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Biology of lac insect, *Kerria lacca* (Kerr) on pigeonpea, *Cajanus cajan* (L.)

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Abstract
The present investigation on "Biology of Lac insect, *Kerria lacca* (Kerr) on pigeonpea, *Cajanus cajan* (L.)" was conducted on *Rangeeni* strain of lac insect in *Baisakhi* season at lac insect gene bank cum garden situated at Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during 2019-20. The study revealed that the mean initial and final density of settlement on lower, middle and upper portion of plant in three set of experiments were 83.70, 80.10, 62.60; 82.90, 79.10, 67.50; 71.50, 72.10, 69.00 and 77.10, 73.40, 56.80; 75.60, 71.30, 59.80; 66.20, 65.70, 62.00 crawlers per sq.cm, respectively. The mean initial mortality and percent settlement of crawlers on lower, middle and upper portion of plant in three set of experiments were 7.89, 8.36, 9.27; 8.81, 9.86, 11.41; 7.41, 8.88, 10.14 and 92.15, 91.48, 90.06; 90.91, 89.98, 88.32; 92.28, 90.78, 89.12 percent, respectively. The duration of sex differentiation on lower, middle and upper portion of plants in three set of experiments were 49.20, 48.80, 48.70; 48.90, 48.80, 47.90 and 49.20, 48.90, 48.10 days, respectively. The mean density of female cells at maturity recorded at lower, middle and upper portion of plant were 4.30, 5.30, 4.40; 4.10, 5.60, 4.00 and 4.40, 4.00, 5.30 female cells per sq.cm in three set of experiment, respectively.

Keywords: *Kerria lacca*, lac insect, life cycle, density, mortality, sex differentiation, maturity

Introduction
Lac insect, *Kerria lacca* (Kerr) belongs to the family Tachardiidae (Kerriidae), super family Coccoidea of the order Hemiptera is an important soft bodied insect as it secrets resin through minute openings in the form of lac to protect its body. The life cycle of lac insect starts with the crawlers, after settlement the nymphs undergo three successive moults to become an adult. The first instar is mobile and crawls over the tender shoot of host trees and settles to feed on phloem sap by piercing its proboscis into phloem region of shoot. To avoid covering of these holes by resin, the lac insect secretes wax, which is white thread-like structure. The duration of each stage depends on the host plant species on which it feeds, lac crop and prevailing environmental conditions [1]. The lac insect basically yields three useful materials *viz.*, resin, dye and wax. The major constituent of lac is the resin (68%). Resin is commonly known as "lac" and is sold in the market as shellac or seedlac or button lac. Other constituents present are dye (1.2%), wax (6%), others (25%) like sugar, proteins, soluble salts, sand, woody matter, and insect body debris [2].

Lac has immense profitable significance as its derived products are biodegradable, non- toxic, environment friendly and have tremendous export potential. In addition to this, the lac insect-host association contributes to the conservation of biodiversity *viz.*, soil flora, fauna and soil micro-organisms [3]. India is the leader in production and export of lac in the world, accounting for more than 50 and 80 percent respectively. Jharkhand state ranks first in lac production with contribution of 57.20 percent followed by Chhattisgarh (17.87%), West Bengal (7.82%), Madhya Pradesh (7.26%) and Maharashtra (5.30%). The lac ecosystem fauna includes 87 species of lac insect belonging to nine genera recorded from all over the world. Though different lac hosts have been recorded in Rajasthan, but it is not cultivated commercially. In Rajasthan lac insectis naturally found in abundance on various hosts [4].

Pigeonpea, (*Cajanus cajan* L.) is a new host of lac and different strains of lac insects are being investigated to enhance its production. On-farm production of lac on pigeonpea resulted in increased demand of lac in China and spread the lac cultivation in the Northern part of The Lao Peoples Democratic Republic (Lao PDR) [6]. Pigeonpea as a promising host in North-East India [5, 6]. It is also recorded as suitable host for lac insect, *K. lacca* in Southern Rajasthan [7]. Pigeonpea is widely cultivated as pulse crop in different parts of the state which could be

utilized for encouraging lac cultivation in the region. Under natural conditions, lac insect occur on common lac hosts but lack of knowledge about the biology of lac insect has hindered the development of lac production particularly in southern parts of Rajasthan. Hence, the present research work has been carried out with the objective, to study biology of lac insect on pigeonpea.

Materials and Methods

The experiment was conducted on *Rangeeni* strain of lac insect in *Baisakhi* season at lac insect gene bank cum garden situated at Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during 2019-20.

The healthy host plants were raised by following the all the agronomic practices. The local perennial variety of pigeonpea was sown to get healthy plants of proper age for lac inoculation with brood lac sticks. The crop was sown in the last week of August 2019 with row to row spacing of 100 cm and plant to plant spacing of 40 cm in plot size measuring 2.0 × 10 sq m. There were 50 plants in each set of experiment which replicated thrice. The brood lac of *Rangeeni* strain needed for the experiment were collected from the mature *Katki* crop of *Rangeeni* strain prevailing in the region on its natural hosts bearing fully matured females. The brood lac were bundled and tied in the month of October-November on host plants at 1-1.5ft above the ground level to provide succulent stem for crawlers to settle down. The brood lac bundles were tied in 60 micron nylon mesh which allows only crawlers to move out retaining the parasitoids inside if any emerges simultaneously with the lac insect crawlers. The nymphs were allowed to emerge from mature females for about two weeks. After the emergence of newly hatched nymphs the phunki lac stick bundles were removed from host plants. Nymph/crawlers of the lac insect were allowed to settle on the one meter length of the succulent stem of pigeonpea. The nymph population settled on the stems of plant more than one meter length were scrapped off with the help of knife and the observations on the different parameters of life cycle of the *Rangeeni* strain of lac insect population prevailing on this part of the stems of 10 tagged plants each was recorded separately.

Observations

To study the life cycle of *Rangeeni* strain lac insect on pigeonpea during *Baisakhi* season 2019, the regular observations on different parameters were recorded on the tagged ten plants in three sets of experiment which started from two weeks after the inoculation of brood lac as per the standard procedure prescribed by Mohanasundaram [8]. Observations were recorded on the following parameters:

Initial density of settlement (number per square cm)

The initial density of settlement was recorded at 7 days after the inoculation of brood lac on the 10 tagged plants in each set of plot where one square cm area was selected randomly and numbers of lac crawlers settled were counted visually by using magnifying glass and by placing a graph paper with one square cm area cut window on the stem of plant. Three such sites from inoculated one meter part were selected at lower, middle and upper part of plant and average was taken as initial density of settlement (number per square cm).

Initial mortality (%)

Observations on initial density were repeated at 21-days after inoculation of brood lac following the same procedure as described earlier. The process of crawlers emergence continues up to 2-3 weeks. The crawlers which were not able to find suitable sites for settlement die due to starvation. Observation at this stage is the true indication of the number of crawlers actually settled and that have started feeding.

$$\text{Initial natural mortality (\%)} = \frac{\text{Initial density} - \text{Density after 21 days of settlement}}{\text{Initial density}} \text{ X } 100$$

Final density of settlement (number per square cm)

The final density of settlement of crawlers was calculated by the following formula:

Final density of settlement = Initial density of settlement – Initial mortality

Percent settlement

The per cent settlement of crawlers was calculated by the following formula:

$$\text{Per cent settlement} = \frac{\textit{Final density of settlement}}{\textit{Initial density of settlement}} x100$$

Duration in days for sex differentiation

At the time of emergence, larvae cannot be differentiated into males or females. After a period of growth, larvae then can be differentiated into male and female lac insects based on their morphological differences (males are elongated while females are round shaped). The observations on time elapsed between date of inoculation to male and female of lac insect differentiation were recorded for the host.

Density at crop maturity (number per square cm)

To study the density of lac insect at crop maturity, the numbers of surviving female cells were counted at maturity when the lac crop matures with appearance of yellow spot on female cell. The numbers of mature females per square cm were counted by following the procedure of placing of graph paper with one square cm cut window.

Statistical analysis

The data recorded on different parameters were subjected to analysis as given below.

Mean density

$$\text{Mean density} = \sum \frac{Xi}{N}$$

Xi = No. of insects settled per square cm
N = Total No. of plant sampled.

Standard Deviation

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Where,
Xi = Number of insects settle per square cm
N = Total number of plants sampled.
μ = Mean density of crawlers settled per sq.cm

Range: Range = Lowest Value to Highest Value

Standard Error

$$\text{Standard Error} = \frac{\text{Standard deviation}}{\sqrt{\text{Number of samples}}}$$

Results and Discussion

Initial, final density of settlement (number per sq.cm)

The initial density ranged from 60-106, 48-102 and 44-87 crawlers per sq.cm on lower, middle, upper parts of plant in I experiment set, respectively (Table 1 & 2). The results show that mean initial density of settlement of 83.70, 80.10 and 62.60 crawlers per sq.cm were recorded in I experiment set on lower, middle, upper portion, respectively. Similarly the mean initial densities of settlement of crawlers observed in II experiment set were 82.90, 79.10 and 67.50 crawlers per sq. cm and the initial density of crawlers ranged from 49-111, 45-105 and 48-82 crawlers per sq. cm on lower, middle, upper portion of plant, respectively. In set of experiment III the mean initial density of settlement of crawlers observed were 71.50, 72.10 and 69.00 crawlers per sq. cm and the initial density of crawlers ranged from 44-96, 46-89 and 53-92 crawlers per sq. cm on lower, middle, upper portion of plant respectively.

The final density of settlement of crawlers ranged from 56-100, 42-94 and 38-82 crawlers per sq.cm on lower, middle, upper portion of plant in I experiment set, respectively (Table 1 & 2). The results show that mean final densities of settlement of crawlers in I experiment set were 77.10, 73.40 and 56.80 crawlers per sq.cm with a deviation of 12.46, 15.41 and 18.08 crawlers per sq.cm on lower, middle, upper portion of plant, respectively.

Similarly, the mean final density of crawlers ranged from 43-104, 42-98 and 40-78 crawlers per sq.cm on lower, middle, upper portion of plant in set of experiment II, respectively. The result also show that mean final density of settlement of crawlers in set of experiment II were 75.60, 71.30 and 59.80 crawlers per sq.cm with a deviation of 19.22, 16.94 and 11.58 crawlers per sq.cm on lower, middle, upper portion of plant respectively. The final density of crawlers ranged from 41-90, 39-83 and 46-85 crawlers per sq.cm on lower, middle, upper portion of plant in III experiment set, mean final density of settlement of crawlers 66.20, 65.70 and 62.00 crawlers per sq.cm and deviation of 17.65, 13.97 and 15.25 crawlers per sq.cm on lower, middle, upper portion of plant, respectively.

The results reveal that the per cent settlement of crawlers on lower portion ranged from 90.91 to 92.28; on middle portion ranged from 89.98 to 91.48 and on upper portion of plant ranged from 88.32 to 90.06 per cent (Table 3). The per cent settlement of crawlers in the I experiment set was 92.15, 91.48 and 90.06 on lower, middle and upper portion of ten plants, respectively. The per cent settlement of crawlers in II experiment set was 90.91, 89.98 and 88.32 on lower, middle and upper portion of plants, respectively. Similarly, the per cent settlement of crawlers on lower, middle and upper portion of plants in III experiment set were 92.28, 90.78 and 89.12 per cent, respectively.

The results of present investigations are in alignment with the findings of Divakara [9], who recorded maximum density (77.8 crawlers/cm2) of insect settlement in *F. macrophylla* as intercrop in under storey of *Dalbergia sisso* 21 days after of inoculation of broodlac. Similarly, the initial density of settlement of larvae ranged between 92.58-126.74 crawlers per sq.cm and 93.12-109.62 crawlers per sq.cm of Kusmi strain on Kusum and Ber trees, respectively [1]. The mean initial density of settlement of 92.60, 84.10, 60.00; 86.70, 91.60, 71.00 and 67.40, 64.70, 61.00 crawlers per sq.cm at lower, middle and upper parts of plants in three plots, respectively. The mean final density of settlement first instar crawlers ranged from 17-114 crawlers per sq.cm with mean of 85.50, 78.20, 53.10; 80.20, 85.90, 65.00 and 61.90, 57.30, 54.60 crawlers sq.cm on lower, middle and upper portion of plant in three plots respectively [7].

Initial Mortality (%)

The data (Table 3) reveal that the first instar crawlers of lac insect which were not able to find suitable sites for settlement, died due to starvation and remaining population at this stage were the true number of crawlers actually settled. The results reveal 7.89, 8.36, 9.27; 8.81, 9.86, 11.41 and 7.41, 8.88 and 10.14 per cent mean mortality of first instar crawlers at lower, middle and upper portion of plant in three sets of experiment, respectively. The results of the present investigation confer the findings of Divakara [9], who recorded minimum per cent mortality of *Rangeeni* strain of lac insect in *C. calothyrsus* (12.48%) and *D. assamica* (22.36%) and maximum percent mortality of *Kusmi* strain in *Jethwi* season in *F. semialata* (27.88%) followed by ber (24.91%) and kusum (18.75%). The mean mortality of Rangeeni strain of lac insect in pigeonpea were 7.55%, 8.12%, 10.39%; 7.70%, 6.46%, 7.49% and 9.09%, 12.27%, 12.58% at lower, middle and upper portion of plant in three plots respectively [7].

Duration (days) of sex differentiation

The result revealed that the sex differentiation of *Rangeeni* strain of lac insect on lower, middle and upper portion of plants in I, II and III experiment set were 49.20, 48.80, 48.70; 48.90, 48.80, 47.90 and 49.20, 48.90, 48.10 days, respectively (Table 3). The present investigation close conformity with findings of Swami [4], who reported that time elapsed between date of inoculation to male and female differentiation of lac insect recorded as duration of pre sexual stages (days) varied from 47 to 51 days on 10 pigeon pea plants in three set of plots. The mean duration of pre-sexual stages recorded were 47.90, 48.50 and 48.70 days respectively for the three plots.

Mature female cells density

The results reveal that in the set of experiment I, the mean density of female cells were 4.30, 5.30 and 4.40 female cells per sq.cm on lower, middle, upper portion of ten plants, respectively (Table 1). In the set of experiment II, the mean density of female cells per sq.cm were recorded as 4.10, 5.60 and 4.00 female cells per sq.cm on lower, middle, upper portion of plant, respectively. Likewise, the data recorded from the plants in set of experiment III reveal that the mean density of female cells were 4.40, 4.00 and 5.30 female cells per sq.cm on lower, middle, upper portion of plant, respectively. The results of present investigation are in full alignment with the findings of Mohanta [1], who also recorded average density of living female cells at crop maturity were 3.38-12.67 cells per sq.cm on palas plant for *Rangeeni* strain

of lac insect. Similarly, the density of female cells during maturity ranged from 01-11 cells per sq.cm on pigeonpea for *Rangeeni* strain of lac insect [7].

Table 1: Mean initial, final and mature female cells density of lac insect on pigeonpea during *Baisakhi* season, 2019

Experiment Set	Parameters	Mean initial density of settlement (per sq.cm)			Mean final density of settlement (per sq.cm)			Mature female cells density (per sq.cm)		
		Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
I Experiment Set	Mean density ($\bar{x}$)	83.70	80.10	62.60	77.10	73.40	56.80	4.30	5.30	4.40
	SD (σ)	13.52	16.31	17.87	12.46	15.41	18.08	1.34	1.16	1.17
	Range (R)	4.28	5.16	5.65	3.94	4.87	5.72	0.42	0.37	0.37
	Mean density ($\bar{x}$)	60 – 106	48 - 102	44 - 87	56 - 100	42 - 94	38 - 82	2 - 6	4 - 7	3 - 6
II Experiment Set	SD (σ)	82.90	79.10	67.50	75.60	71.30	59.80	4.10	5.60	4.00
	SE	19.94	17.58	11.37	19.22	16.94	11.58	1.20	1.71	1.49
	Range (R)	6.30	5.56	3.59	6.08	5.36	3.66	0.38	0.54	0.47
	Mean density ($\bar{x}$)	49 – 111	45 - 105	48 - 82	43 - 104	42 - 98	40 - 78	2 - 6	3 - 8	2 - 6
III Experiment Set	SD (σ)	71.50	72.10	69.00	66.20	65.70	62.00	4.40	4.00	5.30
	SE	18.12	13.71	13.59	17.65	13.97	15.25	1.43	1.15	1.49
	Range (R)	5.73	4.34	4.30	5.58	4.42	4.82	0.45	0.37	0.47
	Range (R)	44 – 96	46 - 89	53 - 92	41 - 90	39 - 83	46 - 85	2 - 7	2 - 6	3 - 7

Table 2: Category wise mean initial and final density of settlement (per sq.cm) of first instar crawlers of *Rangeeni* strain of lac insect on pigeonpea during *Baisakhi* season, 2019

Initial density of settlement per sq. cm									
	I Experiment Set			II Experiment Set			III Experiment Set		
Category	LP	MP	UP	LP	MP	UP	LP	MP	UP
20 – 50	0 (00.00)	1 (48.00)	3 (45.00)	1 (49.00)	1 (45.00)	1 (48.00)	1 (44.00)	1 (46.00)	0 (00.00)
50 – 80	3 (69.00)	4 (71.75)	4 (58.50)	3 (69.00)	5 (73.40)	7 (69.29)	6 (65.83)	6 (68.67)	7 (61.86)
80 & above	7 (90.00)	5 (93.20)	3 (85.67)	6 (95.50)	4 (94.75)	2 (81.50)	3 (92.00)	3 (87.67)	3 (85.67)
Final density of settlement per sq. cm									
	I Experiment Set			II Experiment Set			III Experiment Set		
Category	LP	MP	UP	LP	MP	UP	LP	MP	UP
20 – 50	0 (00.00)	1 (42.00)	5 (41.00)	2 (46.00)	1 (42.00)	2 (43.50)	3 (44.67)	2 (43.50)	4 (47.25)
50 – 80	7 (71.29)	4 (65.75)	3 (66.67)	4 (73.25)	6 (66.50)	8 (63.88)	4 (68.00)	6 (67.67)	4 (65.75)
80 & above	3 (90.67)	5 (85.80)	2 (81.50)	4 (92.75)	3 (90.67)	0 (0.00)	3 (85.33)	2 (82.00)	2 (84.00)

LP = Lower portion of plant; MP = Middle portion of plant; UP = Upper portion of plant

*Figures in parenthesis are average initial and final density of settlement of crawlers (No/cm^2)

Table 3: Mean per cent settlement, mortality and mean duration (days) of sex differentiation of lac insect on pigeonpea during *Baisakhi* season, 2019

Set of Experiment	Mean per cent settlement		
	Lower portion	Middle portion	Upper portion
I Experiment Set	92.15	91.48	90.06
II Experiment Set	90.91	89.98	88.32
III Experiment Set	92.28	90.73	89.12
	Mean per cent mortality per sq.cm		
I Experiment Set	7.89	8.36	9.27
II Experiment Set	8.81	9.86	11.41
III Experiment Set	7.41	8.88	10.14
	Mean duration (days) of sex differentiation		
I Experiment Set	49.20	48.80	48.70
II Experiment Set	48.90	48.80	47.90
III Experiment Set	49.20	48.90	48.10

Conclusion

The biology of lac insect on pigeon pea concluded that the mean per cent settlement of crawlers in three set of experiments were 92.15, 91.48, 90.06; 90.91, 89.98, 88.32 and 92.28, 90.78 and 89.12 on lower, middle and upper portion of plant, respectively. This study helpful for knowing pigeonpea is an also important host crop for lac insect.

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