RESEARCH ARTICLE

DEVELOPMENT AND PARASITIZATION OF *PHENACOCCUS SOLENOPSIS* TINSLEY (HEMIPTERA: PSEUDOCOCCIDAE) ON *BT* COTTON BY *AENASIUS BAMBAWALEI* HAYAT (HYMENOPTERA: ENCYRTIDAE)

S.R. Pawar*, H.R. Desai, G.R. Bhanderi and C.J. Patel

Main Cotton Research Station, Navsari Agricultural University, Surat-395007 (Gujarat), India
Email: grbhanderi@yahoo.co.in

Received-25.05.2017, Revised-26.06.2017

Abstracts: Studies on development and parasitization potential of *Aenasius bambawalei* Hayat on *Bt* cotton mealybug was carried out at the room temperature of 20.63 ± 0.60 ºC and humidity of 64.81 ± 3.02 per cent during January to February 2011 at bio-control laboratory of Main Cotton Research Station, Surat. The parasitoid, *A.bambawalei* preferred III instar nymphs (av. 51.48 ± 21.55 % parasitism) and newly emerged female adult (av. 38.15 ± 11.81 % parasitism) more compared to II instar nymphs of mealybug (av. 4.93 ± 4.96 % parasitism) for parasitism. The developmental period of *A. bambawalei* (oviposition of egg inside to adult emergence) was 10.29 ± 0.86, 10.49 ± 0.80 and 10.56 ± 0.97 days when female adult parasitoid exposed to II Instar nymphs, III instar nymphs and female adult mealybugs, respectively. Maximum parasitoid recovered on 10 days after exposure in both of the preferred stages of mealybug. *Aenasius bambawalei* was solitary endoparasitoid. Female was found parasitizing the mealybug by inserting ovipositor from the ventral side of the mealybug body. On dissection of the parasitized mealybug, white legless larva without appendages prior to mummy formation of parasitized mealybug and brownish black exarate type pupa within mummified body of mealybug observed under microscope. The single female adult of *A. bambawalei* parasitized on an average of 125 ± 13.2 mealybugs. Maximum parasitism (60.00 %) observed by 7-day old age female wasp when exposed to its preferred host (III instar mealybug). The longevity of female adult of *A. bambawalei* was 11 to 16 (av.13.8 ± 1.76) and of male was 1 to 2 (1.20 ± 0.45) days.

Keywords: *A. bambawalei*, Nymphs, Parasitoid, Parasitism, Mummified, Ovipositor, Exarate

INTRODUCTION

Mealybugs are soft bodied insects belonging to the family Pseudococcidae of the order Hemiptera. About 5000 species of mealybug have been recorded from 246 families of plants throughout the world. Among these, 56 species have been reported from 15 genera of family Malvaceae, including cotton and many other plants of economic importance (Ben Dov, 1994). The first report of invasive species of mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) in 2005, was found causing serious damage to cotton was from Gujarat where it was thought to be undescribed. Solenopsis mealybug, *P. solenopsis* (Central and South zone of India) and papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (South zone), mirid bugs *viz.*, *Creontiades biseratense* Distant, *Hyalopeplus linefer* Walker and *Compylomma livida* Reuter (South zone) and flower bud maggot / gall midge, *Dasineura gossypii* Fletcher (Karnataka in South Zone) have emerged as major pests in cotton and posed serious challenges (Jhala *et al.*, 2008; Dharajothi *et al.* 2010, Kumar *et al.*, 2010, Udikeri *et al.*, 2010). The mealybug feeds on phloem tissue, sucking plant sap and causing leaves to distort yellow and even die. It also produces large amount of honeydew. The pest has spread quickly to cotton growing areas posing a serious problem. The pest is hard to kill as it inhabits concealed locations and even in exposed conditions, the congregation of individuals, protection of late age nymphs and adults by loose, cottony waxy substance on body secreted by the Mealybug and oviposition in waxy ovisacs act as barriers to proper penetration and action of insecticides. Management of this mealybug is difficult due to its wide host range, presence of waxy coating on the body and high reproductive potential (Dhawan *et al.*, 2007). Hence, the biological control with parasitoids is of great importance, since, they have proved their value in checking so many homopteran pests (Anil *et al.*, 2008). In past, natural control has played major role in limiting this pest to a minimal level. The present study aimed to study parasitoid potential for the management of mealybug *P. solenopsis.*

MATERIAL AND METHOD

Host preference and development of *A. bambawalei*

The developmental period and extent of parasitization studied during the peak activity of *A. bambawalei* in the field. For the purpose, twigs having maximum dark brown/ reddish mummies brought to the laboratory from field. These twigs were kept under the glass jar (diameter: 14.5 cm and height: 20 cm) tied with muslin cloth with rubber band and observed for parasitoid emergence. Adults of parasitoids emerged out were observed critically for the separation of male and female parasitoids. Males were small, while the females were larger with shiny black body. To determine the total developmental period of parasitoid, *A. bambawalei*, newly emerged pairs were collected in the glass tube (5 x 1 cm) and were expose to different stages of the

*Corresponding Author

mealybug for studying the developmental period and preference of parasitism. For the purpose, cotton seedlings raised in polythene bags under protected condition of polycarbonate house (free from such parasitism) were used and were allowed for infestation of mealybug by releasing female adults of mealybug. Counted number of individuals of different stages of mealybug (2nd and 3rd instar nymphs and freshly emerged female adults) were allowed to retain on the seedlings separately and rests were removed with fine camel hair brush. Such infested seedlings kept under glass jar covered with fine muslin cloth tied with rubber band. Newly emerged pairs of *A. bambawalei* exposed for 24 hours to different stages of mealy bug separately and allowed for parasitization. In the glass jar, honey streak on a paper strip provided as food for the released parasitoids. The developmental period of *A. bambawalei* worked out from date of exposure to date of emergence of adult from mummified cocoons formed after effective parasitism.

Parasitizing potential of *A. bambawalei*

To study the fecundity, longevity and parasitizing potential of *A. bambawalei*, counted number of 3rd instar mealy bug, being preferred stage for parasitization was used. Each pair of parasitoids was offered counted number of third instar nymphs of mealybug on cotton seedlings daily until death. Number of mealybug parasitized by the individual female observed daily for parasitism and estimated for total parasitization during its entire life span. The record of death of male and female parasitoids maintained.

RESULT AND DISCUSSION

Host preference and development period of *A. bambawalei*

Adult parasitoids (pair) were exposed to different stages of host mealybug (II & III instar nymphs and freshly formed female adults) for studying the preference and development period of *A. bambawalei* within the body of the mealybug, *P. solenopsis*. As far as parasitism of *A. bambawalei* to different stages of mealybug is concerned (Plates 1and2), maximum parasitism (Table1) was observed on III instar nymphs (av. 51.48 ± 21.55 %) and it was followed by newly emerged female adult (38.15 ± 11.81 %), while it was minimum (av. 4.93 ± 4.96 %) on II instar nymphs. Thus, *A. bambawalei* mostly preferred III instar nymphs followed by newly emerged female adult as compared to II instar nymphs of mealybug for parasitism. Maximum parasitoids were emerged on 10th day of exposure as the highest emergence of 2.31, 24.3 and 20.61 out of 5.04,

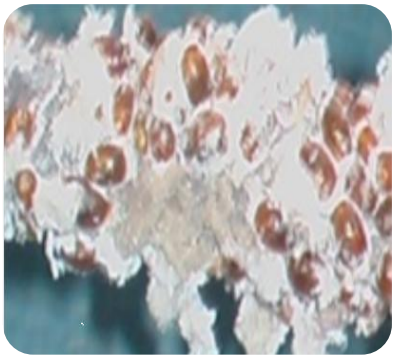

Plate 1: Parasitization of *A. bambawalei* to third instar nymphs of *P. solenopsis*

Plate 2: Parasitization of *A. bambawalei* to female adults of *P. solenopsis*

51.05 and 38.59 per cent of total parasitoids emerged from II instar, III instar and adult mealybug, respectively.

The developmental period of *A. bambawalei* (oviposition of egg inside to adult emergence) was found to be varied from 9 to 12 (av. 10.29 ± 0.86), 9 to 13 (av. 10.49 ± 0.80) and 9 to 13 (av. 10.56 ± 0.97) days when female adult parasitoid exposed to II Instar nymphs, III instar nymphs and adult mealybugs, respectively (Table 1). During entire study, only single adult found to emerge from the single parasitized mealybug in all the stages exposed which clearly indicated the solitary nature of parasitoid. While dissecting the intact body of mealybug within 4 days of exposure for parasitism, white legless larva without appendages observed under microscope while that of from mummified body, on dissecting, brownish black pupa of *A. bambawalei* was clearly observed and it was exarate type (Plate 3). Female found to insert ovipositor from the ventral side of the mealybug body.

Larva of *A. bambawalei* **Mummified body of *P. solenopsis*** **Pupa of *A.bambawalei* inside cocoon**

Exarate pupa of *A. bambawalei* **Emergence hole on cocoon** **Adult from emergence hole**

Plate 3: Development of *A. bambawalei* on *P. solenopsis*

Earlier Ashfaq *et al.* (2010) reported that the mummy formation did not differ significantly when unparasitized third instar mealy bug nymphs and adults analyzed separately. Further, they reported that adult eclosion started 11 days after exposure and continued until 13 days after exposure. The result of the study showed that a significantly higher number of adults emerged on 11th day. Similarity of the present data in this regard with that of above mentioned workers, confirmed the ongoing discussion.

Parasitism potential of *A. bambawalei*

The data presented in Table 2 revealed that the fecundity of *A. bambawalei* was recorded to be 96 to 145 (av. 125.00 ± 13.20) in five different sets having pairs of *A. bambawalei*. 7-day-old age female wasp when exposed to its host III instar mealybug (Figure 1) observed maximum parasitism (60.00 per cent). The longevity of female adult of *A. bambawalei* was 11 to 16 (av. 13.8 ± 2.17) days and of male was 1 to 2 (av. 1.20 ± 0.45) days. The parasitoid development recorded by Pala Ram (2009) which showed that *A. bambawalei* was solitary endoparasitoid taking 12 to 14 days to complete its development in the host and the mating took place soon after the adult emergence. The female oviposited an egg into the mealybug body through ventral surface of the host, which turned into a mummy after 5 to 6 days of oviposition. They also concluded that the third instar mealy bugs were most preferred stage for parasitization and single female parasitized 38 to 163 (fecundity) mealybugs during its lifetime at the rate of 2 to 17 mealybugs per day. The present findings are somewhat similar with these observations.

Table 1. Preference and developmental duration of *A. bambawalei* on *P. solenopsis* reared on *Bt* cotton

Date of release of parasitoid	Number of mealybugs exposed	Number of parasitoid emerged on different days after exposure							Total	Per cent parasitism
		8	9	10	11	12	13	14		
A. Host: II instar nymph										
03-Jan	45	0	0	2	1	0	0	0	3	6.67
03-Jan	50	0	1	3	2	1	0	0	7	14.00
03-Jan	45	0	0	0	0	0	0	0	0	0.00
04-Jan	43	0	0	1	1	0	0	0	2	4.65
04-Jan	47	0	1	2	1	0	0	0	4	8.51
05-Jan	55	0	1	1	1	0	0	0	3	5.45
05-Jan	49	0	0	0	0	0	0	0	0	0.00
06-Jan	45	0	0	0	0	0	0	0	0	0.00
06-Jan	50	0	1	2	1	1	0	0	5	10.00
07-Jan	47	0	0	0	0	0	0	0	0	0.00
Total	**476**	**0**	**4**	**11**	**7**	**2**	**0**	**0**	**24**	**5.04**
Parasitism (%)		**0.00**	**0.84**	**2.31**	**1.47**	**0.42**	**0.00**	**0.00**	**5.04**	**4.93 ± 4.96**
Developmental duration (days)			**9 to 12 (10.29 ± 0.86)**							
B. Host: III instar nymph										
03-Jan	55	0	1	9	4	3	0	0	17	30.91
03-Jan	39	0	3	17	11	6	2	0	39	100.00
03-Jan	59	0	1	12	9	4	1	0	27	45.76
04-Jan	40	0	0	11	7	3	4	0	25	62.50

Date of release of parasitoid	Number of mealybugs exposed	Number of parasitoid emerged on different days after exposure							Total	Per cent parasitism
		8	9	10	11	12	13	14		
04-Jan	45	0	2	12	9	3	1	0	27	60.00
05-Jan	58	0	3	19	10	4	1	0	37	63.79
05-Jan	48	0	0	10	5	2	0	0	17	35.42
06-Jan	46	0	0	9	5	1	1	0	16	34.78
06-Jan	44	0	3	11	6	3	0	0	23	52.27
07-Jan	51	0	0	8	4	2	1	0	15	29.41
Total	**485**	**0**	**13**	**118**	**70**	**31**	**11**	**0**	**243**	**50.10**
Parasitism (%)			**2.68**	**24.3**	**14.4**	**6.39**	**2.27**		**51.05**	**51.48 ± 21.55**
Developmental duration (days)			**9 to 13 (10.49 ± 0.80)**							

Table 1. Preference and developmental duration of *A. bambawalei* on *P. solenopsis* reared on *Bt* cotton (Continued)

Date of release of parasitoid	Number of mealybugs exposed	Number of parasitoid emerged on different days after exposure							Total	Per cent parasitism
		8	9	10	11	12	13	14		
C. Host: Female adult (newly emerged)										
03-Jan	45	0	2	6	4	2	0	0	14	31.11
03-Jan	55	0	3	18	8	3	1	0	33	60.00
03-Jan	47	0	1	12	9	3	1	0	26	55.32
04-Jan	49	0	0	10	5	2	0	0	17	34.69
04-Jan	47	0	1	7	3	1	0	0	12	25.53
05-Jan	55	0	2	14	7	2	1	0	26	47.27
05-Jan	49	0	0	8	6	1	0	0	15	30.61
06-Jan	45	0	0	6	7	1	0	0	14	31.11
06-Jan	50	0	1	9	4	1	0	0	15	30.00
07-Jan	53	0	2	12	5	0	0	0	19	35.85
Total	**495**	**0**	**12**	**102**	**58**	**16**	**3**	**0**	**191**	**38.59**
Parasitism (%)			**2.42**	**20.61**	**11.72**	**3.23**	**0.61**		**38.59**	**38.15 ± 11.81**
Developmental duration (days)			**9 to 13 (10.56 ± 0.97)**							

Table 2. Parasitism potential of *A. bambawalei* on *P. solenopsis* (III instar) reared on cotton at MCRS, Surat

Age / Pair No.	No. of parasitized mealybug at different age of female parasitoid (out of 25 III instar mealybug exposed)																	Total fecundity	Longevity (days)	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		Female	Male
1	8	10	12	14	13	15	18	12	11	9	7	6	5	3	1	1	-	145	16	1
2	8	9	11	13	14	16	13	11	9	7	5	3	2	-	-	-	-	121	13	2
3	11	12	13	11	12	14	15	13	11	8	6	4	2	-	-	-	-	132	13	1
4	10	9	10	8	9	12	17	16	13	9	6	5	3	2	1	1	-	131	16	1
5	9	11	10	12	11	13	12	7	6	4	1	-	-	-	-	-	-	96	11	1
Total	**46**	**51**	**56**	**58**	**59**	**70**	**75**	**59**	**50**	**37**	**25**	**18**	**12**	**5**	**2**	**2**	**-**	625	-	-
Average (± SD)	9.2	10.2	11.2	11.6	11.8	14	15	11.8	10	7.4	5	3.6	2.4	1	0.4	0.4		125 ± 13.8	13.8 ± 2.17	1.20 ± 0.45

Parasitism (%)	36.8	40.8	44.8	46.4	47.2	56	60	47.2	40	29.6	20	14.4	9.6	4	1.6	1.6		500		

Note: Each set of exposed mealybugs were critically observed for adult emergence daily after 8th day of exposure

Fig. 1: Parasitizing efficiency of *A. bambawalei* at different age after emergence

ACKNOWLEDGEMENT

We acknowledge with thanks to Dr. Sushila Joshi, Insect Identification Service, Division of Entomology, New Delhi for prompt identification of mealybug parasitoid, *Aenasius bambawalei* Hayat (08.02.2010) as well as to Research Scientist (Cotton) for providing necessary facilities under the RKVY project, "Community Approach for Implementation of IPM for Mealybug in Cotton"

REFERENCES

Anil, K., Kurtadikar, J. S., Wadnerkar, D. W. and Nemade, P. W. (2008). Studies on the safety of pesticides to grapevine mealybug predator, *Cryptolaemus montrouzieri* Aiyar. *Pestology*, **32** (4):17–27.

Ashfaq, M., Ghulam, S. S., Ali, R. N., Shahida P. A. and Shahid M. (2010). Report of a parasitic wasp (Hymenoptera: Encyrtidae) parasitizing cotton mealybug (Hemiptera: Pseudococcidae) in Pakistan and use of PCR for estimating parasitism levels. *Biocontrol Sci. and Tech.*, 20(6): 625-630.

Ben-Dov, Y. (1994). *A systemic catalogue of the mealybugs of the World*. Intercept Limited, UK, 686 p.

Dharajothi, B., Surulivelu, T., Sonai Rajan, T., Manjula, R. and Kumaran, N. (2010). Occurrence and seasonal dynamics of mealy bug, mirid bug and predators on cotton in Coimbatore district of Tamil Nadu. National Conference on Paradigm Shift in Cotton Research and Cultivation held on October 19-21, 2010 at Surat. Compendium of Abstracts. pp-12.

Dhawan, A. K., Singh, K., Saini, S., Mohindru, B., Kaur, A., Singh, G. and Singh, S. (2007). Incidence and Damage Potential of Mealybug, *Phenacoccus solenopsis* Tinsley, on Cotton in Punjab. *Indian J. Ecol*., **34**(2): 166-172.

Jhala, R. C., Bharpoda, T. M. and Patel, M. G. (2008). Occurrence of Mealy Bugs, *Phenacoccus solenopsis* Tinsley and *Phenacoccus solani* Ferris (Hemiptera: Pseudococcidae) on Cotton in Gujarat. *Insect Environ.*, **13**(4): 149-150.

Kumar, V., Maisuria, I. M., Patel, C. J., Desai, H. R., Sheth, D. B. and Seema Bhaduriya (2010). *Eco-friendly Management of Mealybug in Cotton*, Main Cotton Research Station, NAU, Athwa Farm, Surat 395 007.

Pala, Ram., Saini, R. K. and Vijaya (2009). Preliminary studies on field parasitization and biology of solenopsis mealy bug parasitoid, *Aenasius bambawalei* Hayat (Encyrtidae: Hymenoptera). *J. Cotton Res. Dev.*, **23**(2): 313-315.

Udikeri, S. S., Patil, S. B., Guruprasad, G. S., Vandal, N., Kundari, V., Kranthi S. and Sharma, R. M. (2010). Potential threat of mirid bugs and flower bud maggots for *Bt* cotton cultivation: status / report and case studies from Karnataka. National Conference on Paradigm Shift in Cotton Research and Cultivation held on October 19-21, 2010 at Surat. Compendium of Abstracts. pp-6.