Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(3): 502-504
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Received: 06-03-2019
Accepted: 10-04-2019

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Effect of weather parameters on life cycle duration of lac insect (*Kerria* spp.) (Kerridae: Hemiptera)

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Abstract
The study on life cycle duration of lac insect revealed a minimum duration of 149 days during summer 2016 and the highest of 199 days during winter 2017. Variation of life span was more in *Kerria lacca* 149-199 days but in the case of *K. chinensis*, life span varied from 155-194 days. The correlation analysis of weather parameters with life cycle duration of lac insect showed a highly significant positive correlation (r = 0.85**) with morning relative humidity and significant negative correlation (r = -0.68*) with total rainfall. The multiple linear regression analysis showed that total rainfall, maximum temperature, bright sunshine hours, morning and evening relative humidity were the major weather parameters which affected the life cycle duration of *Kerria* spp and these five weather parameters exhibited the highest Adjusted Coefficient of Determination of 86.37 per cent and explained 93.94 per cent of the total variation occurring in the crop growth period.

Keywords: *Kerria* spp., weather, correlation, regression, life cycle duration

Introduction

Lac insect (*Kerria* spp., Kerridae, Hemiptera) is one of the economically important insect which secretes resins of wide commercial utility right from small cottage industry to pharmaceutical industries. Lac resin is the only resin of animal origin which is secreted as a protective covering around the body of the tiny scale insect and it is being secreted throughout their body except mouth, two bracheal pores and anus. Out of the nine genera and 99 species of lac insects reported throughout the world, 2 genera and 26 species are found in India [1] out of which *Kerria lacca* is the most widely available species in the country. It has two different strains, *Rangeeni* and *Kusumi* and both the strain produces two crops in a year (bivolatine). Kusumi strain is superior [2, 3] and it produces two crops, *Jethwi* (Jan-feb. to June-July) and *Aghoni* (June-July to Jan-Feb.).

Most of the weather parameters like temperature, relative humidity, rainfall etc. have much influence on herbivory life either directly or indirectly through influencing host plant vigour. Intensity of change in climatic ecosystem has showed a direct and indirect affect on the prey and host relationship, their immune responses and rate of development, their fecundity and various physiological functions [4, 5, 6]. The effect of weather parameters with critical periods of development of rangeeni strain of *Kerria lacca* was studied at Namkum, Ranchi [7]. However, the study was confined to correlation of weather parameters with lac production data. No study was done to evaluate the effect of weather parameters with the life cycle duration of lac insect in Assam condition. In this regards, an attempt was made to correlate the major weather parameters which influence the life cycle duration of lac insect and also to develop a maturity forcasting model.

Materials and Methods

The life cycle durations of lac insect was recorded in the lac park, AAU, Jorhat which is maintained for conservation of lac insect genetic resources. The lac park is situated 26°44´N latitude and 94°10´E longitude at an altitude of 91 m above mean sea level. Being situated in the subtropical zone, the climate is characterized by hot and humid summer and dry and cool winter. Monsoon season normally starts from the first week of June and extend up to September and the intensity of rainfall decreases from October.

Mean annual rainfall is more than 2000 mm per annum and average humidity is around 85 per cent. The temperature gradually increases from March and reaches maximum during August.

The durations of each life cycle of lac insects were recorded since 2016 from crawler emergence (Date of inoculation) to harvesting of the crops (next crawling). All total five crops of kusumi strain of *Kerria lacca* and five crops of *Kerria chinensis* have been successfully harvested till September, 2018. Thus, there were ten generations of lac insect since 2016 to 2018. Daily meteorological parameters *viz.*, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, bright sunshine hours (BSSH) and rainfall were collected from the Department of Agricultural Meteorology, AAU, Jorhat and average of each parameters were calculated out for each life cycles (*i.e.*, from inoculation up to harvesting) and these average weather data were correlated with life cycle durations of lac insect. In order to develop a statistical forecasting model for assessing the duration of life cycle of the insect by means of weather parameters, multiple correlation techniques were applied and the best fit regression line with minimum number of variables was developed based on Adjusted Coefficient of Determination (Adj. R^2) and Root Mean Square Error (RMSE) using XLSTAT software.

Results and Discussion

Correlation analysis

The life cycle durations of lac insect varied from the lowest of 149 days (during summer, 2016) to the highest of 199 days (during winter, 2017) (Table 1). Both the highest and the lowest duration were recorded for *K. lacca.* Duration of summer crop of the kusumi strain of *K. lacca* was varied from 149 to 166 days, while in case of *K. chinensis*, it varied from 155 to 165 days. The winter crop of *K. lacca* varied from 196 to 199 days, but in case of *K. chinensis*, shorter duration was recorded (168 to 194 days) (Table 3). The correlation analysis of lac insect showed a highly significant positive correlation (r = 0.85**) with morning relative humidity indicating extended crop duration with high morning relative humidity. Total rainfall has established a significant negative correlation (r = -0.68) with the life span of lac insect. When we individually correlate the weather parameters with each species, *Kerria lacca* has established a highly significant positive correlation (r = 0.96*) with morning relative humidity (Table 2). Delayed emergence of scale insect crawlers coincided with unfavorable climatic conditions such as low temperature or very high relative humidity [8]. Earlier experimentation result with scale insect also revealed that very high humidity inhibited crawler activity in *Aulacaspis tegalensis* crawlers [9].

Table 1: Correlation of weather parameters with life cycle duration of lac insect

Species	Seasons	Duration	Maximum Temperature (°C)	Minimum temperature (°C)	Morning relative humidity (%)	Evening relative humidity (%)	Rainfall (mm)	BSS (Hrs)
K. lacca	Summer	149	29.1	20.5	93.1	72.5	9.1	3.2
	Winter	196	30.0	19.5	96.1	69.7	4.0	4.6
	Summer	161	28.9	19.2	94.6	68.5	6.5	4.4
	Winter	199	30.0	20.3	95.9	74.1	6.2	5.0
	Summer	166	28.7	18.8	94.6	69.2	5.1	3.8
K. chinensis	Summer	165	32.2	24.8	94.6	76.7	9.1	2.9
	Winter	168	26.8	14.1	96.0	62.3	2.7	6.0
	Summer	155	32.4	25.0	94.7	77.5	11.0	3.9
	Winter	194	27.0	15.5	96.6	68.2	1.7	4.9
	Summer	155	32.4	24.4	93.2	73.9	10.2	4.2
Correlation co-efficient			-0.32	-0.43	0.85**	-0.22	-0.68*	0.52

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

Table 2: Correlation of weather parameters with life cycle duration of Kusumi strain of *K. lacca*

Seasons	Duration	Maximum Temperature (°C)	Minimum temperature (°C)	Morning relative humidity (%)	Evening relative humidity (%)	Rainfall (mm)	BSSH (Hrs)
Summer	149	29.1	20.5	93.1	72.5	9.1	3.2
Winter	196	30.0	19.5	96.1	69.7	4.0	4.6
Summer	161	28.9	19.2	94.6	68.5	6.5	4.4
Winter	199	30.0	20.3	95.9	74.1	6.2	5.0
Summer	166	28.7	18.8	94.6	69.2	5.1	3.8
Correlation co-efficient		0.88	0.07	0.96*	0.27	-0.69	0.87

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

Table 3: Correlation of weather parameters with life cycle duration of *K. chinensis*

Seasons	Duration	Maximum Temperature (°C)	Minimum temperature (°C)	Morning relative humidity (%)	Evening relative humidity (%)	Rainfall (mm)	BSSH (Hrs)
Summer	165	32.2	24.8	94.6	76.7	9.1	2.9
Winter	168	26.8	14.1	96.0	62.3	2.7	6.0
Summer	155	32.4	25.0	94.7	77.5	11.0	3.9
Winter	194	27.0	15.5	96.6	68.2	1.7	4.9
Summer	155	32.4	24.4	93.2	73.9	10.2	4.2
Correlation co-efficient		-0.77	-0.72	0.82	-0.51	-0.85	0.36

Regression analysis

The multiple linear regression technique applied for Jorhat district situated in the upper Brahmaputra valley zone of Assam for identifying the weather parameter playing major role in determining duration of the life cycle of lac insects and thereby developing a forecasting model, generated a best fit regression line (Fig. 1) based on the criteria of highest Adjusted R^2 which contained five weather parameters (Table 4). It was observed that total rainfall, maximum temperature, bright sunshine hours, morning and evening relative humidity were the major weather parameters which affected the life cycle duration of *Kerria* spp. These five weather parameters exhibited the highest Adjusted Coefficient of Determination (Adj. R^2) of 86.37 per cent and explained 93.94 per cent of the total variation occurring in the crop growth period with minimum Root Mean Square Error (RMSE) of 6.30.

Actual Duration = 165.64141 + 2.59322*Tmax - 4.54689*RH-I + 5.47165*RH-II - 11.20503*RF + 10.09025*BSSH

Table 4: Meteorological parameter playing major role in determining the duration of the life cycle of lac insects

No. of variables	Variables	RMSE	R^2 (%)	Adj. R^2 (%)
5	Maximum Temperature / Morning Relative Humidity / Evening Relative humidity / Rainfall / Bright sunshine hours	6.30	93.94	86.37

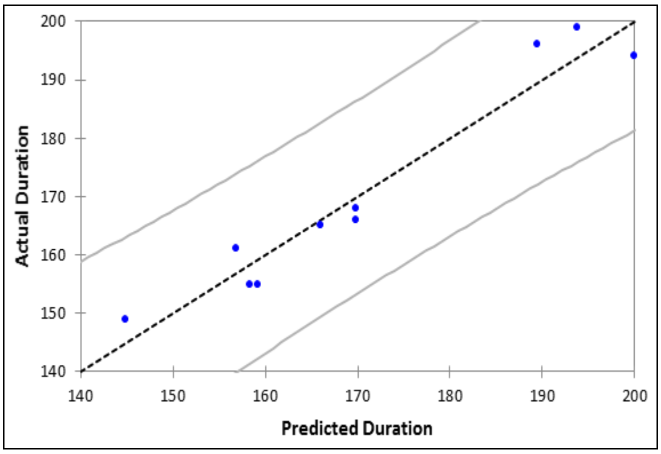

Fig 1: Predicted duration Vs actual duration

The extended range forecast issued by India Meteorological Department, New Delhi for various sub divisions of India can be used to predict the duration of the crop and thereby, the emergence time of the lac insects can be known before hand. Such knowledge will not only help the farmers to make the host plants ready for the next season but also to strengthen the marketing channels for intra and inter nation export. Moreover, such lines of regression will also facilitate researchers not only to study the impact of weather on the lac insects to the future projections of climate change but also in modifying the microclimatic regimes near the host crops for enhancing the final yield.

Acknowledgement

The authors are grateful to Dr. K. K. Sharma, Director and Project Co-ordinator, ICAR-IINRG, Ranchi, for his support and encouragement in conducting the present study.

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