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Impacts of abiotic factors on population fluctuation of *Melanitis leda* ismene (Cramer) and *Cnaphalocrocis medinalis* (Guenee) of paddy in Mizoram, India

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Abstract
The present investigation was undertaken to know the impact of abiotic factors on the population fluctuation of *Melanitis leda ismene* (Cramer) (Lepidoptera: Satyridae) and *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: Pyralidae) in rice agro-ecosystem under rain fed low land conditions in Mizoram, India during *Kharif* season in both 2013 and 2014. Results showed that *C. medinalis* were the first to attack the crop during last week of August, whereas *M. leda ismene* was recorded during second week of September i.e., 37th SMW. The incidences of *C. medinalis* and *M. leda ismene* varied due to season. The highest incidences of *C. medinalis* (6.8/10plants) and *M. leda ismene* (16.3/10plants) were found during September. Minimum temperature and rainfall showed significant correlation with incidecnes of *C. medinalis* and *M. leda ismene*. During the pooled year when there was abrupt fall in morning RH, rainfall and rainy days a build-up in *M. leda ismene* incidence was observed. When there was increase in morning RH and rainfall a build-up in *C. medinalis* incidence was recorded. These studies clearly indicate that weather factors play a vital role in *C. medinalis* and *M. leda ismene* incidence, which is essential for development of management strategies.

Keywords: weather factors, seasons, interaction, seasonal abundance, eastern Himalayas

Introduction
Rice is grown under diverse growing conditions such as irrigated, rain fed low land, rain fed up land and flood prone ecosystems [1]. Modern and high yielding varieties heavily fertilized and the practice of multi-cropping rice throughout the year favours the buildup of insect pest populations. For instance, some 500 species of insects and spiders may appear in a rice field in a particular season out of these, only few are potential threat [2]. Leaf feeding insect pests of paddy is the major importance because of their ability to defoliate or to remove the chlorophyll content of the leaves leading to substantial reduction in yield [2]. In India, yield loss in rice due to insect pests has been estimated from 21 to 51% varying from region to region as per variation in the agro climatic conditions [3]. Rice leaf folder, *Cnaphalocrocis medinalis* (Guen.) (Lepidoptera: Pyralidae) and green horned caterpillar, *Melanitis leda ismene* (Cramer) (Lepidoptera: Satyridae) have become major pests of paddy in many parts of India including Mizoram. Rice leaf folders occur in all rice growing areas and are more abundant during the rainy seasons. They are commonly found in areas where rice is heavily fertilized and shady areas [4]. With the expansion in rice areas due to modern agricultural practices, high yielding varieties and indiscriminate use of nitrogenous fertilizers the leaf folders has now reached major status. Cloudy weather with low sunlight favours pest build-up. The yield loss is from 30 to 80% due to leaf folder epidemic situation [4]. *Melanitis leda ismene* generally occurs in low numbers in rice and does not cause yield loss [5]. However, occasional high populations have been reported in Iloilo, Philippines; in Kanpur, Uttar Pradesh, India; in Manipur, India; in Timur Province, Java, Indonesia, and in Guangdong, China.
Local weather patterns have a significant impact on the abundance of insect pests populations in crops. Components of abiotic factors, mainly temperature and moisture, can either promote insect population growth or cause populations to decline. The damage due to insect pests depends upon their population development and abundance in the field which, in turn, rely upon their dynamically of the physical factors of their immediate environment [6].

A thorough understanding of the exact role between the change in abiotic factors and those in the insect pest incidence may not only help anticipate the insect pest losses to the crop, but also help avoid them through some well-timed pest management strategies [7]. Abiotic factors like temperature, relative humidity and rainfall play a vital role in the development of pests fluctuation of these causes variation in the population present study was planned to explore the impact of abiotic factors on population fluctuation of *C. medinalis* and *M. leda ismene* of paddy in rain fed low land conditions.

The influence of abiotic factors on incidences of *C. medinalis* and *M. leda ismene* is essential for development of control measure for insect pests. Recent studies showed that though the infestation was noticed throughout the rice growing areas of Mizoram, it was found high in September [4]. Therefore, these studies clearly indicate that besides the availability of new leaves and shoots, abiotic factors also play an important role in *C. medinalis* and *M. leda ismene* incidence [8]. For developing weather-based pest forewarning system, information regarding population dynamics in relation to prevalent abiotic factors is needed [9]. Moreover, the same weather factors also influence the growth and development of crop. Therefore, a thorough understanding of interaction between abiotic factors and insect pest dynamics is pre-requisite for weather-based pest forecasting model. Hence, the present study was undertaken to know the impact of abiotic factors on the leaf feeding insect pests (*C. medinalis* and *M. leda ismene*) in rice agro-ecosystem in Mizoram, India.

Materials and Methods

Field Experiment

The present investigation was undertaken at the research farm, ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram, India during *Kharif* season in both 2013 and 2014. The rice cultivar planted was Gomati (duration 135 days) during *Kharif* season in both year 2013 and 2014. The field was ploughed by power tiller, and kept under standing water up to 10-15 cm depth for about 15 days. Around 2000 m^2 area was taken to study the act of abiotic factors on the population fluctuation of *M. leda ismene* and *C. medinalis* in lowland rice. The total area was divided into ten equal segments and considered each one as a replication. The rice crop was established by manual transplanting of 25 days old seedlings with spacing of 20×10 cm row to row and plant to plant, respectively. All the recommended agricultural practices were followed in raising the crop [10]. No plant protection measure was taken throughout the crop season.

Meteorological Data

A weather record from August to October for *Kharif* 2013 and 2014 was obtained from the Meteorological Unit, ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram, India. Daily reported weather variables include mean minimum and maximum temperature, morning and evening humidity, rainfall and rainy days; these variables were collected and recorded at the weather station.

Sampling and Observation

Observations on the incidence of *M. leda ismene* and *C. medinalis* were recorded starting from initial appearance to up to harvest during *Kharif* season in both 2013 and 2014. Sampling was done at weekly interval accounting larvae and adults of *M. leda ismene* and *C. medinalis* by counting number /plant/hill from 10 randomly selected plants in 10 hills.

Statistical Analysis

Mean number of insects for the pooled year was determined for each week during *Kharif* season in both year 2013 and 2014. Data analyses were with methods of Gomez and Gomez [11] using SAS Software Version 9.3 [12]. The weekly data on *M. leda ismene* and *C. medinalis* incidences were subjected to correlation analyses with average weekly weather factors for the pooled year to find out the influence of abiotic factors on insects infestation. Data were analyzed using two-way ANOVA for seasonal incidence of *M. leda ismene* and *C. medinalis* during two seasons. All ANOVA were performed on original values. If interactions were significant they were used to explain the results. If interactions were not significant means were separated using Tukey's HSD test.

Results and Discussion

Melanitis leda ismene

Melanitis leda ismene caused severe damage to the rice crop and it also categorized as major pest of paddy in Mizoram. The data presented in Table 1 revealed that week (F = 3.946; df = 7, 30; P = 0.004) had affected the pattern of *M. leda ismene*. Season (F = 1.085; df = 1, 30; P = 0.306) and the interaction (week×season) (F = 0.358; df = 7, 30; P = 0.920) had no effect on the *M. leda ismene* population. During the crop season, *M. leda ismene* incidence started from second week of September i.e., 37th standard meteorological week (SMW) (Table 2). The population fluctuation of *M. leda ismene* (per 10plants) varied from 0.0±0.0 to 6.8±2.4 in the pooled year (average of 2013 and 2014). The *M. leda ismene* population reached a peak on 37th SMW (6.8±2.4 per 10plants) followed by a decline on 38th SMW. Earlier, Boopathi *et al*. [4] observed that *M. leda ismene* was found more incidence during first week of September (3.42/10plants). In the present investigation, the highest *M. leda ismene* incidence was during September in the pooled year (16.3 per 10plants). Similarly, Boopathi *et al*. [4] and Lumaban and Litsinger [5] reported that *M. leda ismene* was found highest during September (8.17 per 10plants) which is lesser than the present investigation. The highest and lowest *M. leda ismene* incidence (per 10plants) were predicted during second week of September i.e., 37th SMW (6.7) and first week of September i.e., 36th SMW (-0.5), respectively (Fig. 1).

During the pooled year when there was abrupt fall in morning RH, rainfall and rainy days a build-up in *M. leda ismene* incidence was observed (Table 2). A peak incidence of *M. leda ismene* was recorded as soon as morning RH, rainfall and rainy days below 90%, 26.5mm and 5.5 days, respectively. *M. leda ismene* incidence and respective weather parameters during the pooled year revealed that decrease in morning RH (2-9% from normal of 83%), rainfall (2-8 mm from normal of 14 mm) and rainy days (1.0-2.5 day from normal of 3.5 days) by >97% favours the population build-up of *M. leda ismene*. Earlier, Boopathi *et al*. [4] reported that all the weather factors (temperature, RH and rainfall) favoured the population buildup of *M. leda ismene* by 45%.

Correlation coefficient between *M. leda ismene* incidence and abiotic factors revealed that *M. leda ismene* incidence had positive significant correlation with minimum temperature (r = 0.761) and evening RH (r = 0.817) in the pooled year (Table 3), while rainfall (r = -0.714) had negative significant correlation with *M. leda ismene* incidence. Maximum temperature, morning RH and rainy days showed non-significant correlation with *M. leda ismene* incidence. Studies by Boopathi *et al.* [4] reported that *M. leda ismene* had non-significant correlation with all the weather parameters *viz*., minimum temperature (r = 0.633), maximum temperature (r = -0.301), maximum relative humidity (r = -0.262), minimum relative humidity (r = 0.114) and rainfall (r = -0.393).

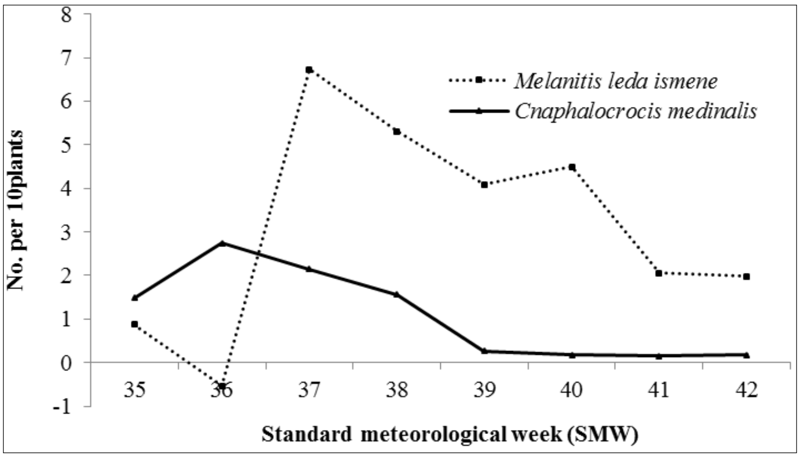

Fig 1: Predicted weekly incidences of Melanitis leda ismene and Cnaphalocrocis medinalis on paddy under rain fed low land conditions**.**

Table 1: Analysis of variance (ANOVA) for seasonal incidences of *Melanitis leda ismene* and *Cnaphalocrocis medinalis* on paddy under rain fed low land condition during two seasons.

Source	df	Melanitis leda ismene		Cnaphalocrocis medinalis	
		***F* value**	***P* value**	***F* value**	***P* value**
Season (S)	1, 30	1.085	0.306 ns	0.987	0.328 ns
Week (W) Interaction	7, 30	3.946	0.004**	8.524	<0.001
S × W	7, 30	0.358	0.920 ns	0.423	0.880 ns

ns, ** non-significant or significant at $P \leq 0.01$

Table 2: Effect of abiotic factors on the incidences (no./10plants±SE) of *Melanitis leda ismene* and *Cnaphalocrocis medinalis* on paddy under rain fed low land condition during two seasons (Pooled data of 2013 and 2014).

Month	SMW	No./10plants±standar error*		Abiotic factors					
		M. leda ismene	*C. medinalis*	Temperature (ºC)		Relative humidity (%)		Rainfall (mm)	Rainy days
				Maximum	Minimum	Morning	Evening		
August	35	0.0c±0.0	1.3bc±0.6	30.3	22.0	85.9	51.4	21.8	5.0
September	36	0.0c±0.0	2.8a±0.2	30.2	21.6	89.8	50.1	26.5	5.5
	37	6.8a±2.4	2.2ab±0.4	29.9	22.3	87.8	54.1	20.8	4.0
	38	5.0ab±2.3	1.5b±0.5	29.7	22.9	86.5	55.1	14.1	3.5
	39	4.5ab±1.8	0.3cd±0.3	30.2	22.7	85.2	56.0	16.2	4.5
October	40	4.5ab±1.0	0.2d±0.2	30.6	23.1	79.4	52.5	2.9	2.5
	41	2.2bc±0.9	0.2d±0.2	30.5	23.0	72.1	49.4	6.7	2.5
	42	2.0bc±0.3	0.2d±0.2	29.6	22.5	79.7	45.3	0.6	0.5

SMW: Standard meteorological week *Data in interaction analyzed with Least Squares Means and means separated with standard error of the mean at $P<0.01$. In a column, means followed by a common letter(s) are not significantly different by Tukey's at $P<0.01$

Table 3: Correlation between abiotic factors and incidences of *Melanitis leda ismene* and *Cnaphalocrocis medinalis* on paddy under rain fed low land condition (Pooled data of 2013 and 2014).

Abiotic factors	*Melanitis leda ismene*	*Cnaphalocrocis medinalis*
Maximum temperature (ºC)	-0.267ns	-0.247ns
Minimum temperature (ºC)	0.761*	-0.750*
Morning relative humidity (%)	0.064ns	0.801*
Evening relative humidity (%)	0.817*	0.202ns
Rainfall (mm)	-0.714*	0.855**
Rainy days (d)	-0.169ns	0.696ns

ns,*,** non-significant or significant at $P \leq 0.05$ or $P \leq 0.01$

Cnaphalocrocis Medinalis

The incidence of *C. medinalis* was noticed from vegetative stage to till harvest and caused severe damage to the rice crop. Week (F = 8.524; df = 7, 30; P < 0.001) had affected the *C. medinalis* incidence (Table 1). Season (F = 0.987; df = 1, 30; P = 0.328) and the interaction (week×season) (F = 0.423; df = 7, 30; P = 0.880) did not affected on the incidence of *C. medinalis*. The population fluctuation of *C. medinalis* varied from 0.2±0.2 to 2.8±0.2 (Table 2). The *C. medinalis* incidence reached a peak on first week of September, i.e. 37th SMW (2.8±0.2 per 10plants) followed by a decline on second week of September, i.e. 38th SMW during the pooled year. Earlier, Boopathi *et al*. [4] observed that *C. medinalis* was found more population during third week of September (0.33/10plants). The most *C. medinalis* incidence was found during September (6.8/10plants) in the present investigation. Similarly, Boopathi *et al*. [4] reported that *C. medinalis* incidence was found more during September (0.75 per 10 plants) which is lesser than the present investigation. The maximum incidence of leaf folder was found during 37^{th} SMW and 38^{th} SMW in month of September with 4.35 and 5.58% leaf damage/hill, respectively in midland normal transplanted rice ecosystem and midland SRI rice ecosystem [13]. Earlier, Islam *et al*. [14] and Kalita *et al*. [15] reported that the population of *C. medinalis* had reached its highest level during September to November. Studies by Gangwar [16] observed that the leaf folder usually was most abundant during the rainy season. The seasonal incidence of larval population (0.50 larva/plant) and percent damaged leaves (0.55) of rice leaf roller, *C. medinalis* initiated from 36^{th} SMW and reached its peak level (3.12 larvae/plant and 3.20 per cent damaged leaves) during 43^{rd} SMW in *Kharif* 2005 [17]. The highest *C. medinalis* incidence (per 10plants) was predicted during first week of September i.e., 36^{th} SMW (2.74) and the least *C. medinalis* incidence (per 10plants) was predicted during second week of October (0.15) (Fig. 1).

When there was increase in morning RH and rainfall a build-up in *C. medinalis* incidence was recorded (Table 2). A peak *C. medinalis* incidence was observed as soon as morning RH and rainfall crossed 85% and 20mm, respectively. The *C. medinalis* incidence and respective abiotic factors revealed that an decrease in maximum temperature (1^0C from normal of 30^0C) and minimum temperature (1-2^0C from normal of 23^0C) and increase in morning RH (2-6% from normal of 83%), evening RH (1-4% from normal of 52%), rainfall (2-12mm from normal of 14mm) and rainy days (1.0-2.5 days from normal of 3.5 days) by >99% favour the population build-up of *C. medinalis*. Earlier, Boopathi *et al*. [4] reported that all the weather factors (temperature, RH and rainfall) favoured the population buildup of *C. medinalis* by 87%.

Cnaphalocrocis medinalis had positive significant correlation with morning RH (r = 0.801) and rainfall (r = 0.855), while minimum temperature had negative significant correlation with *C. medinalis* incidence (r = -0.750) in the pooled year (Table 3). However, other abiotic factors showed non-significant correlation with *C. medinalis* incidence during pooled year. Studies by Boopathi *et al*. [4] reported that *C. medinalis* had negative significant correlation with maximum temperature, whereas other weather factors showed non-significant correlation with *C. medinalis* incidence. The correlation studies revealed that minimum temperature (r = 0.573*), average temperature (r = 0.546*) showed significant positive correlation with percent incidence of leaf folder [10]. Earlier, Gangwar [13] reported that high humidity and optimum temperature are the important factors for the leaf folder abundance.

Conclusion

The objective of this present investigation was to study the impact of abiotic factors on the population fluctuation of *M. leda ismene* and *C. medinalis* on paddy under rain fed low land conditions in Mizoram. The present study results indicated that a buildup of *M. leda ismene* and *C. medinalis* was manipulated by crop seasons and abiotic factors. On the basis of correlation analysis minimum temperature, morning RH, evening RH and rainfall were the main contributing abiotic factors for incidences of *M. leda ismene* and *C. medinalis*. This method is extremely useful for determining the incidence and saves precious time by avoiding field observations. However, further studies are needed to standardize the weather variables for improving the precision of *M. leda ismene* and *C. medinalis* incidence estimates.

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