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Aprostocetus purpureus, a Major Parasitoid of Indian Lac Insect, *Kerria lacca* (Coccoidea: Tachardiidae)

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Abstract: Relative abundance of lac associated fauna was analyzed during summer season (*baisakhi*) crops for two consecutive years, which revealed that, parasitoids alone constitute 93 and 89 per cent population among lac associated fauna, followed by predators and hyper parasitoid on *ber*, respectively during 2011-12 and 2012-13. Similar trend was observed on *palas* for both the years. Among them, *Aprostocetus purpureus* was significantly more abundant which constitute 71.56 per cent on *ber* and 74.47 per cent on *palas*, respectively during 2011-12 and 2012-13. In recent years, 538 per cent increase in *A. purpureus* population over the four decade. The per cent population of *A. purpureus* was mainly observed more during the critical period *i.e.*, 17 to 22 week after inoculation. Interestingly, male lac insect was more vulnerable towards parasitization than female. A significant negative correlation with relative humidity was observed during critical period of *baisakhi* crop. The observations indicate the resurgence of *A. purpureus* as the most serious pest of lac insect causing huge economic losses.

Key Words: *Aprostocetus purpureus, Kerria lacca,* Lac associated fauna, Relative abundance

India is the largest producer of lac in the world and is a major source of livelihood to millions of economically backward population especially tribals in Jharkhand, Madhya Pradesh, Chhattisgarh, Maharashtra, West Bengal, etc. National lac production trends in India during 1980-81 to 2012-13 have shown an inconsistence and fluctuating production. The lac production of the country can be viewed as summation of the contribution of four crops, contributed by two crops each of these strains. The contribution of rangeeni strain has shown a sharp decline in total production (151.5 t annum^{-1}), whereas, kusmi strain has shown the increasing production (214.5 t annum^{-1}). This change could be attributed to promoting *kusmi* lac production, especially on ber during winter (aghani) crop and drastic decline in the production of summer (baisakhi) *rangeeni* lac crop (180 t annum^{-1}), which used to be the major lac crop (Anonymous, 2014).

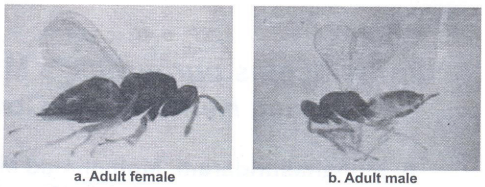
Lac is the only natural resin of insect origin derived mostly from a few species of *Kerria* (Coccoidea: Tachardiidae) belonging to a specialized group of scale insects, that are phytosuccivorous and thrive well only on specific plants called lac-hosts. The Indian lac insect, *Kerria lacca* is represented by two strains rangeeni and kusmi. Both the strains complete two cycles in a year, thus each producing two crops. But their life cycle patterns differ due to genetic differences in their developmental response to temperature. Thus, these two forms exhibit differences in their vulnerability to deviations from the normal climatic conditions.

K. lacca is associated with a large pest complex comprising mainly of predatory and parasitic insects. The parasitoids and predators of the Indian lac insect have been held responsible for causing about 50 per cent loss in normal crop. There are several parasites and predators of lac insects and another set of parasites of lac predators which are intimately associated with each other in the biotic complex (Varshney, 1976). Thirty five species of primary and 45 species of secondary parasitoids have been reported in lac insect ecosystem, which are highly responsive to climate changes in view of their relatively shorter life cycle. Among primary parasitoids, *Aprostocetus purpureus* as the most dominant inimical parasitoids among the composition of lac associated fauna particularly in Baisakhi (summer) crop and causes major damage to the lac crop during critical crop growth period. *A. purpureus* is an endoparasitoid and completes 10-12 generation in a year. Sharma *et al.* (2010) reported that 58 per cent of the living lac insects were parasitized with *A. purpureus*. The present investigation was aimed to study the emergence profile of *A. purpureus* and its correlation with weather parameters at Ranchi, Jharkhand on ber and palas.

MATERIAL AND METHODS

The *rangeeni* strain broodlac was cultured on *ber* (*Ziziphus mauritiana*) and *palas* (*Butea monosperma*) during summer season (Baisakhi) crop 2011-12, 2012-13 and 2013-14 at Institute Research Farm, Ranchi (Jharkhand). Lac insect samples (one meter length of encrustation) were collected randomly from inoculated trees one month after inoculation at every 15 days interval till harvest under three replications. The samples were caged in parasitoid

emergence cage (20×20×30cm), fitted with glass tubes to collect parasitoids by exploiting their phototropic behaviour. Lac associated fauna (parasitoids and predators) were collected from cage every day continuously upto one month. Among lac associated fauna, *A. purpureus* were morphologically identified and population abundance was recorded and correlated with weather parameters. Per cent lac insect (male and female) parasitization was observed through microscope by pricking method in the month of March 2014 during summer crop 2013-14.



a. Adult female b. Adult male

Fig. 1. *Aprostocetus purpureus*

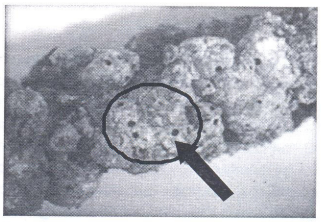


Fig. 2. Holes showing symptom of parasitization

RESULTS AND DISCUSSION

A brief morphological description of *A. purpureus* and symptom of infestation (Fig. 1-3) are given below.

Adult female measures 1.5-1.8 mm in length, is black coloured, shining, very slightly punctulate with rounded head. Eye is pink in colour; antennae are brown, elongate, scape reaching a little beyond ocelli; 8 funicle joints and the pedicellus nearly all of equal length, the club 3-jointed, the last joint short and pointed. Mesonotum and scutellum slightly reticulate, the median groove of the mesonotum and the two longitudinal grooves of the scutellum are well marked. Wings are large hyaline, reaching beyond the end of the abdomen. Marginal nerve longer than submarginal; pterostigma as long as a third of the marginal nerve and pubescence not in rows. Legs yellow, the base of the coxae stripes above and below the femora and the end of tarsi brownish with 4 segments, a shortened, straight fore tibial spur, marginal and stigma nerves light yellow Abdomen a little longer than the thorax, slightly broadened until beyond the middle then sharply pointed, ovipositor slightly protruding, black with purplish and greenish reflection, base of abdomen more or less yellow (Fig. 1a).

Adult male measures 1.2 mm in length with other morphological features almost similar to female except in few cases *viz.*, antennae with long bristles arranged in half-circles, abdomen shorter than the thorax with male genetalia, with the 1st segment yellow, legs clear yellow; coxae, part of femora, and of tarsi brown (Fig. 1b) (Ferriere, 1928).

Grub is apodus pink colour with outer white cover, yellowish body with pink colour eye of immature adult stage and black colour body with pink colour eye before emergence. The symptom of parasitized lac insect has been depicted in figure 2.

Relative abundance of lac associated fauna during rangeeni crops: During baisakhi crops, the parasitoids alone constitute (93 and 89 per cent) population among lac associated fauna followed by predators (4 and 7 per cent) and hyper parasitoid (3 and 4 per cent) on ber, respectively during 2011-12 and 2012-13. Among them, *A. purpureus* was significantly the most abundant and constituted 71 and 56 per cent population, followed by *Tachardiaephagus tachardiae* (21 and 14 per cent) and *P. clavicornis* (1 and 18 per cent), respectively during 2011-12 and 2012-13. The major predators *viz.*, *Eublemma amabillis* and *Pseudohypatopa pulverea* and hyperparasitoid, *Bracon greeni* populations were at par with each other during baisakhi 2011-12. In addition, *Marietta javensis* and *Apanteles tachardiae* were also recorded on ber during baisakhi 2012-13. Similar trend was observed on palas, wherein *A. purpureus* was the most abundant and constituted 74 and 47 per cent population, followed by *T. tachardiae* (16 and 26 per cent), respectively during 2011-12 and 2012-13. *P. clavicornis, Marietta javensis*, *E. amabillis, Bracon greeni* and Coleopteran beetles were at par with each other during baisakhi 2011-12. In addition to that, *Erencyrtus dewitzi*, *Eupelmus tachardiae*, *P. pulverea* and *A. tachardiae* were also recorded on palas during baisakhi 2012-13 (Table 1). The per cent increase in lac associated parasitoids was compared between the recent years (2011-12 and 2012-13) with four decade backs (1972-73 and 1973-74). There was 361 per cent increase in total parasitoids population, among them the population of *A. purpureus* increased very high (538 %) followed by *T. tachardiae* (120 %) and *P. clavicornis* (5 %) while other parasitoids (*Coccophagus tschirchi*, *E. dewitzi*, *E. tachardiae, M. javensis*) decreased 4.71 per cent (Table 2). It clearly reveals that the parasitoids populations increased many fold over a period, *A. purpureus* being the most abundant. Srivastava *et al.* (1984) found that among the parasitoids of lac insect, *Aprostocetus* (*Tetrastichus*) *purpureus* and *T. tachardiae* were of regular occurrence and

were recorded in large numbers in all the four lac crops (baisakhi, katki, jethwi and aghani). Sharma *et al.* (1997) also reported higher abundance of *A. purpureus* and *T. tachardiae,* constituting 55.82 and 28.37%, respectively of the total population of parasitoids.

Emergence profile of *A. purpureus* during summer season crops: The weekly emergence profile of *A. purpureus* revealed significant differences in *A. purpureus* population on week and host plant basis. The maximum *A. purpureus* population per meter lac encrustation in samples collected 21 WAI on ber (37) and 22 WAI on palas (28) during baisakhi 2011-12, whereas, during 2012-13 the maximum emergence was 20 WAI on ber (57) and 21 WAI on palas (41) (Table 3). In baisakhi 2013-14, maximum *A. purpureus* population was 17 WAI on *ber* (64) and 20 WAI on *palas* (17) (Table 3). Further per cent lac insect parasitization was more in male lac insect (64 %) as compared to female (36 %) during baisakhi 2013-14. The longer duration of crop period (8 months in baisakhi) with more parasitization at initial stage lead to more adverse effect on the crop. This is one of the major reasons for summer crop mortality.

***A. purpureus* population during critical period of *rangeeni* summer crops:** Among the lac associated fauna, 78 and 66 per cent population of *A. purpureus* on *ber* were recorded only during crtical crop period (17 to 22 WAI before sexual maturity) for baisakhi 2011-12 and 2012-13, respectively. Similarly in palas, 62 and 49 per cent population of *A. purpureus* were recorded only during crtical period (17 to 22 WAI before sexual maturity) for baisakhi 2011-12 and 2012-13, respectively. However, in baisakhi 2013-14, *A. purpureus* alone constitut 100 per cent population during crtical period causing complete lac insect mortality on ber and palas. Yield ratio of 1.13 and 2.08 was on ber and 1.79 and 3.39 on palas of mature lac crop during baisakhi 2011-12 and 2012-13, respectively. Lesser broodlac ratio during 2011-12 was due to higher parasitization during critical period compared to 2012-13. However, no havest could be made during baisakhi 2013-14 due to hundred per cent mortality during critical crop growth period. Monobrullah (2010) analyzed the samples from four different locations and average parasitization 54 per cent. The parasitoid emergence was 248-364 in January and 416-573 in March from 10 cm length of lac encrustations during critical periods, which was indicative of very high level of parasitization leading to the collapse of lac insect populations.

Impact of abiotic factors on insect pest of lac insect: Emerging population of *A. purpureus* during critical crop growth period (17 to 22 WAI) and weather parameters *viz.,* temperature, relative humidity and rainfall were correlated during baisakhi 2011-12 and 2012-13. Positive correlation

Table 1. Per cent composition of lac associated fauna summer *rangeeni* (*baisakhi*) *crops*

Lac associated fauna	Ber		Palas	
	2011-12	2012-13	2011-12	2012-13
Tachardiaephagus tachardiae	20.61	13.73	15.54	25.91
Aprostocetus purpureus	71.47	55.71	73.86	46.92
Parechthrodryinus clavicornis	1.06	17.99	1.65	2.54
Eupelmus tachardiae	-	-	0.00	0.18
Erencyrtus dewitzi	-	-	0.00	0.18
Marietta javensis	0.00	1.16	0.37	0.36
Eublemma amabilis	3.17	3.09	2.74	16.30
Pseudohypatopa pulverea	1.06	4.45	0.00	3.80
Coleopteran	-	-	0.55	0.36
Bracon greeni	2.64	0.19	5.30	0.18
Apanteles tachardiae	0.00	3.68	0.00	3.26
CD (p= 0.05)	14.79	9.00	7.83	7.64

Table 2. Comparative analysis of lac associated parasitoids population (Number kg^{-1} broodlac sample)

Year	Total parasitoid population	*A. purpureus*	*T. tachardiae*	*P. clavicornis*	Other parasitoids
1972-73 to 1973-74*	28.4	17.0	9.1	1.7	0.56
2011-12 to 2012-13	130.7 (361.0)	108.4 (537.7)	19.9 (119.9)	1.8 (5.2)	0.53 (-4.71)

*Mean of two crop seasons adopted from Srivastava *et al.* (1976)
Figures in parentheses is per cent increase over initial population

Table 3. Weekly emergence profile of *Aprostocetus purpureus* during summer rangeeni (baisakhi) crops

Period	2011-12			2012-13			2013-14		
	Ber	*Palas*	Mean	*Ber*	*Palas*	Mean	*Ber*	*Palas*	Mean
8 WAI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9 WAI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10 WAI	0.00	0.25	0.13	0.00	0.00	0.00	0.00	0.00	0.00
11 WAI	1.00	0.50	0.75	0.00	0.00	0.00	0.00	0.00	0.00
12 WAI	3.50	0.25	1.88	0.00	0.67	0.33	0.00	0.00	0.00
13 WAI	2.25	0.25	1.25	0.00	9.00	4.50	0.00	0.00	0.00
14 WAI	6.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00
15 WAI	0.00	0.25	0.13	0.00	0.67	0.33	0.00	0.00	0.00
16 WAI	0.00	0.00	0.00	0.67	0.00	0.33	0.00	1.67	0.83
17 WAI	1.25	14.50	7.88	0.67	0.00	0.33	63.67	9.00	36.33
18 WAI	0.50	10.50	5.50	0.00	0.00	0.00	12.00	0.00	6.00
19 WAI	21.25	5.00	13.13	0.67	0.00	0.33	2.00	4.33	3.17
20 WAI	22.75	1.50	12.13	57.33	0.00	28.67	3.33	16.67	10.00
21 WAI	37.25	3.00	20.13	3.67	40.67	22.17	1.67	10.00	5.83
22 WAI	22.00	27.75	24.88	1.00	1.67	1.33	0.00	7.00	3.50
23 WAI	0.75	5.50	3.13	0.67	2.67	1.67	0.00	0.00	0.00
24 WAI	1.00	2.50	1.75	0.67	0.00	0.33	0.00	0.00	0.00
25 WAI	1.25	0.75	1.00	0.33	0.67	0.50	0.00	0.00	0.00
26 WAI	0.50	0.00	0.25	0.00	0.33	0.17	0.00	0.00	0.00
27 WAI	0.00	0.50	0.25	0.00	0.00	0.00	0.00	0.00	0.00
28 WAI	0.00	0.50	0.25	0.00	0.00	0.00	-	-	-
29 WAI	0.00	0.50	0.25	1.33	0.00	0.67	-	-	-
30 WAI	0.00	0.00	0.00	0.33	0.33	0.33	-	-	-
31 WAI	0.00	0.00	0.00	1.33	10.33	5.83	-	-	-
32 WAI	0.00	0.00	0.00	7.33	1.00	4.17	-	-	-
33 WAI	0.00	0.00	0.00	0.00	1.67	0.83	-	-	-
34 WAI	0.00	0.00	0.00	16.67	13.67	15.17	-	-	-
35 WAI	0.00	0.00	0.00	3.00	2.33	2.67	-	-	-
36 WAI	0.00	0.00	0.00	0.33	0.67	0.50	-	-	-
37 WAI	0.00	2.25	1.13	0.00	0.00	0.00	-	-	-
38 WAI	0.00	0.50	0.25	0.00	0.00	0.00	-	-	-
39 WAI	1.00	2.00	1.50	0.00	0.00	0.00	-	-	-
40 WAI	0.00	5.25	2.63	0.00	0.00	0.00	-	-	-
41 WAI	6.75	13.75	10.25	0.00	0.00	0.00	-	-	-
42 WAI	3.25	3.25	3.25	0.00	0.00	0.00	-	-	-
43 WAI	3.00	0.00	1.50	-	-	-	-	-	-
44 WAI	0.00	0.00	0.00	-	-	-	-	-	-
45 WAI	0.00	0.00	0.00	-	-	-	-	-	-
Mean	3.56	2.66		2.74	2.47		4.13	2.43	
CD (p= 0.05)									
Week		2.05			2.00			2.11	
Host plant		0.47			0.48			0.67	
Week × Host plant		2.89			2.83			2.99	

WAI: week after inoculation

Table 4. Correlation between abiotic factors and population of *Aprostocetus purpureus* at Ranchi

Crop/critical period (Week After Inoculation)	Host plant	Temperature (^{0}C)		Relative humidity (%)		Total rainfall (mm)
		Maximum	Minimum	Maximum	Minimum	
Summer (baisakhi) crop 2011-12						
(17 to 22)	Ber	0.215	0.059	-0.329(*)	-0.292(*)	-0.017
	Palas	0.219	0.088	0.002	-.040	-0.146
Summer (baisakhi) crop 2012-13						
(17 to 22)	Ber	0.088	0.196	0.095	0.079	0.079
	Palas	0.129	0.267	-0.020	-0.023	-0.031

*Significant

with temperature and significant negative correlation with relative humidity was on ber in baisakhi (2011-12) during the critical periods. In baisakhi (2012-13), positive correlation with temperature and negative correlation with relative humidity during critical period on *palas* (Table 4) indicated that the summer crop is vulnerable to weather parameters. Ramani (2009) analyzed the critical weather data recorded at Ranchi during past ten years in comparison to the previous decade and revealed clear deviations from the normal weather pattern; changed rainfall pattern; reduced post monsoon and winter rain spells; overall fall in relative humidity and deviations in maximum and minimum temperature pattern over seasons coupled with heavy incidence of *A. purpureus* resulting in lac crop mortality. A very high incidence of, *A. purpureus* (108 nos. kg^{-1} broodlac) was recorded in summer rangeeni lac insect populations during 2011-12 and 2012-13, whereas, it was less than 17 nos. per kg during 1972-73 and 1973-74 (Srivastava *et al.*, 1976) showing 538 per cent periodical increase in 2011-12 and 2012-13 as compared to 1972-73 and 1973-74.

The observations indicate the resurgence of *A. purpureus* as the most serious pest of lac insect causing huge economic losses. *A. purpureus* was earlier considered as minor pest of lac insect but nowadays, has acquired the status of most dreaded pest of the lac insect. Parasitization at an early development stage of lac insect by *A. purpureus* leads to complete failure of the lac crop, so it has assumed the status of key pest in the lac ecosystem in the changing scenario of climate change.

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