistical parameters: The field study data was used to generate a quantitative estimate of the pest at various phases of crop growth. The following statistical approaches were used to calculate Mean density, Relative density, and Species Abundance in order to determine population parameters:

$$\text{Mean Density} = \frac{\sum x_i \times 100}{N}$$

Where x_i = Number of insects in ith sample and
N= Total numbers of plants sampled.

$$\text{Relative Density (RD)\%} = \frac{\text{No. of individual of one species} \times 100}{\text{total no.s of individual of all species.}}$$

iii) Species Abundance: It was calculated as the number of individuals of a species observed per plot. The relative abundance of one species in relation to all other species in an environment is referred to as relative species abundance. These are the indicators that are relevant for computing biodiversity.

3. Results

The observations from the two years have been collated and presented together. Four insect species have been identified as black gram pests, causing crop damage. *Spilosoma obliqua* (Fam. Arctiidae), *Maruca testulalis* (Fam. Noctuidae), *Lampides boeticus* (Fam. Lycaenidae), and *Omiodes indicata* (Fam. Pyralidae) were insect pests identified in the field and from the order Lepidoptera (4 families) (Table 1).

Table 1: Insect pests with nature of damage:

Sl. N.	Common name	Scientific name	Order/Family	Nature of damage	Status of damage
1	Leaf weber	*Omiodes indicata*	Lepidoptera/Pyralidae	Leaves	High
2	Bihar Hairy caterpillar	*Spilosoma obliqua*	Lepidoptera/Arctiidae	Leaves	High
3	Spotted Pod borer	*Maruca testulalis*	Lepidoptera/Noctuidae	Leaves, pods	High
4	Blue butterfly	*Lampides boeticus*	Lepidoptera/Lycaenidae	Flowers, Pods, Leaves	Medium

3.1 Composition and nature of damage: During the two-year survey, the majority of insect pest species discovered were mostly foliage eaters (Table 1). The most important defoliators included *Omiodes indicata*, *Spilosoma obliqua,* and *Maruca testulalis*. Among the pod sucking insect pests discovered in the crop field were *Maruca testulalis* and *Lampides boeticus*. *Lampides boeticus* was the insect that caused floral damage, but it can also cause damage to other sections of the plant. *Omiodes indicata*, a leaf weber, feeds on the green components of the leaves, forcing the leaves to curl to fit the insect. This pest is one of the most damaging to this crop. *Maruca testulalis* not only damages pods but also acts as a leaf weber, causing leaf damage. Caterpillars of *Spilosoma obliqua* eat predominantly on the undersides of leaves. They eat on chlorophyll in the leaf, which causes it to appear colourless. Pest incidence was rated as high, medium, or low depending on the severity of the damage. As the status was high in both years of the study, *Omiodes indicata* (larva), *Maruca testulalis* (larva), and *Spilosoma obliqua* (larva) all caused severe damage. The damage status of *Lampides boeticus* (larva) was medium.

3.2 Population succession: The crop field's mean population/plant and total population/standard week from weekly observations in 2016 and 2017 were recorded (Tables 2 and 3). All pests recorded in the investigation were detected in the field during the 39th and 40th standard weeks. *Omiodes indicata* was first found in the 36th standard week, with a mean population of 0.8/plant, and peaked in the 39th standard week, with a population of 1.53/plant. However, the first appearance in 2017 happened during the 37th standard week, with a mean population of 0.2/plant. With a mean population of 1.46 per plant, this pest peaked around the 40th standard week. According to data obtained in 2016, the population of spotted pod borer (*Maruca testulalis*) ranged from 0.13 to 0.4 larvae per plant over the season. Its population was first reported during the 36th standard week, with 0.4 pod borer larvae per plant. This was the highest population, which gradually dropped to 0.13/plant between the 38th and 42nd standard weeks. The spotted pod borer population was first seen in the 37th standard week of 2017, with a mean population of 0.2/plant, and peaked at 0.46/plant in the 40th and 41st standard weeks. *Lampides boeticus* appeared in the 35th standard week of 2016 with a mean population of 0.46/plant and peaked in the 39th standard week with a mean population of 1.06/plant. After the 42nd standard week, the population began to decline. It debuted in the 37th standard week of 2017 with a mean population of 0.26/plant and peaked in the 40th standard week with a population of 1.6/plant. After the 44th standard week, the population was reduced to zero. The observational data revealed that the initial appearance of the bihar hairy caterpillar was recorded during the 38th standard week, with a larval population of 2.46 larvae/plant, which peaked at 2.93 larvae/plant during the 39th standard week. In the black gram crop field in 2016, 362 individual insect specimens from four species and four families were observed, while 336 individual specimens were observed in 2017 (Table 4).

Table 2. Total individual and mean population of insect pests during 2016:

Std. Week	*Omiodes indicata*		*Lampides boeticus*		*Spilosoma obliqua*		*Maruca testulalis*	
	Total	Mean (per plant)	Total	Mean (per plant)	Total	Mean (per plant)	Total	Mean (per plant)
35	-	-	7	0.46	-	-	-	-
36	2	0.13	8	0.53	-	-	6	0.4
37	4	0.26	9	0.6	-	-	5	0.33
38	9	1.26	11	0.73	37	2.46	2	0.13
39	23	1.53	16	1.06	44	2.93	4	0.26
40	11	0.73	12	0.8	41	2.73	6	0.4
41	6	0.4	12	0.8	22	1.46	3	0.2
42	9	0.6	-	-	-	-	2	0.13
43	6	0.4	-	-	-	-	3	0.2
44	-	-	7	0.46	9	0.6	-	-
45	-	-	-	-	14	0.93	-	-
46	-	-	5	0.33	7	0.53	-	-
Total	70	-	87	-	174	-	31	-

Table 3. Total individual and mean population of insect pests during 2017:

Std. Week	*Omiodes indicata*		*Lampides boeticus*		*Spilosoma obliqua*		*Maruca testulalis*	
	Total	Mean (perplant)	Total	Mean (perplant)	Total	Mean (perplant)	Total	Mean (perplant)
36	-	-	-	-	-	-	-	-
37	3	0.2	4	0.26	-	-	3	0.2
38	5	0.33	9	0.6	2	0.13	6	0.4
39	16	1.06	8	0.53	22	1.46	5	0.33
40	22	1.46	24	1.6	37	2.46	7	0.46
41	12	0.8	6	0.4	26	1.73	7	0.46
42	5	0.3	5	0.33	22	1.46	4	0.26
43	12	0.8	7	0.46	8	0.53	17	1.13
44	2	0.13	-	-	-	-	6	0.4
45	3	0.2	-	-	9	0.6	-	-
46	-	-	-	-	-	-	12	0.8
47	-	-	-	-	-	-	-	-
Total	80	-	63	-	126	-	67	-

Table 4. Species Abundance with mean density and relative density in 2016 and 2017:

Sl.No	Insect pest species	Year	Abundance				Mean Density per plot	Relative Density
			P-I	P-II	P-III	Total		
1	*Omiodes indicata*	2016	32	15	23	70	38.89	19.34
		2017	30	22	28	80	44.44	23.81
2	*Spilosoma obliqua*	2016	66	63	45	174	96.67	48.07
		2017	45	39	42	126	70.00	37.50
3	*Maruca testulalis*	2016	11	13	7	31	17.22	8.56
		2017	25	19	23	67	37.22	19.94
4	*Lampides boeticus*	2016	39	32	16	87	48.33	24.03
		2017	27	17	19	63	35.00	18.75

3.3 Influence of temperature and relative humidity: The relationship between pest population incidence and temperature and relative humidity was evaluated, and the majority of the time the correlation was minimal (Table 5). According to a correlation study conducted in 2016, a non-significant positive link was identified between maximum temperature and the pest populations of *Omiodes indicata, Lampides boeticus, Spilosoma obliqua* and *Maruca testulalis*. Similarly, the minimum temperature had a non-significant positive link with *Spilosoma obliqua* and *Maruca testulalis*, but a substantial positive correlation with *Lampides boeticus* and *Omiodes indicata*. According to the correlation study, a non-significant positive association was identified in 2017 between maximum temperature and the pest populations of *Lampides boeticus* and *Maruca testulalis*. The pests that exhibited a strong positive relationship with maximum temperature were *Omiodes indicata* and *Spilosoma obliqua*. Similarly, minimum temperature correlated with *Spilosoma obliqua* and *Omiodes indicata* but not with *Lampides boeticus* and *Maruca testulalis*. In 2016, the maximum relative humidity exhibited a non-significant negative connection with *Maruca testulalis*. Maximum relative humidity had a substantial inverse relationship with *Lampides boeticus*, *Omiodes indicata* and *Spilosoma obliqua*. The minimal relative humidity had a non-significant negative correlation with all insect pests during the investigation. Maximum relative humidity and *Lampides boeticus*, *Omiodes indicata*, *Spilosoma obliqua,* and *Maruca testulalis* were found to have non-significant positive relationships in 2017. There was a non-significant negative correlation with *Omiodes indicata*, *Spilosoma obliqua,* and a significant positive correlation with *Maruca testulalis*, as well as a non-significant positive correlation with *Lampides boeticus* over the investigation period.

Table 5. Correlation coefficient (r) during 2016 and 2017:

Insect pests	Abiotic factors							
	Maximum temperature		Minimum temperature		Max. relative humidity		Min. relative humidity	
	2016	2017	2016	2017	2016	2017	2016	2017
Lampides boeticus	0.47	0.44	0.56 S	0.53 S	-0.86 S	0.02	-0.40	0.49
Omiodes indicata	0.33	0.77S	0.5 S	0.37	-0.66 S	0.41	-0.29	-0.01
Spilosoma obliqua	0.13	0.63 S	0.39	0.29	-0.61 S	0.38	-0.26	-0.01
Maruca testulalis	0.2	0.42	0.06	0.51 S	-0.11	0.21	-0.41	0.61 S

S-correlation is significant at P-0.05, others are non-significant.

4. Discussion

4.1 Composition and nature of damage: Various scholars researched on the composition of black gram insect pests from the order Lepidoptera and reported their findings on the pests' qualitative and quantitative composition. The bulk of prior workers' outcomes closely mirrored our current findings. Singh and Singh (1977) [20] found *Spilosoma obliqua* as an important pest in a dry land farming system in Delhi. Though the conclusions of this study differ in various respects, the presence of *Spilosoma obliqua* was compatible with our current findings. *Spilosoma obliqua* and *Maruca testulalis* were discovered to have similarities with the findings of Dhuri and Singh (1983) [4], who identified thirty insect species as major pests in Delhi at various crop stages. Dhuri *et al*. (1984) [5] reported *Spilosoma obliqua* from their investigation as well. Sahoo and Patnaik (1994) [16] found *Maruca testulalis* (*M. vitrata*) as a serious insect problem on green and black gram, among other insect pests. Singh and Kalra (1995) [19] discovered 16 insect pests on black gram, with *Maruca testulalis* being the most similar to the current findings. During the kharif 2001, 2002, and summer 2002 seasons, Nayak *et al*. (2005) [13] from Uttaranchal, India investigated the insect pest complex of black gram and discovered more than 70 species of insect pests at various stages of crop growth, including *Maruca vitrata* as an important insect pest on this crop at the flowering and poding stages, which is similar to the current study. According to Soundararajan and Chitra (2012) [22], the principal pests of black gram included the spotted pod borer (*Maruca vitrata*) as well as other key pests. *Spilosoma obliqua*, *Lampides boeticus* (Linn.), and *Maruca vitrata* (Geyer) were among the insect pests discovered infesting black gram (*Vigna mungo* L.) in Pantnagar, Uttarakhand, by Yadav and Patel in 2015 [26]. Mohapatra *et al*. (2018) [10] also discovered insect pests such as the bihar hairy caterpillar *Spilosoma obliqua* Walker.

The available literature was thoroughly examined, and some notable differences in findings from other similar research were observed. The most important thing to remember is that each insect's pest status is determined by the prevailing agro-climatic circumstances in the study area. In a paddy nursery field, our research site was surrounded by paddy crops. Some of the insect pests recognised as major problems by other workers in other parts of the country were not found in this site. In this study, *Maruca testulalis* (Geyer) was discovered to be the major pod borer rather than *H. armigera*. Aside from pod damage, the pod borer was largely found inside certain curled tender leaves in the current study.

4.2 Population succession: In a study on the succession and population build-up of insect pests on greengram and blackgram under a dry land cropping system in Delhi, Singh and Singh (1977) [20] discovered *Spilosoma obliqua* arrived in the middle of September in the early stages of crop growth. *Spilosoma obliqua* first appeared in the middle of September in both 2016 and 2017, on the 37th and 38th standard weeks, respectively. As a result, both findings are consistent with present research. The pod borer *Maruca testulalis* was a regular occurrence in Hisar, India, according to Singh and Kalra (1995) [19], and was acknowledged as a significant pest that had a major role in diminishing crop output. Despite the fact that the pod borer population was not plentiful, the current experiment demonstrated severe damage. According to Chandra and Rajak (2004) [2], Pod borer (*Maruca vitrata*) was observed during the pod development stage and remained active till pod maturation. According to Sonune *et al*. (2010a) [21], the incidence of *Maruca vitrata* on black gram began after the 5th week of August with 0.80 larvae/plant, steadily climbed to a peak of

3.84/plant during the 4th week of August, and then gradually fell to 3.35/plant by the first week of September. However, in the current study, it was shown that *Maruca testulalis* (*Maruca vitrata*) initially arrived in September from the 36th standard week in 2016 and the 37th standard week in 2017, with a peak population of 0.4/plant, and remained active until the 42nd standard week. The aforementioned findings were consistent with the findings of Shivaraju *et al*. (2011) [18] on the incidence of *Maruca testulalis*. They reported that the outbreak began in the first week of September, with a mean frequency of 2.0-17.50 larvae per quadrate, and peaked on black gram in the second week of October in Karnataka. However, the new study revealed that the pest's abundance was lower than previously thought.

4.3 Influence of temperature and relative humidity: We only looked at maximum and minimum temperatures, as well as maximum and minimum relative humidity, in this study to see how they affected insect pest population. Correlation studies of pest populations with various parameters revealed no meaningful association in the majority of the time. According to Naik *et al*. (2015) [12], the effect of abiotic conditions on black gram pest incidence found that high mean ambient temperature and high relative humidity supported pest population building. The population of spotted pod borers was significantly and adversely connected with maximum temperature during both seasons; however, during summer, there was also a strong and positive correlation with minimum relative humidity and a negative correlation with minimum temperature. Throughout the summer, the hairy caterpillar population had significantly negative associations with relative humidity, although the association with temperature was significantly favourable. According to Kumar *et al*. (2021) [8], maximum temperature had a non-significantly positive connection (r=0.123) with the population of bihar hairy caterpillar larvae. Minimum temperature, morning relative humidity, and evening relative humidity, on the other hand, were shown to have a non-significant negative connection (r = -0.357, -0.014, and -0.499, respectively) with the bihar hairy caterpillar larval population. Correlation tests revealed a significantly negative association (r= -0.559) between lowest temperature and spotted pod borer larvae population. Morning relative humidity correlated positively (r= 0.278), whereas maximum temperature and evening relative humidity correlated negatively (r = -0.104, -0.063, respectively) with spotted pod borer larvae population. From August through October, Chaudhary (2006) [3] noticed the spread of *Spilosoma obliqua*. According to Sharma *et al*. (1997) [17], bihar hairy caterpillar larval populations had a non-significant positive relationship with minimum temperature and a non-significant negative relationship with minimum temperature, morning relative humidity, and evening relative humidity. These findings are consistent with the current findings. Minimum temperature and evening relative humidity were negatively correlated with the spotted pod borer larval population, whereas maximum temperature and bright sunshine hours were positively correlated (Kumar and Singh, 2016) [7], whereas spotted pod borer larval population showed significant negative correlation with minimum temperature (Yadav *et al*. 2015) [25]. The presence of spotted pod borer was found to be positively associated to relative humidity (Sahoo and Senapati, 2000) [15]. These findings are consistent with the current findings.

5. Conclusion

The experiments for this work was conducted on a field that was completely covered by paddy on all sides, and the crop was cultivated in a mixed cropping pattern in a paddy nursery field with a 60-day gap between sowing paddy seeds and sowing of the black gram seeds. During the investigation years of 2016 and 2017, from September through November, all of the Lepidopteran pests' activity was seen and recorded. According to the findings, 4 insect pests belonging to four families of the order Lepidoptera are damaging to the black gram. *Spilosoma obliqua* (Fam. Arctiidae), *Maruca testulalis* (Fam. Noctuidae), *Lampides boeticus* (Fam. Lycaenidae), and *Omiodes indicata* (Fam. Pyralidae) represented the order Lepidoptera. Pest infestations began in the 35th standard week in 2016 and the 36th standard week in 2017, with the majority of them culminating in the 39th and 40th standard weeks in both years of investigation. *Maruca testulalis*, *Spilosoma obliqua*, and *Omiodes indicata* were found to be high (major) damage-causing insect pests, while *Lampides boeticus*, was a minor (low) pest. The highest abundance found was in *Spilosoma obliqua*.The weather parameters exhibited a non-significant correlation in most of the cases except a few.

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