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Natural occurrence of lac insect, *Kerria lacca* and its conservation in Jammu and Kashmir

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Abstract
Surveys were conducted in various districts of Jammu region namely, Jammu, Samba, Kathua, Udhampur, Reasi and Rajouri, for searching sample lac insect (*Keria* sp.; Kerriidae: Hemiptera) on naturally infected trees of Ber (*Zizyphus mauritiana*) during June to December, 2014 to 2017. It was found that natural occurrence is highly threatened through human interventions, inclining temperature during summer coupled with the occurrence of parasitoids and predators. Eleven strains of *Rangeeni* insects were collected and maintained *insitu* and *exsitu*. The density of settlement of lac insect ranged between 48.3 to 162.0 no. of crawlers/cm^2 in *Rangeeni* strain on *Flamengia*. The range of resin output per cell as 5.60-8.15 mg for summer crop of *Rangeeni* strain. Conservation initiatives enhanced the frequency of natural occurrence of lac insect in the region with 13.5 per cent increased. For in situ conservation, a gene bank was established wherein sufficient quantity of natural lac was multiplied on the bushy host and distributed on the 475 host plants for four small scale demonstrations. The mean yield per tree on ber was 12.8 kg (brood lac) and 1.86 kg mature lac. On the basis of these trials it was concluded that cultivation of lac has high potential for sustaining livelihood for both men and women particularly in the off-agricultural season in this lac growing regions of the country.

Keywords: Natural occurrence, conservation, *Kerria lacca*, Jammu & Kashmir

1. Introduction
About 70 percent of the Lac, a natural resin, produced by tiny lac insects mainly *Kerria lacca* (Kerr) belonging to family Tachardiidae (Homoptera) is exported [1]. 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 Kandi areas of Jammu and Kashmir. Lac insect genetic resources exist in the form of a vast array of populations which have evolved and adapted over many centuries, to the range of environmental conditions encountered throughout the country resulting in several breeds, types and strains, each with their own genetic make-up, and each adapted to its own specific niche. On an average around 28 per cent of total agriculture income is contributed by lac cultivation in India [2]. The lac insect genetic resources available throughout the country are under threat due to the disappearance of a substantial number of local populations as many lac insects and associated fauna have been abandoned or its habitat destroyed [3].
The future improvement and development of lac insect is dependent upon the availability of this genetic variation, which is its principal resource. Promoting and encouraging lac culture will not only check environmental degradation, but also conserve associated fauna and flora for posterity. Conservation is of particular concern in regions of rapid agricultural change, where indigenous stocks and farming methods are being replaced. Areas where climatic extremes or particular parasitic conditions have resulted in genetically modified and unique local stocks which are able to survive under extreme conditions should be a high priority. Such conservation efforts are particularly important in the light of predicted global climate change, and the ability of microbial and insect parasites to evolve and adapt to modern chemical control methods. Not long ago, collection (gathering) of lac was carried out practically throughout the country including Jammu & Kashmir which contributed significantly to national lac production, but now its share is almost negligible. However, natural occurrences of lac insect, locally called as korh in J&K is well established particularly on ber plants. It is pertinent to mention that lac was found abundantly before 1947 and people used to collect and sell it commercially. Interestingly, this State is bestowed with ample of lac host plants,

Therefore it cultivation can be revived for the benefit of farming community of the region by scientific cultivation through systematic intervention. Inview of fast shrinking area of lac cultivation elsewhere in the country, the region has been earmarked as a "green area" for conservation of biodiversity of the lac insect ecosystem. Jammu Based on ground realities, it has been realized that the vast area of Jammu region (Jammu, Kathua and Samba districts) i.e., southern plains of Jammu region known as kandi belt (Rainfed areas) are bestowed with lac host plants *viz.*, Ber, Palas and Ficus. Therefore, it warrants cultivation of lac on commercial scale through large scale demonstration and extensive training programmes for the rural people of the area as well as extension workers at frequent intervals. Keeping this in mind, the present study was planned on conservation and promotion of lac cultivation in the region.

2. Material and Methods

2.1 Survey and Natural occurrence

Studies were carried out in the outer and mid hills of the Jammu region, which exhibit a sub-tropical climate. The region is formed by the deposits of rivers Chenab, Tawi and Ravi and their tributaries surrounded by Shivalik Hill range to the north, east and southeast, and the Trikuta Range around it in the northwest. The area has a very large summer and moderate winter, with temperatures falling below the freezing period. In winter, dense smog is very inconvenient and even drops to 2 ^{o}C in summer, especially in May and June, very severe sunlight or the hot wind can raise temperatures to 46 ^{o}C. The annual average is 1100 mm, with the bulk of rain coming in months from June to September, although winter can be quite wet. The vegetation is of a subtropical nature, dominated by shrubby shrubs, evergreen shrubs, climbers and tall grasses. Selection of sites with major host plants of lac insects (Palas, Kusum and Ber) were planned as per input from locals and Forest Department the areas. The geophysiography of study sites were undertaken keeping in the view of the altitude of natural blocks, forest types and zones. Culture method was adopted as per Indian Institute of Natural Resins and Gums (IINRG), Ranchi and from scientific publications. For procuring information regarding location of lac insect infested trees in various parts of Jammu region, surveys were conducted for three consecutive years 2014-17 in the districts of Jammu, Samba, Kathua, Udhampur, Reasi and Rajouri for searching sample lac insect (*Kerria* sp.; Kerriidae: Hemiptera) in naturally infected trees of Ber (*Zizyphus mauritiana*), Palas (*Butea monosperma*), Kikar (*Acacia nilotica*) Khair (*Acacia catechu*) and Pipal (*Ficus religosia*). The lac infested trees and branches were tagged and data regarding the maturational phase of lac insect infestation and the host tree were noted carefully. Frequency of occurrence, mortality and prevalence percentage were also observed (Fig 1).

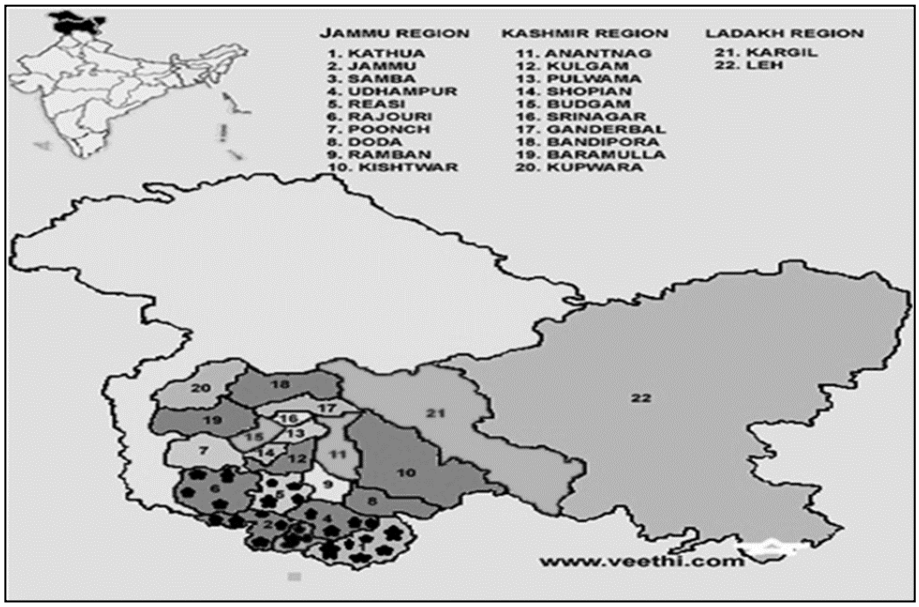

Fig 1: Natural occurrence of lac in Jammu and Kashmir. *represent the blocks with presence of insect

2.2 Conservation Methods

2.2.1 *In-situ* Conservation

Partial brood was allowed for natural inoculation on the host plants for sustaining and conserving native strain. 475 plants were inoculated for in situ conservation. Artificial Inoculation was also done by cuttingbrood twigs in size 20 - 30 cm in length. Then, the cut pieces of brood twig were tied to fresh tree twigs in such a way that each stick touches the tender branches of trees at several places. This was done on *Ber*, *Kikar*, *Palas*, *Khair* and *Ficus*.

2.2.2 *Ex-situ* Conservation

Plants of *Flemingia semialata* were raised in nursery for rearing Lac insects for the purpose of conservation. About one thousand seedlings of *F. semialata* were planted and raised in optimum protected natural condition. Brood lac sticks were wrapped in muslin cloth bags and were inoculated on the succulent branches of one year old substitute experimental host i.e. *F. semialata* both in nursery and in pots as well. 'Phoonki' were removed after complete emergence and settling of Lac insect crawlers on the branches. Observation on the settlement rate, Mean brood cells/30 cm stick of lac and Mean weight of fresh 100 cells of Lac insects were recorded.

2.3 Collection and Maintenance of Strains

The lac insects samples collected from the different lac hosts from different localities were inoculated on *Flamengia* plants

at SKUAST- Jammu. After inoculation the emergence and settlement data were recorded for each sample of lac insect on host plants. To prevent the infestation of lac insects with different natural enemies and fungi different pesticides were sprayed on host plants at different stages of lac insect. All the strains were maintained on bushy host after maturity in every season.

2.3.1 Density of settlement
One square cm area was selected at random and numbers of lac crawler settled were counted [4-5]. Five such sites were counted from each plant from five places and mean was taken as density of settlement.

2.4 Biological Attributes
Lac insects collected from different locations were maintained in the Lac Insect Field Gene Bank at Division of entomology, SKUAST-J and evaluated on *Flemingia semialata* planted in pots for pre- harvest and post-harvest parameters by destructive sampling method. Observations on pre- harvest productivity linked parameters i.e., initial mortality (%), and post-harvest productivity linked parameters i.e., resin weight per female insect (mg) and fecundity (no. of crawlers per female) were taken.

2.4.1 Fecundity (Number of young ones produced by the female insect)
To record the fecundity of lac insect, the mature female cells were placed individually into glass vials plugged with cotton for about a month and the total number of emerged larvae per female were counted and taken as fecundity of the female lac insect.

2.4.2 Initial Mortality percentage
Observations on initial density were repeated at 21-days after inoculation of broodlac following the same procedure as described earlier. The process of crawler emergence continues up to two weeks. The crawlers which were not able to find suitable sites for settlement die due to starvation. Observation at this stage represented true indication of the number of crawlers actually settled and that have started feeding. The initial mortality (%) was calculated by the following formula.

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

2.4.3 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). Whenit 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.

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

3. Results and Discussions
3.1 Natural occurrence
During the survey the natural occurrence was recorded in four districts *viz*., Jammu, Udhampur, Kathua and Reasi. In Jammu, the frequency of occurrence was 2.1% on ber plant(Table 1).Unlike other parts of India, we found the natural occurrence of lac on only ber (*Zizyphus mauritiana* Lam. and *Z. jujube* Lam,). However it was never recorded on palas (*Butea monosperma* Lam.) pipal (*Ficus religosia* Linn.), pipal (*Ficus benjamina* Linn.) calandra (*Calandra spp*), siris (*Albizzia lebbek* Denth.), Custard Apple (*Annona squamosa* Linn.), Khair (*Acacia catechu* Willd.), Arhar (*Cajanus cajan* Linn.) Gular (*Ficus racemosa* Linn.) Babool (*Acacia*.), Amaltas (*Cassia fistula* Linn.) and bargad (*Ficus bengalensis* Linn.) as reported elsewhere in India [7]. The prevalence of lac in potential host plants in Jammu region was highest (100%) on the protected trees grown in religious places like temples or *Ziarat*. It was also observed that at almost all sites, only yellow or crimson colored *Rangeeni* strains developed well on the natural hosts with varying densities. It was ascertained that the lac insect was highly prone to summer mortality in the region and its natural occurrence is highly threatened through human interventions, coupled with the occurrence of parasitoids and predators. Among these factors, the whole pruning of trees for fodder by nomadic *Bakerwal* community contributed to the extent of 74 per cent decline of lac. In view of this shrinking distribution in the Jammu region, efforts should be made to conserve local hosts and available strains of lake insects by raising awareness and popularizing the culture of the lake in the region.

Table 1: Natural abundance of lac insect in Jammu region

Location	Plant observed	Total no. of plants observes	Living	Dead	Remarks
Jammu	Ber	130	3	18	Collected
	Palas	63	0	0	-
	Ficus	32	0	0	-
Udhampur	Ber	82	1	6	Collected
	Palas	11	0	0	-
	Ficus	13	0	0	-
Kathua	Ber	78	2	4	Collected
	Palas	22	0	0	-
	Ficus	11	0	0	-
Samba	Ber	50	2	7	Not Collected*
	Palas	53	0	0	-
	Ficus	29	0	0	-
Rajouri	Ber	15	0	0	-
	Palas	08	0	0	-
	Ficus	04	0	0	-
Reasi	Ber	16	1	1	Collected
	Palas	12	0	0	-
	Ficus	06	0	0	-

3.2 *In-situ* conservation
Not long ago, collection (gathering) of lac was carried out practically throughout the country including Jammu & Kashmir which contributed significantly to national lac production, but now its share is almost negligible. However, natural occurrences of lac insect, locally called as korh in J&K is well established particularly on *ber* plants. The first stage of *in situ* conservation of lac is inoculation. It is the process by which newly hatched (brood) nymphs get associated with new branches of host plants. In the present study, among the various host plants (Table 2) that were

inoculated artificially for lac conservation, the success rates of survival on these plants were 34.62, 66.67, 38.46 and 38.89 percent on wild *Ber, Kikar, Ficus* and *Palas*, respectively (Fig 2). The productivity of the lac insect on different hosts depends on the different factors governing the development host which contribute to growth, feeding, secretion and spawning of the lac insect influence the relative resin production by the lake insect [8]. The mean brood cell mortality in each host plant was recorded. It was found that for conservation, Kikar showed the lowest mortality (47.59) while it was highest on *Ber* plant (62.07).This mortality is attributed to the first instar larvae which could not find suitable sites for settlement on host plant could not survive and dies due to starvation within a week or two of its emergence. The observed range confer the findings of [9] who recorded 43.72 to 65.19 per cent mortality of *Rangeeni* strain of lac insect on various hosts. There is no denying the fact that *Palas* and *Ficus* also supported brood maintenance to a desired level but as the local proned these trees for fodder purpose thereby hampering conservation efforts by 32 per cent. As *Kikar* is hardly pruned for local purpose it was found the most suitable for maintenance of brood with mean number of lac sticks per plant (24.97/plant) followed by *Ber* (14.90/plant) and *Ficus* (11.13/plant). In general the lac insect was found distributed around the branch, but on most decline branches, and on shaded parts.

In comparison to plains, mid hills showed better potential for the conservation as the brood cell mortality was lower in these areas probably due to mild temperature in summer. In outer plains, a considerable mortality of lac insect on artificially inoculated plant was observed different hosts with mean survival on wild *Ber* (62.50 per cent) followed by *Palas* (52.78 per cent) and *Khair* (40.62 per cent). However, in mid hills, less mortality was recorded in wild *Ber* (37.50 per cent) and on *palas* (47.22 per cent). Since *Kikar* and *Palas* are not found in mid hills they were not considered. When compared across host plants, the mean number of lac sticks harvested were higher in wild *Ber* (35.14/plant) followed by *Khair* (29.32/plant) and *Palas* (26.19/plant) (Fig 3).

Table 2: Prevalence (%) of lac-insects on different hosts trees found around religious, protected and unprotected conditions

Host	Total plant surveyed (No)	Religious	Protected	Unprotected
Ber	172	100	83	21
Kikar	117	-	100	96
Palas	85	25	17	7
Ficus	45	-	-	-
Khair	56	10	9	5

Table 3: Success rate of In-situ conservation on different host plants in Jammu region

Host Plant	Inoculated (No)	Trees (No) with live lac cells at harvest stage	Brood Position
Ber	172	121	Good
Kikar	117	81	Good
Palas	85	31	Not good
Ficus	45	1	Not good
Khair	56	32	Not good
Total	475	276	

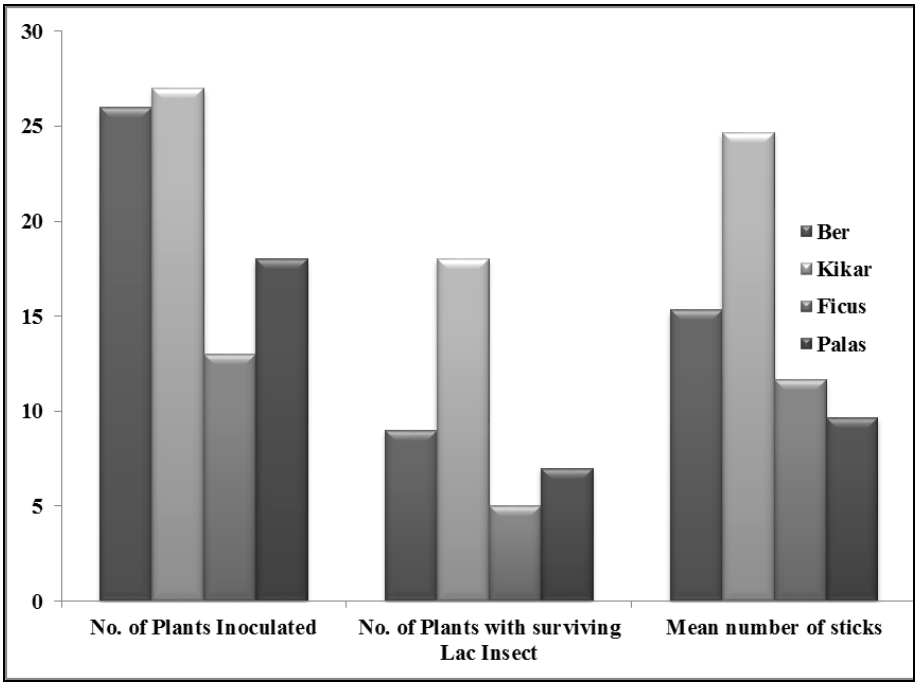

Fig 2: Performance *Rangeeni* lac (Baishakhi) on different hosts for conservation in Jammu plains

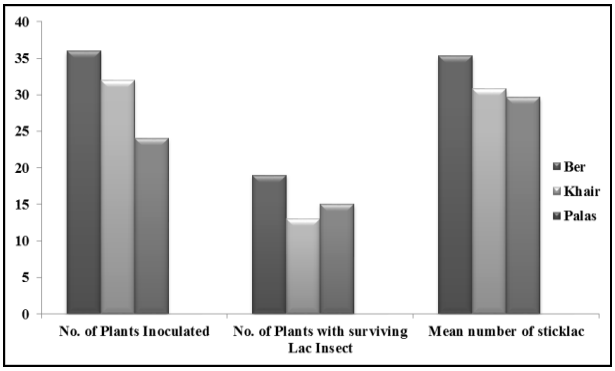

Fig 3: Performance *Rangeeni* lac (Baishakhi) on different hosts for conservation in Jammu mid hills.

3.3 *Ex-situ* Conservation

Eleven collections that survived successfully from previous year collections were re-inoculated on *Flamingia* and being maintained in the gene bank (Table 4). All the eleven collections are surviving with highest settlement rate of 162.0 crawlers/cm^2 in *Bantalab* strain followed by *Gole Market* strain (153.3 crawlers/cm^2). The lowest settlement rate was recorded in *canal road* strain (48.3 crawlers/cm^2). Mean brood cells per 30 cm stick was recorded highest in *Bantalab* strain (21) followed by *Udheywala* strain (33) and lowest in *Canal road* (14). Similarly, mean weight of fresh 100 cells (g) was highest in *Bantalab* (1.84) followed by *Gole market* (1.26) and lowest in *Railway station* strain (0.51).The current density of larvae of the *Rangeeni* strain is well within the range of 93.12-109.62 per m^{2}as reported by different workers [10-11]. The results on mean yield of sticklac of *Rangeeni* strain of lac insect on *Flamengia* was 185.00 gper plant and ranged between 105.30.-320.12 g which confer the findings of [12] who recorded 342.74 g and 219.02 g sticklac yield in *Flemengia* sp in winter and rainy season respectively per plant.

Table 4: Strains of lac insects maintained in the gene bank and their biological parameters

Collection name	Whether surviving or not	Settlement rate	Mean Brood cells/30 cm stick	Mean weight of fresh 100 cells (g)
Gol Market	Surviving	153.3 Crawlers/cm^2	21	1.26
Bantalab	Surviving	162.0 Crawlers/cm^2	43	1.84
Purkhoo	Surviving	95.8 Crawlers/cm^2	18	1.01
Udheywala	Surviving	87.9 Crawlers/cm^2	33	0.98
Kathua	Surviving	112.0 Crawlers/cm^2	22	1.20
Canal Raod	Surviving	48.3 Crawlers/cm^2	14	0.54
Nagrota	Surviving	52.0 Crawlers/cm^2	19	0.87
Cherni Pahari	Surviving	108.9 Crawlers/cm^2	23	1.01
Chi Chi Mata	Surviving	103.1 Crawlers/cm^2	20	0.91
Ghagwal	Surviving	93.0 Crawlers/cm^2	18	0.71
Railway Station area	Surviving	86.3 Crawlers/cm^2	18	0.51

3.4 Biological attributes

Maximum mean mortality summer season *Rangeeni* lac crop was observed in *Chichi Mata* strain (65.73%) followed by *Cherni Pahari* (63.30%) while as, minimum mean mortality percent was in *Canal Road* strain (52.20%). According to Rout *et al.*, (2018) [13] the percent of individuals that died during each age interval/apparent mortality (100qx) was found to be maximum in the 2ndinstar for *F. macrophylla* and *F. semialata* plants which was 16.44 and 45.77 per cent. The probable causes are not only the climatic factors but also the nature of the twigs for the settlement suitability and struggle between to have wider scope for existence in crawling stage with the ultimate result of mortality due to unavailability of proper place to get nourishment for continuing the race. Data on fecundity of summer season *Rangeeni* lac insect revealed the maximum mean fecundity of 222.0 crawlers from single female in the Canal Road strain as against Minimum mean fecundity (116.3) from the strains of *Chi Chi Mata*, which corroborate the earlier findings of [14-15] who evaluated the productivity of Indian lac insect (*Kerria lacca* Kerr) on *F. semialata* and *F. macrophylla* in terms of fecundity and found that the fecundity varied from 253-565 and 297-477 larvae per female cell respectively on the two hosts under study also confers the results of present investigation. The highest resin weight was recorded in *Bantalab* strain with a value of 8.15 followed by *Gole Market* strain (7.67). The lowest resin weight was observed in *Chi Chi Mata* strain with a value of 5.60 (Table 5). These findings of [16] are in conformity with producing efficiency of *Rangeeni* strain of *Kerria lacca* in India on different hosts that varied from 6-9.09 mg.

Table 5: Comparative strain wise productivity linked parameters of lac insect

Collection name	Mortality	Fecundity	Resin Weight
Gol Market	62.63 (7.98)	145.3 (12.09)	7.67 (2.94)
Bantalab	54.47 (7.45)	212.3 (14.59)	8.15 (3.03)
Purkhoo	59.30 (7.77)	197.3 (14.07)	6.08 (2.66)
Udheywala	57.33 (7.64)	203.3 (14.29)	6.47 (2.73)
Kathua	57.07 (7.62)	201.7 (14.23)	6.03 (2.65)
Canal Raod	52.20 (7.29)	222.0 (14.92)	7.03 (2.83)
Nagrota	59.90 (7.80)	189.7(13.80)	6.57 (2.75)
CherniPahari	63.30 (8.02)	132.7(11.56)	5.87 (2.62)
Chi Chi Mata	65.73 (8.17)	116.3(10.82)	5.60 (2.57)
Ghagwal	53.77 (7.40)	220.7 (14.88)	7.23 (2.87)
Railway Station area	58.23 (7.69)	162.3 (12.78)	6.29 (2.70)
S. Em. ±	0.09	0.23	0.04
CD at 5%	0.26	0.67	0.11

3.5 Biotic and abiotic constraints

3.5.1 Effect of Temperature on survival of lac insect

The relationship between the temperature and mortality is depicted in figure 4that showed increased mortality with the increase in temperature. The mortality started increasing from 16th standard week, when the temperature tends to reach around 40 ºC. The temperature is the most important climatic factor affecting lac production [17-18] and it is well established that increasing summer temperature above 40 ºC lead to increased mortality of lac insect.

3.5.2 Parasites and predators

During the investigation 3 species of predators *E. amabilis*, *P. pulverea*, *C. zastrowi* and four species of primary parasitoids *T. tachardiae*, *A. purpureus*, *T. clavicornis*, *E. dewitzi*were recorded on lac host which accounted to about 22 to 35 percent mortality of insect. Among these, *A. purpureus* was the most harmful parasitoids of lac insect followed by *T. tachardiae*. Parasitoids of lac insect were affecting adversely on the resin yield and the fecundity of the insects, particularly during rainy seasons with average reduction between 17.25-39.80% in *Rangeeni* crop. According to Narayanan (1962) [19] super parasitism can occur but typically one parasite larva occurs in single scale. Simultaneously, the predators are more serious and may cause damage to the cells in a crop up to 30-35%.About 20 predators have been reported from different parts of the country, among which *Eublemma amabilis* and *Pseudohypato papulverea* were the most destructive [20]. In order to manage them, we found that two applications of indoxacarb (0.5ml/l) significantly reduced the infestation of parasitoid infected lac cell on *Rangeeni* lac on ber over the control at 90 days after BLI. At 90 days after BLI the mean incidence of parasitoids was lowered from 1.80/2.5sq cm to 0.30/2.5sq cm. However, the parasitiod numbers varied from 13 to 30. Pesticide applications also significantly reduced the mean number predators/parasitoids infested lac cells at harvest. It was 36.33 in case of control and was reduced to 23.61 in treated plants at harvest (Fig 5). This pesticide was found most suitable for protecting lac crop at critical under field conditions with higher fecundity and superior quality broodlac [21].

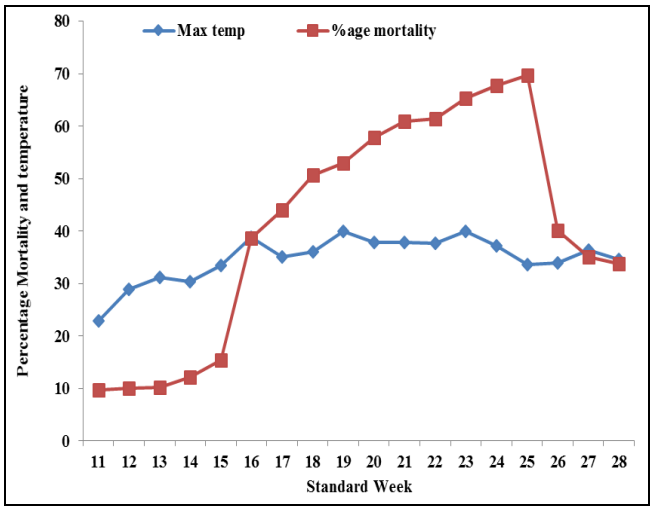

Fig 4: Relation between temperature and mortality of lac insect as observed under field conditions for three consecutive years (pooled data)

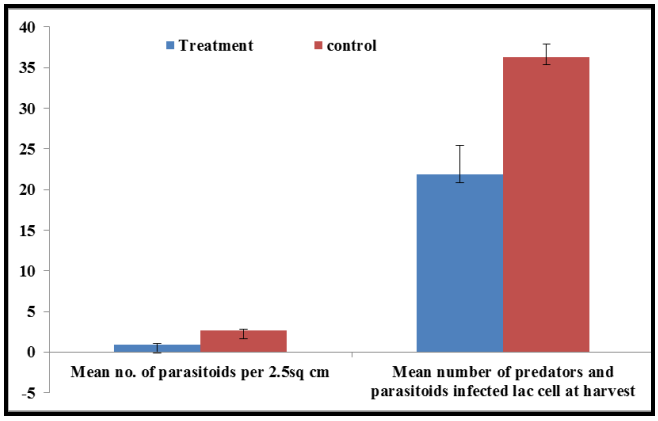

Fig 5: Mean number of parasitoids and predators over control at harvest for three consecutive years (pooled data).

3.6 Small scale field trials

Comparative field performance of *Rangeeni* lac insect of Jammu origin at Raya of district Samba of J&K could result in a better brood lac with output-input ratio of 21. Similar number of plants when inoculated with local brood (Akhnoor) of district Jammu (J&K) produced output-input ratio (18). The mean yield per tree on ber was 12.8 to 18.3 kg (brood lac) and 1.30 to 1.86 kg mature lac. The variation of results with the findings of the present investigation in the yield may be attributed to the size, growth, length of the plants, strain of lac insect and climatic condition etc which may cause difference in the yield of scrapedlac. The gross return for mature lac per tree of Ber was highest around (INR 1612.5) in rainy season and it was lowest during summer crop (INR 758.7). This is attributed to the fact that Lac production is climate dependent and high summer temperature damage laccrop [22].

4. Conclusions

Based on above findings, it has been realized that the vast area of Jammu region (Jammu, Kathua and Samba districts) i.e., southern plains of Jammu region known as kandi belt (Rainfed areas) are bestowed with ample population of lac host plants *viz*., Ber, Palas and Ficus. These plantscould be exploited for cultivation of lac on commercial scale through large scale demonstration and extensive training programmes for the rural people of the area as well as extension workers at frequent intervals. The conducted so far indicated lac cultivation for sustaining livelihood for both men and women particularly in the off-agricultural season. In J&K, the projected production at this level (25 percent of existing host plants) would be about 5000 tonnes with a revenue generation of 40-50 crores for *Rangeeni* strain. The prices of Brood lac are ranging between 300-350/kg while of seed lac is upto 250 Rs/kg. Initially the farmers could be trained to process seed lac to lac dana (used for polishing wood) which will cost around 600/Kg andas the practice is adapted on wider scale efforts on lac processing shall be introduced.

5. Acknowledgements

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