



E-ISSN: 2320-7078

P-ISSN: 2349-6800

JEZS 2019; 7(3): 505-509

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Received: 09-03-2019

Accepted: 13-04-2019

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Study of productivity linked parameters of lac insect, *Kerria lacca* (Kerr) on *Flemingia macrophylla*

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Abstract

Lac insect collections from Hisar, Bhiwani, Umreth-Anand, Barauda, Bijolia-Bhilwara, Aburoad-Sirohi, Chittorgarh, Udaipur were evaluated on *Flemingia macrophylla* for productivity parameters during *katki* crop. The mean initial density for all locations during 2016 and 2017 was non-significant. Maximum mean density was in Chittorgarh (111.33 crawlers/cm²) as against Umreth (70.67 crawlers/cm²) during 2016 [during 2017, 116.00 crawlers in Aburoad as compared to minimum in Hisar (78.67)]. Maximum mean mortality was observed in Bijolia collection (36.42 and 34.30 percent during 2016 and 2017, respectively) with minimum mean mortality in collection from Aburoad (17.19 and 16.05 percent during 2016 and 2017, respectively). Mean fecundity was maximum in Aburoad collection (644.60 and 605.00 crawlers/female) during both years, whereas minimum was in Hisar (310.30 crawlers during 2016) and Bijolia (285.40 crawlers during 2017) which was statistically at par. Maximum mean female cell size was noted in Aburoad collection (2.27 and 4.16 mm during 2016 and 2017, respectively); while minimum cell size was recorded in Bijolia (2.27 and 3.54 mm during 2016 and 2017, respectively). Female cell weight was maximum from Aburoad (15.50 and 16.20 mg), Barauda (15.00 and 15.80 mg) and Udaipur collections (14.90 and 15.70 mg); whereas minimum mean cell weight was in Bijolia collection (10.60 and 10.80 mg) followed by Hisar (11.00 and 11.30 mg) and Bhiwani (11.10 and 11.00 mg) during 2016 and 2017, respectively. The mean resin weight was maximum in Aburoad, Udaipur and Barauda collections whereas mean minimum weight was in Bijolia, Bhiwani and Hisar collections during year 2016 as well as 2017. Study proved Aburoad-Sirohi collection followed by Udaipur and Barauda collections to be a lac insect with higher productivity and can be exploited for further multiplication for commercial cultivation.

Keywords: *Flemingia macrophylla*, *katki*, lac insect collection

1. Introduction

Lac, a natural resin, produced by tiny lac insects mainly *Kerria lacca* (Kerr) belonging to family Tachardiidae (Homoptera). Estimated national production of sticklac during 2013-14 was 21008 tons. About 70 percent of the national lac production is exported [1]. In India, the major lac producing states are Jharkhand, Chhattisgarh, Madhya Pradesh, Maharashtra and West Bengal, which contribute around 96 per cent of the total lac production. It's a highly remunerative crop, paying high economic returns to the farmers and also foreign exchange to country. Lac cultivation is an important source of income for livelihood of forest and sub-forest dwellers in different states; besides, it generates employment for men and women in forest and sub forest areas of Jharkhand, Chhattisgarh, Madhya Pradesh, West Bengal, Maharashtra, Odisha and parts of Uttar Pradesh, Andhra Pradesh, Gujarat and NEH region. On an average around 28 per cent of total agriculture income is contributed by lac cultivation [2]. Fast depleting forests are a serious threat to the biodiversity of lac insects. Many lac insects and associated fauna have become endangered where lac cultivation has been abandoned or its habitat destroyed. Promoting and encouraging lac culture will not only check environmental degradation, but also conserve associated fauna and flora for posterity [3].

Rangeeni and *kusmi* are the two strains of lac insect which have been classified based on their life cycle and preference of the insect for specific host plants. Of the two strains *i.e.*, *kusmi* and *rangeeni* of lac insect, *aghani* (winter) crop of *kusmi* contributes the most in total lac production. Lac insects thrive on the tender twigs of specific host trees *viz.*, *palas* (*Butea monosperma* Lam), *ber* (*Ziziphus mauritiana* Lamk), *kusum* (*Schleichera oleosa* Oken), *semialata* (*Flemingia semialata* Roxb), *bhalia* (*F. macrophylla*) and others.

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Besides these, Lac insects can survive on more than 400 plant species generally growing naturally in the forests as reported by various workers [4-8]. *Kusum* and *semialata* are suitable for *kusumi* lac insect whereas *palas* is used for *kusmi* lac insect. *Ber* and *bhalia* are common for culturing both type of lac insect.

So far, nine genera and 99 species of lac insects have been reported from all over the world; whereas, 2 genera and 26 sp are found in our country [9-12]. Lac insect species are highly degenerative and undergo tremendous changes due to different climatic and geographical differences in their adaptability to new environment, offspring producing ability and resin producing efficiency during the post-metamorphic stage. Differentiated populations, due to geographic separation and host-choice, which have diverged genetically with respect to adaptability to the environment, fecundity, size of the female and their resin producing ability, can be exploited from the lac production point of view. Keeping in mind the host suitability and lac productivity, the present study was planned to study the productivity parameters of lac insect.

2. Material and Methods

Lac insects collected from eight different locations [Hisar, Bhiwani, Umreth (Anand), Barauda, Bijolia (Bhilwara), Aburoad (Sirohi), Chittorgarh and Udaipur] maintained in the Lac Insect Field Gene Bank at dept of entomology, Rajasthan College of Agriculture (MPUAT) Udaipur [One of the cooperating centers of Network Project on Conservation of Lac Insect Genetic Resources (NPCLIGR) lead center at ICAR-IINRG, Ranchi] and evaluated on *Flemingia macrophylla* planted in pots for pre- harvest and post harvest parameters by destructive sampling method. Observations on pre- harvest productivity linked parameters *i.e.*, initial density of settlement (/cm²), initial mortality (%), sex ratio (male - female %) and post harvest productivity linked parameters *i.e.*, size of the female cell (mean of horizontal & vertical diameter), weight of single cell (female) of lac insect at maturity, resin output per female insect (mg) and fecundity (no. of crawlers per female) were taken. Data recorded on various parameters were tabulated and subjected to statistical analysis by using the techniques of analysis of variance [13]. Treatment significance was tested using 'F' test. The significance among different treatment means was judged by critical difference (C.D) at 5% level of significance for comparison among the treatments.

3. Results and Discussion

3.1 Pre-harvest productivity parameters

Data collected on pre- harvest productivity parameters during 2016 and 2017 have been presented in Table 1 and 2.

i) Mean initial density of settlement (Number of crawlers /cm² area)

The mean initial density of settlement in per square cm for rainy season *rangeeni* lac crop in all the locations during both the years (2016-2017) was non-significant. Maximum mean initial density of settlement was recorded in Chittorgarh (111.33 crawlers / cm²) as against minimum initial density of settlement in Umreth, Anand (70.67 crawlers / cm²) during 2016. During the year 2017, maximum mean density was 116.00 crawlers / cm² in Abu road (Sirohi), as compared to minimum density of settlement in Hisar (78.67 crawlers / cm²). Initial density of settlement is a dependent variable

which depends on the quantity of brood lac inoculated. The findings of the present investigation are in close agreement with earlier reports [14] which reported 82.67 ± 04.15 to 118.32 ± 05.31 crawlers /cm² on *B. monosperma* for rainy season crop. The average density of settlement (68.0, 68.53 and 104.73) and initial mortality (5.74, 18.82 and 22.85) were reported from Madurai, Varanasi and Bhathat stocks, respectively [15].

Studies [16] on biological attributes of *rangeeni* lac insect raised on *ber* and *palas* at Jharkhand and West Bengal during 2011-12 revealed minimum and maximum initial density of settlement as 80.4 to 125.2 /cm² area. Study revealed significant differences in pre harvest and post harvest parameters revealing that initial density of settlement showed significant difference only between locations. Thus, findings of the present study are in line with the work of earlier workers.

ii) Mortality (%)

Maximum mean mortality rainy season *rangeeni* lac crop was observed in Bijolia (Bhilwara) collection with values of 36.42 per cent; whereas, minimum mean mortality percent was in Aburoad (Sirohi) 17.19 per cent, which was statistically at par with collection from Udaipur (20.27 per cent), Barauda (20.29 per cent) and Umreth (Anand) 21.24 per cent during the year 2016. Similarly during 2017, maximum mean mortality of 34.30 percent observed in Bijolia (Bhilwara), which was statistically at par with Bhiwani (29.43 per cent) collection. Likewise minimum mean mortality percent was found in Abu road (Sirohi) with values of 16.05 per cent followed by Barauda (20.42 per cent) and Udaipur (21.19 per cent). Findings [16] revealed initial mortality of 26.9 to 62.2 per cent during 2011-12. Study revealed significant differences in pre harvest and post harvest parameters. Findings were also reported that initial mortality differs significantly between locations and hosts which are in accordance with present study.

iii) Sex ratio (male %)

Findings during 2016 for rainy season *rangeeni*, showed maximum mean male percent in the Bijolia (Bhilwara) (34.01%) followed by Chittorgarh collection (32.95). Minimum mean male per cent was in Hisar (14.73%) followed by Bhiwani (17.47%) and Umreth (Anand) 17.83 per cent. During 2017 maximum mean male per cent was from the Bijolia (Bhilwara) collection, which showed 35.14 per cent followed by Chittorgarh (32.50) collection. Collection of Hisar constituted about 17.10 per cent of male population and was followed by Umreth (Anand) with a mean male population of 17.78 per cent and Bhiwani with 18.03 per cent. A sex ratio of 23.5 to 37.9 per cent male reported during 2011-12 [16]. Study revealed significant differences in pre harvest and post harvest parameters. Results also revealed that sex ratio differs significantly between locations and hosts which conform the findings of present study wherein a sex ratio from 14.73 to 34.01 per cent was recorded.

However, both very high and very low male population is not a good parameter from productivity of lac point of view because males do not survive after mating (40-55 days of inoculation) and therefore, female is the principal resin producer. If males population is less, than all the females may not be fertilized which ultimately reduces the resin producing efficiency of the female cells. Resin producing ability of unfertilized females was greatly reduced which was around

one third of that secreted by fertilized females [17].

3.2 Post-harvest productivity parameters

Data collected on post-harvest productivity linked parameters during 2016 and 2017 have been presented in Table 1 and 2.

i) Fecundity (Nos /female)

Data on fecundity of rainy season *rangeeni* lac insect revealed the maximum mean fecundity of 644.60 crawlers from single female in the Aburoad (Sirohi) collection as against minimum mean fecundity (310.30 and 363.30 crawlers) from the collections of Hisar and Bijolia (Bhilwara), respectively. Similarly in 2017 also, the maximum mean fecundity recorded was 605.00 crawlers from single female in the Aburoad (Sirohi) collection, whereas collections of Bijolia (Bhilwara) and Hisar produced the least number of crawlers per female cell (285.40 and 319.80 crawlers, respectively). Genetic variability in biological parameters *i.e.*, fecundity of lac insect reported from 276.2- 747.6 crawlers per female which supports the findings of the present study [18-20]. Productivity of Indian lac insect, *K. lacca* in terms of fecundity, live cell weight and dry cell weight of mature female lac was evaluated on *F. semialata* and *F. macrophylla* [21]. On *F. semialata*, fecundity varied from 253 to 565 eggs, whereas on *F. macrophylla* it was from 297 to 477 eggs. Results of the present study gets support from the work of the above workers.

Biological attributes of *rangeeni* summer lac insect were studied on *ber* and *palas* tree at Jharkhand and West Bengal during 2011-12 [16]. Minimum and maximum values of fecundity of 271 to 353.2 crawlers were reported during 2011-12. Variation in genetic variability reported may, therefore, be attributed to change in type of lac crop (summer *rangeeni*), agro-climatic conditions as well as change in lac host plants. Lac insect *K. lacca* was evaluated on 7 host plants for their relative performance with respect to productivity parameters [22]. Highest fecundity was obtained from *ber* 450.6 crawlers and lowest on *arhar* 315.4 crawlers during *katki* crop; whereas, for *baisakhi* crop, it was 525.2 on *ber* and 407 on *arhar*. *F. macrophylla* produced the 338.0 crawlers per female and 460.8 crawlers during *katki* and *baisakhi* crop, respectively.

ii) Female cell size (mm)

Data on female cell size (mm) for rainy season *rangeeni* lac insect during 2016 showed the maximum mean female cell size of 2.76, 2.69 and 2.68 mm in Abu road (Sirohi), Barauda and Udaipur collections respectively, which were at par with each other. While minimum mean female cell size was recorded in Bijolia- Bhilwara (2.27 mm) collection. The collection of Abu road (Sirohi), Barauda and Udaipur had maximum mean female cell size of 4.16, 4.16 and 4.11 mm during the year 2017 also; whereas, minimum mean female cell size was reported in Bijolia- Bhilwara (3.54 mm) collection followed by Bhiwani (3.58 mm) collection.

Genetic variability in biological parameter *i.e.*, female cell size (mm) of lac insect was reported from 2.74 - 3.68 mm of female cell diameter [18, 19, 23] which are in agreement with the findings of the present study. an average mean diameter of a cell 3.1, 3.17, 3.19 and 3.22 mm found in *rangeeni* strain with respect to host plants *A. auriculiformis*, *F. macrophylla*, *C. moschata* and *B. monosperma*, respectively. Results of the present study are partly in agreement with the works of the earlier workers [24]. Variation in genetic variability reported by

different workers may be attributed to change in agro-climatic conditions as well as host plants. Lac insect *K. lacca* was evaluated on 7 host plants for their relative performance with respect to productivity parameters [22] wherein maximum cell diameter was found in *ber* (3.06 mm), whereas lowest was in *arhar* (2.60 mm) for *katki* crop whereas during *baisakhi* crop it was 3.52 on *ber* and 3.27 on *arhar*, respectively. On *F. macrophylla*, cell diameter was recorded as 2.85 for *katki* and 3.25 mm for *baisakhi* crop.

iii) Female cell weight (mg)

The female cell weight during rainy season *rangeeni* lac insect 2016 revealed the maximum mean cell weight from Aburoad (Sirohi) Barauda and Udaipur collections with mean values of 15.50, 15.00 and 14.90 mg, respectively; whereas minimum mean female cell weight was recorded in Bijolia- Bhilwara with a mean of 10.60 mg followed by Hisar (11.00 mg) and Bhiwani (11.10 mg) collection. During 2017 maximum values (16.20, 15.80, and 15.70 mg) with respect to mean cell weight were from the collections of Aburoad (Sirohi), Barauda and Udaipur; respectively; while, minimum mean cell weight was recorded in the Bijolia- Bhilwara (10.80 mg), Bhiwani (11.00 mg) and Hisar (11.30 mg) collection.

Genetic variability in biological parameters *i.e.*, female cell weight (mg) of lac insect reported 8.05-24.14 mg [18, 19, 23]. The productivity of Indian lac insect, *K. lacca* studied [21] in terms of fecundity, live cell weight and dry cell weight of mature female lac on *F. semialata* and *F. macrophylla* where female cell weight varied from 8.00 to 19.00 mg on *F. semialata* and 9.33 to 18.83 mg on *F. macrophylla*. Cell weight (mg) *rangeeni* strain with values of 10.94, 8.74, 8.91 and 10.55 mg reported on *A. auriculiformis*, *F. macrophylla*, *C. moschata* and *B. monosperma*, respectively; whereas, cell weight from *kusmi* and *rangeeni* strain varied between 19.51 and 10.01 mg, respectively [24]. Results of the present study are partly in agreement with the work of the earlier workers [24]. Variation in genetic variability reported by different workers may therefore, be attributed to change in agro-climatic conditions as well as host plants. Lac insect *K. lacca* was evaluated on 7 host plants for their relative performance with respect to productivity parameters [22]. Maximum live cell weight of a single cell was reported in *ber* (10.12 mg), whereas lowest was on *arhar* (9.40 mg); whereas, for *baisakhi* crop it was 14.21 mg on *ber* and 13.60 on *arhar*, respectively. On *F. macrophylla* cell weight recorded as 9.49 mg for *katki* and 13.67 mg for *baisakhi* crop.

iv) Resin weight (mg)

The mean resin weight recorded as 10.40, 10.20 and 9.90 mg for rainy season *rangeeni* lac insect was maximum from the collections of Aburoad (Sirohi), Udaipur and Barauda, respectively; whereas, mean minimum resin weight was in the Bijolia (Bhilwara) (7.60 mg) collection, followed by Bhiwani (7.80 mg) and Hisar (8.00 mg) collections during the year 2016. Likewise during 2017, mean maximum resin weight was recorded from collections of Aburoad (Sirohi), Barauda, and Udaipur with mean of 9.50, 9.20 and 8.90 mg, respectively; while, mean minimum resin weight was in the collection of Bijolia (Bhilwara), Bhiwani and Hisar (6.50, 6.90, and 7.10 mg).

Genetic variability in biological parameter *i.e.*, resin weight of lac insect was reported as 6.48 - 20.94 mg of resin output [18, 19, 25]. Results of the present study are partly in agreement with above findings. Resin production by individual female cell of

rangeeni strain with values of 9.09, 7.49, 6.0 and 8.76 mg was observed with respect to host plant *A. auriculiformis*, *F. macrophylla*, *C. moschata* and *B. monosperma*, respectively; whereas, resin from *kusmi* strain (16.96 mg) was more than twice than that of *rangeeni* strain (8.07) [24]. Biological attributes of *rangeeni* lac insect on *ber* and *palas* tree were

studied at Jharkhand and West Bengal during 2011-12 and reported mean resin weight of 16.97 to 16.03 mg from *palas* and *ber*, respectively [16]. Variation in genetic variability reported may be attributed due to change in type of lac crop (summer *rangeeni*), agro-climatic conditions as well as change in lac host plants.

Table 1: Comparative location wise productivity linked parameters of lac insect during 2016.

Location	Pre- harvest productivity parameters (Mean)			Post- harvest productivity parameters (Mean)			
	Initial Density of Settlement (Nos / cm ²)	Mortality (%)	Sex ratio (male %)	Fecundity (Nos / Female)	Female cell Size (mm)	Female Cell Weight (mg)	Resin Weight (mg)
Hisar	8.76 (76.67)	5.09 (25.69)	3.83(14.73)	16.93(310.30)	1.73(2.49)	3.38(11.00)	2.89(8.00)
Bhiwani	8.77 (79.67)	5.49 (29.81)	4.20(17.47)	18.86(383.70)	1.70(2.41)	3.39(11.10)	2.87(7.80)
Umreth, Anand	8.26 (70.67)	4.66 (21.24)	4.27(17.83)	20.89(468.30)	1.74(2.55)	3.63(12.70)	3.03(8.80)
Barauda	10.16 (103.00)	4.55 (20.29)	5.07 (25.23)	23.55(566.80)	1.78(2.69)	3.92(15.00)	3.21(9.90)
Bijolia, Bhilwara	9.12 (83.67)	6.07 (36.42)	5.85 (34.01)	18.36(363.30)	1.66(2.27)	3.32(10.60)	2.83(7.60)
Aburoad, Sirohi	9.33 (86.67)	4.18 (17.19)	4.81 (22.88)	24.60 (644.60)	1.80(2.76)	3.98(15.50)	3.28(10.40)
Chittorgarh	10.51 (111.33)	4.77 (22.35)	5.76 (32.95)	20.76 (443.40)	1.73 (2.51)	3.54 (12.10)	2.95 (8.30)
Udaipur	9.98 (100.33)	4.54 (20.27)	5.28 (27.38)	21.72 (506.20)	1.78 (2.68)	3.91 (14.90)	3.25 (10.20)
S. Em. ±	9.15	1.46	1.33	22.22	0.03	0.21	0.19
CD at 5%	NS	4.43	3.91	62.80	0.09	0.61	0.55

* Square root $\sqrt{(X + 0.5)}$ transformation values and figures in parentheses are retransformed values.

NS: Non- significant

Table 2: Comparative location wise productivity linked parameters of lac insect during 2017.

Location	Pre- harvest productivity parameters (Mean)			Post- harvest productivity parameters (Mean)			
	Initial Density of Settlement (Nos / cm ²)	Mortality (%)	Sex ratio (Male %)	Fecundity (Nos / Female)	Female Size (mm)	Cell Weight (mg)	Resin Weight (mg)
Hisar	8.81 (78.67)	5.37 (28.51)	4.12 (17.10)	17.67 (319.80)	2.04 (3.65)	3.43 (11.30)	2.75 (7.10)
Bhiwani	9.34 (87.33)	5.47 (29.43)	4.30 (18.03)	18.50 (353.40)	2.01 (3.58)	3.38 (11.00)	2.71 (6.90)
Umreth, Anand	9.70 (93.67)	4.92 (24.70)	4.27 (17.78)	19.33 (391.10)	2.14 (4.07)	3.72 (13.50)	3.01 (8.70)
Barauda	9.77 (96.33)	4.57 (20.47)	5.18 (26.92)	23.40 (555.90)	2.16 (4.16)	4.03 (15.80)	3.06 (9.20)
Bijolia, Bhilwara	9.51 (90.00)	5.88 (34.30)	5.94 (35.14)	16.63 (285.40)	2.01 (3.54)	3.36 (10.80)	2.62 (6.50)
Aburoad, Sirohi	10.78 (116.00)	4.03 (16.05)	5.15 (26.04)	24.40 (605.00)	2.16 (4.16)	4.08 (16.20)	3.12 (9.50)
Chittorgarh	9.87 (97.00)	5.36 (28.44)	5.68 (32.50)	19.51 (382.70)	2.07 (3.79)	3.61 (12.60)	2.88 (8.00)
Udaipur	9.65 (93.00)	4.65 (21.19)	5.48 (29.67)	21.56 (472.80)	2.15 (4.11)	4.02 (15.70)	3.03 (8.90)
S. Em. ±	6.38	1.84	1.64	13.77	0.03	0.18	0.24
CD at 5%	NS	5.57	4.82	38.91	0.10	0.51	0.69

* Square root $\sqrt{(X + 0.5)}$ transformation values and figures in parentheses are retransformed values.

NS: Non- significant

4. Conclusion

The mean initial density of settlement per cm² was recorded maximum in Chittorgarh (2016) and Abu road (2017) collection, mean percent mortality and mean percent males in Bijolia (Bhilwara) collection, mean fecundity, mean female cell size, mean cell weight and mean resin weight was maximum in Aburoad (Sirohi) collection which proved Aburoad (Sirohi) collection to be a lac insect with higher productivity and can be exploited for further multiplication for commercial cultivation.

5. Acknowledgements

Authors are thankful to ICAR for providing grants under Network project on Conservation of Lac Insect Genetic Resources (NP-CLIGR).

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