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Studies on lac insect (*Kerria lacca*) for conservation of biodiversity in Similipal Biosphere Reserve, Odisha, India

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ABSTRACT

The lac insect, *Kerria lacca* Kerr (Coccoidea: Homoptera) is well known for its valuable resin. It thrives on host plants like Palas, Kusum and Ber. An attempt has been made to study culture of lac in non-conventional method of cultivation in peripheral and buffer zones of Similipal Biosphere Reserve (SBR) where farmers are practicing in a conventional way. The initial density of settlement of larva ranged between 92.58-126.74 no. /cm^2 and 93.12-109.62 no. /cm^2 in Kusmi strain on Kusum and Ber trees, respectively. For Rangeeni strain it was 82.67-118.32 no. /cm^2. The sex ratio (male: female) was found to be 1:3 for all the crops, strains and host plants. The range of resin output per cell was 17.00-21.40 mg for winter crop and 19.00-25.60 mg for summer crop of Kusmi strain on Kusum and Ber plants. For Rangeeni strain on Palas plant it was 05.30-11.20 mg for rainy crop and 18.72 -23.00 mg for summer crop. Moreover, the temperature influenced the life cycle, life span and resin output of this insect. Pruning of trees meet the firewood requirement as fuel and also for household uses, also prevents deforestation and conserve the forest ecosystem. Lac insect has some vertebrate predators like monkeys, squirrels, rats, lizards, woodpeckers, birds and insect predators are Lepidopterans (*Eublemma amabilis*, *Pseudohypatopa pulverea*) and Neuropterans (*Chrysopa madestes*, *C. lacciperda*). So directly or indirectly lac cultivation helps in conservation of biodiversity.

Keywords: Lac insect, Resin, Kusmi, Rangeeni.

1. Introduction

Lac is one of the most valuable gifts of nature to man. It is the only resin of animal origin, being actually the secretion of a tiny scale insect, *Kerria lacca* Kerr (belongs to the family Tachardiidae (Kerriidae), superfamily Coccoidea of the order Homoptera). It basically yields three useful materials: resin, dye and wax. Resin is commonly known as lac found in market as shellac or seedlac or button lac. In India the lac insect is usually found in forests of Himalayan terai, hilly regions of Jharkhand, West Bengal, Odisha, Madhya Pradesh, Uttar Pradesh, Rajasthan, Gujarat and Assam. Lac got its versatile uses in various sectors like paints, inks, micanite, pharmaceuticals, cosmetics, electrical industry, automobiles, Defence, Railways, Marine and Postal department, surface coating industry, confectionery industry, fruit and vegetable coating, soft drinks, chocolate and candy coating, lac dye for textile industry and in slow - release lac coated urea fertilizer for controlled release of urea nitrogen. The life cycle of lac insect starts with first instar larval stage, the crawlers. The crawlers after settlement undergo three successive moulting to become the adult. The first instar is mobile and crawls over the shoot of host trees. It settles and feeds 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 tree species on which it feeds, lac crop and prevailing environmental conditions. On the basis of preference in use for lac cultivation by Indian cultivators, centuries of practical experience and distribution in the country, the lac hosts are placed under three categories, viz. (i) common or major hosts, (ii) occasional hosts, and (iii) rare hosts. Although more than 250 host plant species of *K. lacca* have been identified so far, the first category, i.e., common or major hosts include fourteen species in which three, namely Palas (*Butea monosperma*), Kusum (*Schleichera oleosa*) and Ber (*Zizyphus mauritiana*) are of all India importance contribute 95% of commercial production of lac [12].

As one-third tribal people of Mayurbhanj District reside in Similipal Biosphere Reserve (SBR) and SBR is having healthy vegetation including plenty of Palas and Kusum trees, it is a very suitable eco-region for lac cultivation.

2. Materials and Method

The study was conducted in Similipal Biosphere Reserve, Mayurbhanj, Odisha in the year 2009-10. The land is undulating and filled with valley forest, plain forest and hilly forest. The altitude varies from 50 to 1,150 m ASL. The ecosystem and the climatological parameters vary in an altitudinal gradient. Moreover, the selections of study sites in the Biosphere Reserve were done keeping in the mind the availability of lac in the different ecoclimatic pockets. Furthermore, Survey was taken up in two different zones of SBR with having diversified forest types. These places were Jadida, Jadunathpur (100-200 m ASL) and Chakidi (200-300 m ASL) in peripheral zone, Notto (400-500 m ASL), inner Kendumundi (500-600 m ASL) and Gudugudia (800-900 m ASL) in buffer zone [20]. As per the record of Forest Department the areas in which major host plants of lac insects (Palas, Kusum and Ber) are found, taken as study sites. Assistance was taken from the staff of Forest Department, Government of Odisha. The officials of Nuclear Broodlac Farm, Chakidi and skilled rearers were also used to help in the survey. The geophysiography of study sites were undertaken keeping in the view of the altitude of natural blocks, forest types and zones of SBR. Culture method was adopted as per Indian Institute of Natural Resins and Gums (IINRG), Ranchi and from scientific publications. Month and season-wise values of temperature, humidity and rainfall were observed and calculated (Table 1).

2.1. Cultivation of lac

Indian lac insect is known to have two distinct strains ‘Kusmi’ and ‘Rangeeni’. The Kusmi strain is grown on Kusum or on other alternate host plants using Kusmi broodlac and the crops are (i) Jethwi (June/July) and (ii) Aghani (Jan. /Feb.). The Rangeeni strain thrives on host plants like Palas and it has also two crops; they are (i) Katki (Oct. /Nov.) and (ii) Baisakhi (June/July).

Pruning of host trees and method of inoculation [12], and application of pesticides, forecast of larval emergence and crop harvesting [17, 5] were done in time.

2.2. Density of settlement

One square cm area was selected at random and numbers of lac larvae settled were counted [1, 15]. Five such sites were counted from each plant from five places and mean ± SD was taken as density of settlement.

2.3. Percentage of male and female insects

At the time of emergence sex of lac larvae cannot be distinguished. After a certain period of growth, larvae can be differentiated into male and female lac insects based on their morphological differences [1, 15]. It was done through visual observation. Males were identified by using magnifying lens and compound microscope. The process (as in case of initial density of settlement) was repeated for recording male and female numbers with mean ± SD values. After counting their number, respective percentages of male and female were calculated against initial settlement density of larva.

2.4. Density of female at crop maturity (Number per square cm)

Surviving female lac insects (after emergence of male lac insects) were counted at crop maturity (appearance of yellow spot). Mean ± SD values were calculated for density of females at crop maturity [1, 15].

2.5. Extraction of resin

To measure the weight of resin (per cell) sticklacs collected from fields were weighed and scraped, water soluble materials were removed by water wash, left for air dry and then grinded to get fine products. Resin was extracted by alcoholic solvent extraction method, i.e., dissolved in 90% alcohol (1:4 weight/volume). When it was made into solution, insoluble residues were allowed to settle; the solution was then filtered and was kept open for evaporation of alcohol [6]. Weight of resin (15-20 % wax and other residues) was measured by Physical Monopan balance. To calculate the weight of resin (per cell), resin produced/cm^2 was divided by number of female cells/cm^2 area.

2.6. Statistical Analysis

Student’s t-test was used to find out the level of significance between peripheral and buffer zones of same crop and Fisher’s t-test for same zones in different crops of respective strain on three host plants, like Kusum, Palas and Ber. It was considered statistically significant if $P < 0.05$ or 0.02 or 0.01 or 0.001. Attempts have been made to find out whether there is any correlation between temperatures with that of resin productivity for different zones [7].

3. Results

The result showed that in case of Kusmi strain on Kusum plant the average initial settlement of larva (no./cm^2) in peripheral zone was significantly higher ($P < 0.01$) in summer crop (Jethwi) (112.63) than that of the winter crop (Aghani) (92.58). In buffer zone the average initial settlement of Jethwi was (126.74) and Aghani was (110.91) but it was not significant. The peripheral zone of summer crop (Baisakhi) (105.57) of Rangeeni strain on Palas tree was significantly higher ($P < 0.01$) than that of the rainy crop (Katki) (82.67). The buffer zone of summer crop (Baisakhi) (118.32) was significantly higher ($P < 0.01$) than that of the rainy crop (Katki) (102.42). Peripheral zone of summer crop (Jethwi) (104.62) was significantly higher ($P < 0.01$) than that of the winter crop (Aghani) (93.12) of Kusmi strain in Ber plant. But in buffer zone Jethwi (109.62) was more than that of the Aghani (104.54) but not significant. The initial settlement of larva in buffer zone (110.91) was significantly higher ($P < 0.05$) than that of the peripheral zone (92.58) of winter (Aghani) crop in Kusmi strain of Kusum plant. In case of Jethwi crop the buffer zone (126.74) was significantly higher ($P < 0.05$) than those of the peripheral zone (112.63). In Katki crop the result of initial density of settlement of larva in Rangeeni strain of Palas plant showed that the buffer zone (102.42) was significantly higher ($P < 0.001$) than that of the peripheral zone (82.67). Baisakhi crop of buffer zone (118.32) was significantly higher ($P < 0.05$) than that of the peripheral zone (105.57). In case of Aghani crop of Kusmi strain in Ber plant the result of buffer zone (104.54) was also significantly higher ($P < 0.01$) than that of the peripheral zone (93.12). The Jethwi crop of buffer zone (109.62) was more than that of the peripheral zone (104.62) and not significant (Table 2).

The average percentage of male ranged in between 23.29-29.82 and female between 70. 18-76.7 no. /cm^2. The sex ratio (male: female) was approximately 1:3.
In case of Kusum plant, the average density of settlement of female (no./cm^2) at crop maturity, the Jethwi crop (12.73) of Kusmi strain was significantly higher ($P < 0.01$) than that of the Aghani crop (8.24) in peripheral zone. For the buffer zone, summer crop (Jethwi) (17.18) was significantly higher ($P < 0.02$) than that of the winter crop (Aghani) (12.32). In the case of Rangeeni strain in Palas tree, the peripheral zone of summer crop (Baisakhi) (10.83) was significantly higher ($P < 0.001$) than that of the rainy crop (Katki) (3.38). For the buffer zone the summer crop (12.67) was significantly higher ($P < 0.001$) than that of the rainy crop (6.57). The Jetwi crop (9.14) in Kusmi strain on Ber plant showed that the peripheral zone was significantly higher ($P < 0.001$) than that of the winter (Aghani) crop (8.32). Though the average of buffer zone of Jethwi crop (11.19) was more than that of the Aghani (9.54) but not significant (Table 2).

The density of settlement of female between two zones of Aghani crop revealed that the average of buffer zone (12.32) was more than that of the peripheral zone (8.24) but it was not significant. In case of Jethwi crop of Kusmi strain on Kusum plant, the buffer zone (17.18) was more than that of the peripheral zone (12.73) but there was no significant result. The analysis of Katki crop in Rangeeni strain of Palas plant showed that the buffer zone (6.57) was significantly higher ($P < 0.01$) than that of the peripheral zone (3.38). The result for summer crop (Baisakhi) revealed that the buffer zone (10.83) was not significant with peripheral zone (12.67). During winter crop of Kusmi strain on Ber plant the buffer zone (9.54) and peripheral zone (8.32) had no significant difference. For the Jethwi crop of Kusmi strain in Ber plant though the value of buffer (11.19) was more than that of the peripheral zone (9.14) but not significant (Table 2).
The weight of resin (mg/cell) in peripheral zone of summer crop (Jethwi) (22.50) was significantly higher ($P < 0.001$) than that of the winter crop (18.00) of Kusmi strain on Kusum plant. The analysis for the buffer zone of summer (Jethwi) and winter crop (Aghani) revealed that it was significantly higher ($P < 0.001$). In peripheral zone the summer crop (Baisakhi) (18.72) was significantly higher ($P<0.001$) than that of the rainy crop (Katki) (5.30) in the Rangeeni strain of Palas plant. For the buffer zone the summer crop (Baisakhi) (23.0) was significantly higher ($P < 0.001$) than that of the rainy crop (Katki) (11.20) of Rangeeni strain in Palas plant. In Ber plant the summer crop (19.00) of peripheral zone was significantly higher ($P < 0.05$) than that of the winter crop (17.00). Likewise in buffer zone, when the summer crop (Jethwi) (21.25) was compared with winter crop (Aghani) (18.23), those were significantly higher ($P < 0.001$) (Table 2).

The statistical analysis on winter crop (Aghani) of Kusmi strain on Kusum plant revealed that the buffer zone (21.40) was significantly higher ($P < 0.05$) than that of the peripheral zone (18.00). When the comparison between two zones on SBR were taken on the summer crop (Jethwi) of Kusmi strain on Kusum plant, the buffer zone there was no significant difference between two zones of buffer (25.6) and peripheral (22.50). The buffer zone (11.20) was significantly higher ($P < 0.001$) than that of the peripheral zone (5.30) of rainy crop (Katki) in Rangeeni strain of Palas plant. Baisakhi crop had the value of buffer (23.00) more than that of the peripheral zone (18.72) but that was not significant. In case of winter (Aghani) crop the result for summer crop (Jethwi) of Kusmi strain on Ber showed that though the value of buffer zone (21.25) was more than that of the peripheral zone (19.00) that was not significant (Table 2).

Table 1: Meteorological (climatological) parameters of study sites in SBR at different altitudes during different seasons.

Study site	Altitude (m ASL)	Season	Atmospheric temperature			Relative humidity (%)	Rainfall (mm)
			Max. temp.(^{0}C)	Min. temp. (^{0}C)	Average temp. (^{0}C)		
Peripheral zone (Outer zone)	100-300	Summer	40.10 (01.10)	22.00 (0.69)	31.50 (0.37)	78.00 (01.98)	34.20 (10.42)
		Rainy	36.50 (01.10)	23.25 (0.45)	29.88 (0.75)	89.00 (03.20)	180.30 (38.10)
		Autumn	34.55 (0.25)	22.25 (0.25)	28.40 (0.30)	92.25 (01.15)	257.20 (41.40)
		Dew	32.70 (01.10)	18.75 (01.05)	25.73 (01.10)	90.25 (03.05)	69.70 (39.10)
		Winter	27.20 (01.50)	15.00 (0.70)	21.10 (01.10)	85.60 (01.70)	6.20 (01.00)
		Spring	34.20 (01.19)	17.80 (01.45)	26.00 (01.20)	73.30 (04.75)	16.80 (01.60)
Buffer zone (Middle zone)	500-600	Summer	36.80 (0.55)	20.20 (01.09)	28.50 (0.42)	67.90 (05.73)	38.00 (13.61)
		Rainy	33.60 (01.00)	20.85 (0.15)	27.23 (0.55)	80.45 (04.05)	200.00 (25.40)
		Autumn	30.70 (0.20)	20.45 (0.05)	25.57 (01.00)	84.50 (02.10)	283.70 (12.10)
		Dew	29.50 (01.20)	17.15 (01.15)	23.33 (01.15)	79.65 (01.45)	103.50 (63.00)
		Winter	25.05 (01.55)	14.35 (0.60)	18.93 (0.15)	69.35 (01.15)	06.30 (0.10)
		Spring	31.80 (01.24)	16.60 (0.09)	23.20 (0.66)	63.50 (03.28)	16.30 (2.25)

4. Discussion

The process by which host trees are infested with the lac insects is known as inoculation. In this process, the lac larvae settle on suitable shoots, some 150-300 of them being generally present on one square inch of the surface of a twig and about 150 larvae settle in one square cm area [16]. It was observed that in almost all host plants for each crop, larval settlement (no. /cm^2) was more in buffer zones than the peripheral zones of SBR (Tables 2). This may be due to difference in climatic conditions between two zones (Table 1). It has been reported that the effect of climate on these insects is direct as well as indirect through the effect on the host plants on which these insects depend [9]. The difference in ecoclimatic conditions between buffer and peripheral zones at SBR may be attributed to the forest types. The buffer zone has dense (thick) forest in comparison to peripheral zone (visual observation). The canopy of the buffer zone which seems to be continuous may be preventing the larvae from the extremities of wind, heat, cold and rainfall, thereby producing a conducive environment for lac insect. On the other hand, canopy is not a continuous one as the trees are not densely populated in peripheral zone. So the lac insects are more prone to environmental factors in peripheral zone than that of the buffer zone.

Density of living female at crop maturity is the result of interaction between host suitability and existing environmental factors [19]. The average density at crop maturity varied between 3.38-12.67 no. /cm^2 on Palas plant in both the zones for Rangeeni strain and 8.24-17.18 no. /cm^2 on different host plants for Kusmi strain in both the zones (Table 2). Number of living females (per cm^2) at crop maturity were 5.25% (Katki crop of peripheral zone) to 12.45% (Jethwi crop of buffer zone) of the initial settlement density. Drastic reduction in settlement density of females when compared to initial density of settlement is caused by (i) mortality due to non-feeding at initial stage, (ii) existing biotic/abiotic factors and (iii) death of male insects which die soon after fertilizing the females [19].

Large quantity of lac resin is secreted by female after fertilization, which protects mother insect as well as its young-ones at later stages. It has been found that insect with high fecundity secretes more resin [10]. As the lac insects are usually situated close together, the lac secretion from adjacent cells coalesces with each other and forms a continuous encrustation on the branches of host plant [11]. The range of resin output per cell was 5.30-11.20 mg/cell in rainy season and 18.72-23.0 mg/cell in summer season in Rangeeni strain for both the zones. In Kusmi strain on Kusum and Ber plants, it was 17.0 to 21.40 mg/cell in winter season and 19.00-25.60 mg/cell in summer season for both the zones (Table 2).

Rise in environmental temperature reduce the resin output by the female insect. All other crops on different hosts and zones showed negative correlation (either significant or not) between temperature and weight of resin output. The result suggests that temperature greatly influence the lac production. Besides temperature, other environmental factors such as rainfall, humidity, wind etc. also influence lac production. The temperature recorded at study sites shows that buffer zone has lower temperature than that of the peripheral zone (Table 1) in SBR.

Table 2: Initial density of settlement, settlement of female, weight of resin produced by female of *Kerria lacca* (Kerr) on various host plants in different zones of SBR in 2009-10. Data are Mean ± SD of 5 places.

Host Plants	Strains	Crops	Zones	Settlement of larva (no./cm^2)	Density of settlement of female (no./cm^2)	Weight (mg/cell) of resin produced by female
Schleichera Oleosa (Kusum)	Kusmi	Aghani (winter)	Peripheral	92.58 ± 07.15	08.24 ± 01.80	18.00 ± 01.03
			Buffer	110.91 ±17.15^a	12.32 ± 02.60	21.40 ± 02.58^a
		Jethwi (summer)	Peripheral	112.63 ± 07.03*	12.73 ± 01.62***	22.50 ± 01.15****
			Buffer	126.74 ±13.58^a	17.18 ± 01.86**	25.60 ± 02.67
Butea monosperma (Palas)	Rangeeni	Katki (rainy)	Peripheral	82.67 ± 04.15	03.38 ± 01.12	05.30 ± 01.71
			Buffer	102.42 ± 04.51^d	06.57 ± 02.00^c	11.20 ± 02.04^b
		Baisakhi (summer)	Peripheral	105.57 ± 09.68*	10.83 ±01.58****	18.72 ± 02.26****
			Buffer	118.32 ± 05.31$^{*, a}$	12.67 ± 01.49****	23.00 ± 01.10****
Zizyphus mauritiana (Ber)	Kusmi	Aghani (winter)	Peripheral	93.12 ± 03.73	08.32 ± 0.91	17.00 ± 0.91
			Buffer	104.54 ± 06.02^c	09.54 ± 01.35	18.23 ± 01.48
		Jethwi (summer)	Peripheral	104.62 ± 05.19*	09.14 ± 0.78****	19.00 ± 01.30*
			Buffer	109.62 ± 10.39	11.19 ± 01.31	21.25 ± 02.77****

*P<0.05; **P<0.02; ***P<0.01 and ****P<0.001 in comparison to different crops of same zone of the respective strain for different host plants. ^{a}P<0.05; ^{b}P<0.02; ^{c}P<0.01 and ^{d}P<0.001 in comparison to peripheral zone of same crop of the respective strain for different host plants.

5. Conclusion

Lac insects are exploited for their products of commerce, i.e., resin, dye and wax. Cultivation of lac not only provides livelihood to millions of lac growers, but also helps in conserving vast stretches of forests and biodiversity associated with lac insect complex [18, 2, 3, 4, 8, 13, 14]. The lac ecosystem is a complex multi-tropic web of flora and fauna. Out of 87 species falling under 9 genera recorded from the world, 19 species belonging to 2 genera, namely *Kerria* and *Paratachardina* are found in India. Lac Insects thrive on more than 400 plant species generally growing in the forests which have varied economic, medicinal and social significance. Twenty two species of lac predators, 30 species of primary and 45 species of secondary parasites, besides several fungal pathogens, present a rich biodiversity of this ecosystem [18]. They have further opined that, this natural lac complex also maintains a variety of other tree flora, macro fauna and soil microorganisms. Several of the insect fauna associated with lac insects are species-specific (exclusive to the ecosystem) and hence, loss of even one species of lac insect poses a danger of losing many other related species [18]. Promoting and encouraging lac culture will not only check environmental degeneration but also conserve associated fauna and flora for posterity.

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