Environment and Ecology 41 (4B) : 2726—2733, October—December 2023
Article DOI: https://doi.org/10.60151/envec/RLGU3947
ISSN 0970-0420

Settlement Behavior of Crawlers of *Rangeeni* strain Of lac Insect on Different Host

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Received 13 May 2023, Accepted 11 September 2023, Published on 29 November 2023

ABSTRACT

Under the auspices of NP-CLIGR, the Department of Entomology, RCA, Udaipur conducted the current inquiry on investigations on the settlement behavior of Rangeeni lac bug, *Kerria lacca* (Kerr) on various hosts during 2021–2022. To determine the best location for lac brood tying and the ideal configuration of plant hosts in a field from which the greatest amount of lac could be harvested, the settlement behavior of lac insect crawlers on various hosts was examined in relation to the cardinal direction and twig girth of the host plant. On the *Acacia* host the crawlers traveled the greatest mean distance, 19.67 cm, from the site of inoculation, followed by Flemingia, Ber, Palas, and Pigeon pea. On the Kikar and Custard Apple, the crawlers traveled the least mean distance, 10.49 cm and 12.93 cm, respectively, from the site of brood lac inoculation. There was a negative connection between the crawlers' initial settlement and the diameter of the host twig (r = -0.26). Regardless of where the plants were located, the lower part of the host plant was where crawlers settled more frequently. As opposed to branches developing in the east and west of the plant, lac insect crawlers favored branches growing in the north and south of the plant.

Keywords Crawlers, Host, Lac insect, Rangeeni, Settlement behavior.

INTRODUCTION

One of nature's gifts to man, lac is extremely valuable economically. Being the secretion of the tiny scale insect *Kerria lacca* (Kerr), which is a member of the family Tachardiidae (Kerriidae), superfamily Coccoidea, and the order Hemiptera, it is the only resin of animal origin (Mohanta *et al*. 2014). For millions of people living in poverty, particularly tribal people dominating forests and sub-forests regions in various states of the country, it is a cash crop of commercial importance and key source of income (Shah *et al.* 2015). In India, there are two genera and 26 species of lac insects, with *Kerria lacca* being the most prevalent and important for commerce (Kerr). More than 80% of the overall lac production is contributed by the Indian lac bug *Kerria lacca* (Kerr) (Roonwal *et*

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al. 1958, Sharma *et al*. 1997). For their food requirements lac insects depend on plants as hosts. Earlier only four species were known as lac host plants. Firstly, four species are known as host plants of lac insects but recently more than 400 plant species have been found to be lac insect hosts globally which are divided into three categories as per their suitability and distribution i.e. common, occasional, and rare. The Flemingia spp., Ber, Palas and Kusum host plants are considered important for lac production (Bashir *et al*. 2022).

The lac insect is widespread throughout the world and feeds on plant sap with its piercing and sucking mouth by piercing its proboscis into the phloem area of the shoot to consume phloem sap. In order to protect its body during the feeding period, it secretes a resin, which after drying is retrieved as lacparts (Lalita 2020). According to Singh (2006), the resin, also known as "lac," "shellac," "seedlac," and "button lac," makes up 68% of lac. Other ingredients include color (1.2%), wax (6%), and others (25%) such as sugar, proteins, soluble salts, sand, woody debris, and so on. With more than 50% and 80% of global lac production and exports, respectively, India is the industry leader.

There are up to 21 plant species in the state of Rajasthan, according to the NP-CLIGR survey, of which Ber (*Ziziphus mauritiana*), Palas (*Butea monosperma*), Kikar (*Pithecellobium dulce*), and Sitafal (*Annona squamosa*), which are all readily available and suitable for commercial cultivation in the state, have been identified (Swami *et al*. 2021). The Rajasthan state is home to the Rangeeni strain of lac bug, which thrives best on ber (*Ziziphus mauritiana*). The best conditions for lac cultivation are found in states with semi-arid climates. The main crop grown on *Ziziphus mauritiana* in Rangeeni Lac is the *Baisakhi* crop.While, trees are infected in June and July to produce rainy season crop, which matures in October and November, host trees are typically inoculated with broodlac during October and November to raise summer Rangeeni crop, which matures in June (8 months) and July (4 months) (Monobrullah *et al*. 2015). The amount and quality of the larvae, the rate at which they develop, and the method of inoculation with regard to their location all play a significant role in the lac insect's settlement on host trees. The lac bug often prefers to establish on nearby, appropriate branches, with little settlement being seen in distant branches.

The amount and quality of the lac produced primarily depend on the population or number of crawlers that are finally able to settle on the host in relation to the cardinal direction, the host's available surface area, the host's girth, the insect's life cycle, and the development or maturity of the female cell at harvest. With all of this in mind, it is necessary to determine the settlement behavior of lac insect crawlers on the many hosts that are available in the area of the most prevalent strain, the Rangeeni strain, during the *Baisakhi* season.

MATERIALS AND METHODS

The present investigations were carried out at the lac insect gene bank and lac laboratory under NP-CLIGR, Department of Entomology, RCA, Udaipur during *Baisakhi* season of 2021-22. The materials used and methodologies adopted are described as under:

Settlement behavior of crawlers on different host

Utilizing the three branches of the different host plants—Ber, Palas, Flemingia, Pigeon pea, Kikar, Custard apple, *Acacia* sp. the experiment was conducted to examine the settlement behavior of Rangeeni lac insect crawlers on various hosts in terms of the distance travelled by crawlers for settlement, the effect of girth of host plant twigs on settlement and development of crawlers, and pattern of settlement on different cardinal directions on the branchesat Department of Entomology, Rajasthan College of Agriculture, Udaipur (Rajasthan) during the *Baisakhi* season of 2021-22.

Observations

Distance travelled by crawlers for settlement (cm):

From the moment the crawlers make touch with the host following emergence until they settle, the crawlers' distance was measured.

Effect of girth of twigs of host plants on settlement of crawlers: The initial settlement density of crawlers per square centimeter on each host plant was recorded, together with the girth (mm) at the same site, which was measured with the use of a Vernier caliper, in order to determine the impact of twig girth on settlement of crawlers.

Pattern of settlement in different cardinal directions: Twenty days after brood lac inoculation, settlement densities of lac insects in the prime cardinal directions of east, west, north, and south from each host were recorded in order to determine the patterns of settlement on various cardinal directions. Using a magnifying glass, the settlement density was counted visually from each of the four branch directions. With the exception of Flemingia and Pigeon pea, horizontal branches were preferred. These branches were chosen to record the settlement density on the upper and lower sides of the branches. The density of lac crawler settlement on five horizontal branches from various hosts, including Ber, Palas, Kikar, Custard Apple, and *Acacia* sp., was counted on both the upper and lower sides. Plants were selected in such a way that all directions receive an almost equal amount of sunlight. The simple correlation between girth of host plant and initial settlement of crawlers (per sq cm) was computed.

RESULTS

Settlement behavior of crawlers on different host

To understand the behavioral and settlement patterns of lac insects in relation to the cardinal direction and twig girth of the host plant, the settlement behavior of lac insect crawlers was investigated on several hosts. The experiment was designed so that all of the chosen hosts, including Ber, Palas, Flemingia, Pigeon pea, Kikar, Custard apple, and *Acacia sp*., which are all available at the Lac Insect Gene Bank, Department of Entomology, RCA, get light from all angles. In 2021–2022, the Rangeeni strain of lac bug was used in the experiment on a variety of hosts at the Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur. Studies on the settlement patterns of lac bug crawlers on seven distinct hosts have tabulated and presented in Tables 1 - 4.

Distance travelled by crawlers for settlement (cm)

After emerging, the crawlers moved from the injection site to various areas of the host to establish themselves. According to the observations made about the crawlers' journey distance for settling on various hosts and shown in Table 1, the kind of hosts and the quantity of brood lac injection have a significant impact on the crawlers' trip distance. Regardless of the hosts, the crawlers that emerged from the brood lac infected at the lower region of the plant traveled more and thus covered considerably more surface area than the crawlers that emerged from the brood lac inoculated at the upper portion of the plant. The *Acacia* sp., where crawlers travelled a mean distance of 19.67 cm from the site of inoculation, was where they traveled their largest mean distance, according to observations presented in Table 1 and Fig. 1. It was followed by the Flemingia, where the crawlers' mean distance from the injection site was 17.33 cm. From the location of inoculation, crawlers on Ber moved an average distance of 17.07 cm, followed by crawlers on Palas and Pigeon pea, who moved an average distance of 16.24 cm from the place of inoculation on each host branch. On Kikar and Custard apples, where the mean distance travelled from the location of brood lac inoculation was 10.49 cm and 12.93 cm, respectively, the crawlers' minimal mean distance from the brood lac was measured.

Effect of girth of twigs of host plants on settlement of crawlers

Every host branch included in the study had its circumference measured, and the measurement was

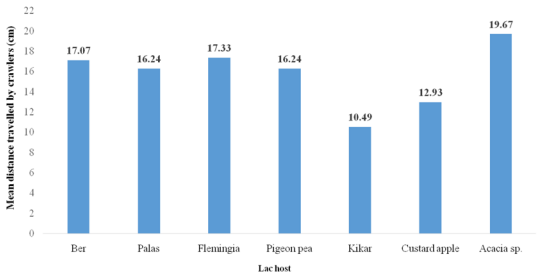

Fig. 1. Mean distance travelled by crawlers of Rangeeni strain lac insect for the settlement on different host during *Baisakhi* season, 2021-22.

Table 1. Distance travelled by crawlers for the settlement on different host during *Baisakhi* season, 2021-22.

Sl. No.	Lac host	Distance travelled by crawlers (cm)									Overall mean (cm)
		Host 1			Host 2			Host 3			
		B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3	
1	Ber	20.00	18.40	17.80	20.10	16.30	10.10	8.30	21.40	21.20	17.07
2	Palas	26.00	6.20	18.00	20.00	9.00	11.00	22.00	19.00	15.00	16.24
3	Flemingia	20.00	17.00	15.00	16.00	6.00	25.00	26.00	23.00	8.00	17.33
4	Pigeon pea	26.00	6.20	18.00	20.00	9.00	11.00	22.00	19.00	15.00	16.24
5	Kikar	11.30	15.40	15.30	14.10	7.00	6.30	5.40	6.90	12.70	10.49
6	Custard apple	17.30	17.00	17.10	18.00	2.00	3.00	7.00	20.00	15.00	12.93
7	*Acacia sp*	25.00	17.00	22.00	20.00	18.00	15.00	27.00	21.00	12.00	19.67

*B_1: Branch 1; B_2: Branch 2 and B_3: Branch 3.

compared to the location of each crawler on each host. During the experiment, it was found that the first settlement of the Rangeeni strain of lac insect crawlers during the crop of the *Baisakhi* season was negatively linked (r = -0.26) with the diameter of the host twig. Data illustrated in Table 2 and Fig. 2 show that Flemingia twigs had the shortest mean girth of 5.97 mm and the highest mean first settlement of lac crawlers, or 90.4 crawlers per square centimeter. After Flemingia, Pigeon Pea was the host with the next-highest twig girth, with a mean twig girth of 6.90 mm and a mean initial settlement of 86.4 crawlers per sq. cm. Palas came in second with a mean twig girth of 8.18 mm and a mean initial settlement of 82.4 crawlers per square centimeter. *Acacia* sp., Custard apple, Kikar, and Ber all had mean twig girth measurements of 8.94, 9.10, 12.78, and 14.52 mm, respectively, resulting in mean initial settlement measurements of 86.0, 54.2, 57.2, and 89.6 crawlers per square centimeter.

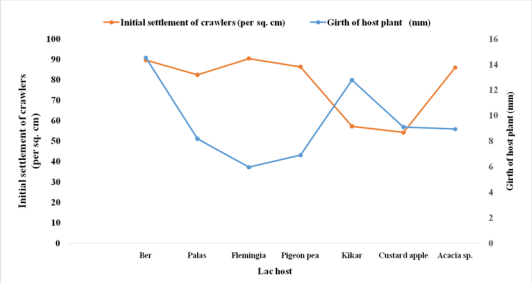

Fig. 2. Effect of girth of twigs of host plants on the settlement of crawlers of Rangeeni strain lac insect during *Baisakhi* season, 2021-22.

Table 2. Effect of girth of twigs of host plants on the settlement of crawlers during *Baisakhi* season, 2021-22.

Sl. No.	Lac host	Girth of host plant (mm)						Initial settlement of crawlers (per sq cm)					
		1	2	3	4	5	Mean	1	2	3	4	5	Mean
1	Ber	14.23	15.02	14.23	15.23	13.89	14.52	96	92	84	82	94	89.6
2	Palas	8.15	8.19	7.98	8.56	8.03	8.18	95	73	80	83	81	82.4
3	Flemingia	6.17	6.45	5.16	5.94	6.13	5.97	88	86	98	88	92	90.4
4	Pigeon pea	6.48	6.49	7.86	6.56	7.15	6.90	82	74	90	98	88	86.4
5	Kikar	12.56	13.45	11.65	12.68	13.56	12.78	62	50	64	52	58	57.2
6	Custard apple	9.56	9.46	8.94	7.98	9.56	9.10	56	60	46	58	51	54.2
7	*Acacia* sp.	9.56	9.46	8.98	7.56	9.16	8.94	82	92	98	78	80	86.0
	Correlation factor (r) between girth of plant and initial settlement									**-0.26**			

Pattern of settlement in different cardinal directions

The observations made regarding the mean settlement density in relation to the four cardinal directions—North, West, East, and South—showed that the direction of the sun had a significant impact on the settlement density on the various branches of the seven different hosts that were present in various directions. On the entire host, the mean settlement density was higher in the north and south than in the east and west. Additionally, compared to the upper region of the host plants, the mean settlement density was higher in the bottom portion of the host plants. Table 3 and Fig. 3 observations on the mean settlement density made on various hosts show that the mean settlement density on branches facing north was highest in relation to other directions and ranged from 79.20 to 112.60 crawlers per square centimeter at the top of the host plants compared to 82.40 to 119.80 crawlers per square centimeter at the bottom. The average settlement density on the branches facing south ranged from 39.0 to 86.60 crawlers per square centimeter at the top and lower sections of the host plants, respectively, and from 44.80 to 90.20 crawlers per square centimeter.The lowest mean settlement density of crawlers, which was measured at the upper and lower portions of the host plants, varied from 25.80 to 65.40, 35.60 to 80.80, and 28.40 to 68.60, 39.00 to 87.60 crawlers per sq cm in the west and east branches, respectively.

Only the remaining hosts, namely Ber, Palas, Kikar, Custard apple, and *Acacia* sp., were used to record the mean settlement density of crawlers in various cardinal directions because the hosts Flemingia and Pigeon pea lack horizontal branches to record the settlement density in cardinal directions of the branches. The average number of crawlers per square centimeter on the five hosts was 112.60, 89.60, 79.20, 84.40, and 95.60, respectively, whereas at the lower portion of the host on Ber, Palas, Kikar, Custard apple, and *Acacia* sp. on branches facing north, the average number of crawlers per square centimeter was 119.80, 92.40, 82.40, 87.80, and 99. In south direction, the average settlement density was found to be 86.60, 60.60, 39.00, 41.80, and 64.60 crawlers per square centimeter on Ber, Palas, Kikar, Custard apple, and *Acacia* sp., respectively, while it was 90.20, 63.40, 44.80, 46.20, and 68.80 crawlers per square centimeter at branches on lower portions of the host plants respectively.

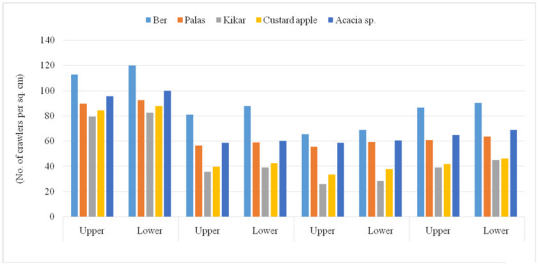

Fig. 3. Settlement pattern of crawlers of Rangeeni strain lac insect in different cardinal directions on different host during *Baisakhi* season, 2021-22.

The maximum mean settlement density of crawlers in east and west direction was recorded on the branches of Ber, the maximum mean settlement

Table 3. Settlement pattern of crawlers in different cardinal directions on different host during *Baisakhi* season 2021-22.

S. No.	Lac host	Mean settlement density (No. of crawlers per sq. cm)							
		North		East		West		South	
		Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
1	*Ber*	112.60	119.80	80.80	87.60	65.40	68.60	86.60	90.20
2	*Palas*	89.60	92.40	56.20	58.80	55.40	59.00	60.60	63.40
3	*Kikar*	79.20	82.40	35.60	39.00	25.80	28.40	39.00	44.80
4	Custard apple	84.40	87.80	39.40	42.40	33.20	37.60	41.80	46.20
5	*Acacia sp*	95.60	99.80	58.60	60.20	58.40	60.40	64.60	68.80
Standard deviation		11.30	12.61	15.23	16.21	14.20	14.06	16.30	15.69

density of crawlers was measured to be 80.80, 65.40 and 87.60, 68.60 crawlers per sq cm at the top and lower portions of the plant, respectively. On Palas, Kikar, Custard Apple, and *Acacia* sp., the mean settlement density of crawlers was 56.20, 58.80; 35.60, 39.00; 39.40, 42.40, and 58.60, 60.20 crawlers per sq cm in the east, and 55.40, 59.00; 25.80, 28.40; 33.20, 37.60, and 58.40, 60.40 crawlers per sq cm in the in west direction at upper and lower portion of the plant, respectively.

Discussion

To determine the best location for lac brood tying and the ideal configuration of plant hosts in a field from which the greatest amount of lac could be harvested, the settlement behavior of lac insect crawlers on various hosts was examined in relation to the cardinal direction and twig girth of the host plant. The findings illustrated in Figs. 1 - 4 demonstrated that, regardless of the placement of the plants, crawlers settled more frequently on the bottom part of the host plant. As opposed to the branches developing in the east and west of the plant, the lac insect crawlers preferred the branches growing in the north and south of the plant for their residence. As the lac insect grows well on the succulent branches of the plants, the results also show that the branch girth of the host plants affects the settlement of the crawlers. During the experiment, it was discovered that the diameter of host plant branches was adversely connected with the crucial settlement of Rangeeni strain lac insect crawlers. The findings of the current study demonstrated that the type of hosts, cardinal orientations of the host plants, branch out growths, and diameters of the host's branches all have a significant impact on the settlement pattern.

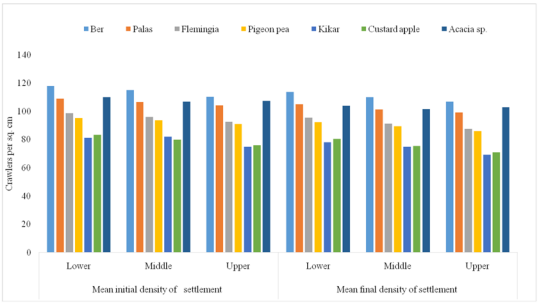

Fig. 4. Mean initial and final density of crawlers of Rangeeni strain lac insect on different host during *Baisakhi* season, 2021-2022.

According to observations of how crawlers behave during settlement on various hosts, the type of host has a significant impact on how far crawlers must go during settlement. The data collected on seven different hosts show that the crawlers covered an average distance of 10.49 cm on the Kikar plant, whereas they covered an average distance of 19.67 cm on the *Acacia* sp. host. The settlement of the lac crawlers was also impacted by the cardinal directions. According to the observations of crawler settlement on various host plants shown in Table 4 and Fig. 4, the Flemingia host had the highest mean initial settlement of crawlers with a mean initial settlement of 90.4 crawlers per sq cm, while the Custard apple had the lowest mean initial settlement of crawlers with 54.2 crawlers per sq. cm during the *Baisakhi* season of 2021–2022. On the upper and lower portions of the plant, respectively, the north had the highest mean settlement density (112.60 and 119.80 crawlers per square centimeter), followed by the south (86.60 and 90.20 crawlers per square centimeter), the east (80.80 and 87.60 crawlers per square centimeter), and the west (65.40 and 68.60 crawlers per square centimeter) (Fig. 3).

The findings of the present study are consistent with those of Hazarika *et al.* (2018), who noted that during the summer, the initial settlement density of lac crawlers was highest in the north (97.0 crawlers per square centimeter) and east (89.2 crawlers per square centimeter), while for the winter crop, the highest settlement density was observed in the west (31.2 crawlers per square centimeter) and south (34.6 crawlers per square centimeter) (57.2 crawlers per sq cm). Similar to the findings of the current investigation, Kalahal *et al.* (2017) found that the mean initial density of settlement on pigeon pea was higher on the lower parts of the plants as compared to the middle and upper parts, with 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 plot.

The findings of the present studies are also consistent with Sharma *et al*. (2019) findings, as their earlier research showed that the mean initial density of crawlers varied from 64.20 crawlers per square centimeter on the upper portion of pigeon pea to 93.93

Table 4. Effect of different host on settlement of lac insect (Rangeeni strain) during *Baisakhi* season 2021-22.

Lac host	Mean initial density of settlement (per sq cm)			Mean final density of settlement (per sq cm)			Mean per cent settlement (%)			Mean initial percent mortality (%)		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Ber	118.00	115.00	110.33	113.67	110.00	107.00	96.35	95.65	96.99	3.65	4.35	3.01
Palas	109.00	106.67	104.33	105.00	101.33	99.33	96.37	94.99	95.22	3.63	5.01	4.78
Flemingia	98.67	96.00	92.67	95.67	91.33	87.67	97.01	95.15	94.64	2.99	4.85	5.36
Pigeon pea	95.33	93.67	91.00	92.33	89.33	86.00	96.89	95.39	94.52	3.11	4.61	5.48
Kikar	81.33	82.00	75.00	78.00	75.00	69.33	95.97	91.59	92.53	4.03	8.41	7.47
Custard apple	83.33	80.00	76.00	80.33	75.33	71.00	96.49	94.15	93.47	3.51	5.85	6.53
Acacia sp.	110.00	107.00	107.33	104.00	101.67	103.00	94.56	95.05	95.97	5.44	4.95	4.03
SEm±	**3.24**	**1.65**	**1.81**	**2.30**	**1.65**	**1.27**	**1.84**	**2.26**	**1.81**	**1.84**	**2.26**	**1.81**
CD at 5 %	**6.95**	**3.54**	**3.88**	**4.92**	**3.54**	**2.73**	**3.95**	**4.86**	**3.89**	**3.95**	**4.86**	**3.89**

crawlers per square centimeter on the lower portion of Ber, indicating more settlement on lower portions of the plants than on upper portions.The result obtained are also in close conformity with findings of Rahman *et al*. (2021) who studied morphological parameters of lac host viz., *Flemingia semialata, F. strobilifera, Indigofera teysmannii, Ficus religiosa, Zizyphus mauritiana, Litchi chinensis, Hibiscus rosa*-sinensis, *Cajanus cajan* and revealed that the girth of the bark of the plants possesses significant negative correlation with the settlement density of crawlers as well as production of lac.

There hasn't been a lot of research on the settlement behavior of the crawlers of the lac insect on various hosts, but the findings of the current investigation are very much in line with those of earlier researchers, and the finding that there is a higher settlement of crawlers on lower parts of the plant on succulent branches with the best girth in the north and south directions receives full support from those earlier findings.

CONCLUSION

To understand the behavioral and settlement patterns of lac insects in relation to the cardinal direction and twig girth of the host plant, the settlement behavior of lac insect crawlers was investigated on several hosts. The crawlers on the *Acacia* host covered the greatest mean distance, 19.76 cm, followed by the Flemingia (17.33 cm), Ber (17.07 cm), Palas (16.24 cm), and Pigeon pea (16.24 cm). On Kikar and Custard apples, crawlers traveled the shortest distance from the location of brood lac inoculation, with mean distances of 10.49 cm and 12.93 cm, respectively. During the *Baisakhi* season, there was a stronger initial settlement in the lower region of the plant as compared to the upper portion, and the girth of the host twig was negatively linked (r = -0.26) with the initial settlement of the crawlers of the Rangeeni strain. The average initial settlement measured on all hosts in the north ranged from 79.20 to 112.60 crawlers per square centimeter at the upper portion of the plants as opposed to 82.40 to 119.80 crawlers per square centimeter at the lower portion of the plants, and was at its highest in the north direction in comparison to other directions.

The mean initial density of settlement of first instar crawlers of Rangeeni strain of lac insect on Ber, Palas, Flemingia, Pigeon pea, Kikar, Custard apple and *Acacia* sp. from upper portion to lower portion ranged from 110.33 to 118.00, 104.33 to109.00, 92.67 to 98.67, 91.00 to 95.33, 75.00 to 81.33, 76.00 to 83.33 and 107.33 to 110.00 crawlers per sq cm, respectively with mean per cent initial mortality ranging from 3.01 to 4.35% on Ber, 3.63 to 5.01% on Palas, 2.99 to 5.36% on Flemingia, 3.11 to 5.48% on Pigeon pea, 4.03 to 8.41% on Kikar, 3.51 to 6.53% on Custard apple, and 4.03 to 5.44% on *Acacia* sp. during *Baisakhi* season 2021-22.

The lower portion of the Ber host recorded the

highest mean final density of settlement of crawlers (113.67 crawlers per sq. cm), while the lower portion of the Kikar host recorded the lowest mean final density of settlement of crawlers of Rangeeni strain of lac insect (78.00 crawlers per sq cm) during *Baisakhi* season, 2021–2022.

ACKNOWLEDGMENT

The head of the entomology department at the Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, is acknowledged by the authors for his encouragement and for giving the tools they needed to carry out their research.

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