Chapter 15

Studies on Egg Parasitoids of *Helopeltis spp.* *(Hemiptera: Miridae)*

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Abstract

Survey conducted consecutively for three years from 2010 to 2013 at the Directorate of Cashew Research, Puttur and the Shanthigodu Experimental station, Karnataka, South India determined three species of egg parasitoids; *Telenomus* sp. (Hymenoptera: Platygastridae), *Chetostricha* sp. (Hymeoptera : Trichogrammatidae) and *Erthymelus helopeltidis* (Hym: Myrmaridae) on *Helopeltis* spp. *Telenomus* sp. was the predominant species and was recorded throughout the season except during the month of March and April. It showed maximum parasitism during monsoon (June and July) season (range of 6.89-28.21%), exhibiting significant positive correlation with rainfall (r =0.33). The occurrence of *Chaetostricha* sp. and *E. helopeltidis* were comparatively lower with a maximum of 1.80 and 2.25 per cent, respectively during the month of December as former showing significant negative correlation with minimum temperature (r = -0.63). The mean developmental period of *Telenomus* sp. was 20.6 ± 1.13 days and male and female longevity were 2.83 ± 0.16 and 4.52 ± 0.11 days, respectively. Five distinct kinds of behaviour were observed; drumming with antennae on the eggs, ovipositor insertion, egg marking, walking and resting.

Keywords: cashew, *H. antonii*, *Telenomus* sp., biological control

Contents

15.1 Introduction

15.1.1. Tea mosquito bug (TMB) (*Helopeltis* spp.)

Tea mosquito bug (TMB) (*Helopeltis* spp.) is one of the major pests of cashew (*Anacardium occidentale* L.) damaging tender shoots, inflorescence, immature nuts and apples at various stages of development resulting in a yield loss of 30-50 per cent. The nymphs and adults suck the sap of the young plants and succulent parts (Karmawati, 2007). Typical feeding damage by *Helopeltis* spp. appears as a discoloured necrotic area or a lesion around the point of entry of the labial stylets inside the plant tissue. The infestation of inflorescence results in "blossom blight". Three species of TMB, *Helopeltis antonii* Signoret, *Helopeltis bradyi* Waterhouse and *Helopeltis theivora* Waterhouse were recorded in India (Stonedahl, 1991; Sundararaju, 1996). Among them, *H. antonii* is the dominant species (Sundararaju and Bakthavatsalam, 1994; Sundararaju, 1996; Srikumar and Bhat, 2012). It is one of the most destructive pests of tea causing damage to tea plant resulting in significant loss of crop yield in Bangladesh, SriLanka, Vietnam, Indonesia, Malaysia and Africa.

15.1.2. *Helopeltis* spp. In cashew

On cashew, the bug lays eggs not only on the young shoots, inflorescence stalks and developing nuts, but also on the petioles and ventral midribs of leaves (Ambika and Abraham, 1979). The eggs are white ovo-elongate (slightly narrower apically) and laterally compressed apically with about 1.0 x 0.3 mm in size. The eggs are embedded in the plant tissue singly or in small groups with the operculum and respiratory filaments exposed (Ambika and Abraham, 1979; Sundararaju and Sundarababu, 2000).

Though the eggs are laid deep and concealed, they are often attacked by a range of hymenopteran parasitoids such as *Telenomous* sp. (Platygastridae), *Ufens* sp. and *Chaetostricha* sp. (Trichogrammatidae) and *Erythmelus helopeltidis* Gahan and *Gonatocerus* sp. (Mymaridae) (Sundararaju and Sundarababu, 2000; Sundararaju, 1996). Parasitism by *Telenomus* sp. is always negligible in the eggs of *H. antonii* laid on neem and is totally absent in east coast of Tamil Nadu, while it is a dominant species in cashew ecosystem of west coast of India. Among the abiotic factors, temperature has shown positive influence on extent of parasitism (Sundararaju, 1996).

15.1.3. Management practice

At present, chemical control measures are recommended for management of *H. antonii* on cashew (Sundararaju, *et al.* 1993). Since, there is potential restriction in USA and EEC countries in importation of cashew kernels containing pesticides residues, developing integrated pest management with main emphasis on non- insecticidal control methods *viz*., biological control is required (Stonedahl, 1991; Srikumar et al., 2014; Bhat and Srikumar, 2014). In view of the allegedly ecocidal episode of endosulphan in managing cashew pests in North Kerala, Mahapatro (2008) has emphasized an IPM package for managing the bug. Since biocontrol largely relies on natural enemy complex in any IPM strategy, the studies on egg parasitoids of TMB gain ample relevance using natural control like- Climatic factors, Topographic features, Predators and Parasites, etc., applied control like- Cultural control, Mechanical control, Physical control, Chemical control, Biological control, Microbial control, Regulatory control and Integrated control, Breeding of resistant agrotypes, Ionizing radiation, Chaemosterilant, etc.

Very recently a series of observations were recorded on natural enemies and their role in suppression of *Helopeltis antonii* Signoret in the cashew plantations of Zonal Agricultural Research Station, Brahmavar and Pethri village, Udupi district and in maidan (plains) tracts of Chintamani, Karnataka during 2006–2008 and recorded the yellow crazy ant, *Oecophylla smaragdina* Fabricius was the most effective predator against TMB (Naik et al., 2015).

Cultural control options were proposed by Ahmed and Mamun (2015). Biological Control Biological methods of control involve the conservation, preservation and introduction of natural enemies of tea pests, like predators, parasitoids and pathogens for suppression of pests within tolerable levels. The minor status of several pests such as aphids, scale insects, flushworms and leaf rollers is due to the action of these natural enemies. Efforts towards the conservation and augmentation of natural enemies in the tea ecosystem, could offer significant advances in biological control programme of *Helopeltis* in tea.

15.1.3.1. Predator

Recently, *Chrysoperla carnea* has been identified as a predator of thrips and Helopeltis. Preying mantis has been found to capture and feed on all stages of Helopeltis theivora both in laboratory and in field condition. Many reports from different countries are available to control the Helopeltis with Hymenopteran ants.

15.1.3.2. Parasitoid

The egg parasitoid, Erythmelus helopeltidis was found effective against tea mosquito bug, *Helopeltis theivora* (Sudhakaran and Muraleedharan, 1998). Percentage parasitism in the field varied between 52 and 83% and this is the first record of this species attacking H. theivora.

15.1.3. 3.Pathogens

Several microbes are pathogenic to tea pests. A local strain of Beauveria bassiana has been found effective against Helopeltis. The nymphs are parasitized by an emtomopathogenic nematode, Agamermis paradecaudate. Certain entomopathogenic fungi, Verticillium lecani, Paecilomyces fumosoroseus and Hirsutella thompsonii may also effective against Helopeltis.

15.1.3.4. Use of botanicals

Botanical products are environmentally safe, less hazardous, economic and easily available. Certain products derived from indigenous plants are used for tea pest control. Products containing azadirachtin, an oxygenated triterpenoid obtained from the seed kernel of neem, Azadirachta indica is now being evaluated against certain tea pests and has been found effective against Helopeltis. Besides, Mahogany, Karanja, Datura, Tobacco, Bishkatali, Katamehedi, Lantana, Xanthium and Clerodendrum extracts may also effective against this pest (Mamun and Ahmed, 2011).

15.1.3. 5. Use of sex pheromone

Sex pheromones have been utilized extensively in IPM programme in field crops but their use is rather unknown in plantation crops like tea. Sex pheromones could be integrated into the pest management programme in tea (Noguchi et al., 1981; Hiyori et al., 1986). Sex pheromones of the tea mosquito Helopeltis theivora were studied at UPASI Tea Research Institute to determine the presence and activity of sex pheromones to H. theivora (Sudhakaran et al., 2000). Responses of the tea mosquito bug, Helopeltis theivora to female sex pheromone compounds were measured using wind tunnel and electroantennogram (EAG) bioassays (Sachin et al., 2008). This female sex pheromone blend may be useful for tea mosquito control and management programs.

15.1.4. Objectives

Understanding the recent trends of seasonal abundance of egg parasitoids of *Helopeltis* spp. is prerequisite for developing an integrated management system for the pest. The specific objectives of the present study were to record the egg parasitoids, biology and behaviour of *Telenomus* sp. and to consider the role of weather in their population dynamics.

15.2. Distribution

15.2.1. Survey

The current study was undertaken during June 2010 to May 2013 at the Directorate of Cashew Research, Puttur, and the Shanthigodu Experimental station, (12.45° N latitude, 75.4° E longitude and 90 m a.s.l) (Dakshina Kannada province), Karnataka, South India. Field surveys were done during forenoon at cashew plantations and the cashew plant parts (shoot, petiole, midrib, inflorescence rachii and fruits) containing eggs of TMB were collected. The eggs were counted under a stereomicroscope and exposed to carbendazim (0.1%) solution for 10 minutes to prevent fungal growth on eggs. After treatment, samples were dried to remove the dampness of carbendazim solution and placed in a plastic container (250 ml capacity) fitted with a glass tube (75 x 7.5 mm). The container (except the glass tube) was completely wrapped with a black paper. The parasitoids emerged were identified and deposited at Zoological Survey of India, Calicut.

15.2.2. Abiotic factors recorded

In order to assess the influence of weather parameters, data on minimum and maximum temperature (°C) forenoon and afternoon humidity (%), rainfall (mm) and sunshine (h) recorded at the meteorological observatory were correlated with per cent parasitization using Spearman's rank correlation (Siegel and Castellan, 1988). Prediction equation was derived using multiple regression analysis with weather factors for estimating the population of parasitoids (Gomez and Gomez, 1984).

15.2.3. Egg parasitoids population
A total of 8037 eggs were observed and the results indicated the existence of three species of egg parasitoids *viz.*, *Telenomus* sp. (Hymenoptera: Platygastridae) (Figure 15.1), *Chaetostricha* sp. (Hym: Trichogrammatidae) and *Erthymelus helopeltidis* Gahan (Hym: Mymaridae). Of the three species, *Telenomus* sp. was predominant with 6.32 per cent parasitism (range of 0 to 28.21%), whereas *Chaetostricha* sp. and *E. helopeltidis* showed relatively low level of parasitism of 0.30 and 0.16 per cent, with a range of 0 to 2.22 and 0 to 2.25 per cent, respectively (Table 15.1). The population was higher during December to February, as number of host eggs observed was higher (peak time of *Helopeltis* spp. infestation).

The solitary egg parasitoids *viz.*, *Telenomus* sp. laricis group, *Chaetostricha* sp., *Ufens* sp. and *E. helopeltidis* regulate *Helopeltis* spp. on cashew, cocoa and neem in Oriental countries (Ibrahim, 1989; Sundararaju, 1993; Sundararaju and Sundarababu, 1996; Rajmohana et al., 2013). Egg parasitoids of genus *Telenomus* and *E. helopeltidis* are particularly promising (CIBC, 1983). In Malaysia, *E. helopeltidis* has been reported to parasitize up to 36% of the fertile eggs of *H. cinchonae* on tea (Lever, 1949) and 11- 47% of the eggs of *H. theivora* on cococa (Ibrahim, 1989). The studies conducted at different cashew regions of Tamil Nadu, the *Telenomus* sp. was found to be absent (Sundararaju, 1996). In the present study, *Telenomus* sp. was observed throughout the year with a range of 0 to 28.21 per cent parasitism, whereas *Chaetostricha* sp. was noted mostly during cropping season (November-May) with relatively low level of parasitization (0.0-2.22 %) and *E. helopeltidis* with parasitism of 0 to 2.25 per cent is in accordance with these earlier reports.

15.2.4.. Parasitism and cropping seasons
The seasonal per cent parasitism indicated that *Telenomus* sp. occurred almost throughout the year and acted as major mortality factor of *Helopeltis* and extended parasitization during cropping period (Srikumar et al., 2014). The activity of *Telenomus* sp. was completely absent during March and April (summer season) showing significant negative correlation with maximum temperature (r= -0.39) (Table 2). *Telenomus* sp. exhibited maximum parasitism during June and July (monsoon season) ranging from 6.89 to 28.21 per cent, showing significant positive correlation with rainfall (r =0.35). The afternoon humidity also exhibited significant positive correlation with *Telenomus* sp. parasitization (r = 0.38).

The occurrence of *Chaetostricha* sp. and *E. helopeltidis* were comparatively low mostly restricted to cropping season (December-March) with a maximum of 2.22 and 2.25 per cent, respectively. *Chaetostricha* sp. showed significant negative correlation (r = -0.58) with minimum temperature and *E. helopeltidis* showed significant positive correlation (r = 0.39) with forenoon humidity. When the parasitism percentage was subjected to multiple regression analysis with abiotic factors, the F value was found to be 2.48 and *Telenomus* prediction equation was derived with weather factors and presented in the Table 15.3.

Figure 15.1. ***Telenomus*** **sp. male and female**

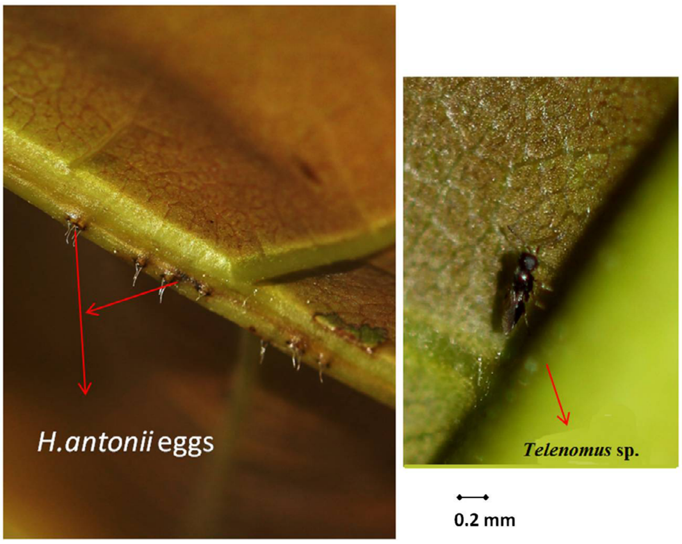

Figure 15.2. ***H. antonii*** **eggs and** ***Telenomus*** **sp. walking behaviour**

Table 15.1. Seasonal activity of egg parasitoids of *Helopeltis* spp.

Months	No. of *Helopeltis* spp. eggs observed	Per cent parasitism		
		Telenomus sp.	*Chaetostricha* sp.	E. helopeltidis
Jun-10	39	28.21	0.00	0.00
July	251	10.76	0.00	0.00
August	312	7.69	0.00	0.00
September	263	2.28	0.00	0.00
October	136	1.47	0.00	0.00
November	106	3.77	0.00	0.00
December	222	9.91	1.80	2.25
Jan-11	402	9.70	0.75	0.25
February	135	8.15	2.22	0.00
March	178	0.00	0.00	0.00
April	120	0.00	0.00	0.00
May	281	9.96	0.00	0.00
June	305	6.89	0.00	0.00
July	259	9.65	1.16	1.54
August	133	5.26	0.00	1.50
September	77	6.49	0.00	1.30
October	115	6.09	0.00	0.00
November	192	4.17	1.04	0.00
December	195	3.59	1.54	0.00
Jan-12	605	6.61	0.33	0.00
February	589	5.09	0.00	0.00
March	201	0.00	0.00	0.00
April	92	0.00	0.00	0.00
May	249	1.61	0.00	0.00
June	408	7.35	0.49	0.00
July	280	11.79	0.00	0.00
August	67	11.94	0.00	0.00
September	192	1.56	0.00	0.00
October	144	12.50	0.00	0.00
November	361	11.91	0.00	0.00
December	192	6.77	0.00	0.00
Jan-13	104	6.73	0.00	0.00
February	224	10.27	0.89	0.00
March	343	0.00	0.00	0.00
April	121	0.00	0.00	0.00
May	144	1.39	0.00	0.00
Total	8037	6.32	0.30	0.16

Prediction equation with six weather parameters for *Telenomus* population

$$(y) = 127.84 + 0.15\,X_1 - 0.12\,X_2 - 1.92\,X_3 + 0.66\,X_4 + 2.57\,X_5 - 0.01X_6$$

Where X_1 = Maximum temperature
X_2 = Minimum temperature
X_3 = Humidity forenoon
X_4 = Humidity afternoon
X_5 = Rainfall
X_6 = Sunshine hours

In the current study, the temperature and afternoon humidity and rainfall had significant correlation indices on *Telenomus* sp. parasitism, whereas minimum temperature and sunshine hours influenced *Chaetostricha* sp. and forenoon humidity on *E. helopeltidis* parasitism. Among weather parameters, temperature, relative humidity and rainfall may play a role in natural enhancement of population of *Telenomus* sp. and *Chaetostricha* sp. (Sundararaju, 2004).

The low R^2 value (0.38) when subjected to multiple regression analysis indicated that dependence of parasitoids remained unexplained in light of the abiotic factors when taken together. The size of R^2 value provides information on the size of the portion of the variability of dependent variable explained by the linear function of the independent variables (Gomez and Gomez, 1984). It means that some other factors have also considerable influence on parasitoid population.

15.3. Laboratory experimenters

The longevity of adult parasitoid was determined by providing 10 per cent honey solution in the form of minute droplets. Attempts were made to breed predominant parasitoid, *Telenomus* sp. on *H. antonii*. For this purpose fresh eggs of *H. antonii* were exposed to parasitoid. Oviposition behaviour and duration of development of the *Telenomus* sp. were also observed.

Females of *Telenomus* used in the experiment were allowed for mating with males in plastic container (250 ml capacity). Fresh *H. antonii* eggs laid on tender cashew shoots fixed in glass vial (5 ml capacity) with wet absorbent cotton were offered to these females. Ten females of 2 to 3 days old were used in the experiment. A total of 102 eggs of less than 24 h were offered to *Telenomus* sp. The females were kept individually in glass beaker (22 × 11 cm), with a wet muslin cloth sleeve.

From the moment the female first showed interest for the eggs, her behaviour was then observed for 2 h with help of magnifier metal hand lens (10x) and stereomicroscope. The distinct kinds of behaviour observed in the process of oviposition were recorded; the duration of each behaviour step was measured using a chronometer. Sex ratio was estimated from successfully emerged individuals but failed eggs were also dissected and taken into account. The duration of each behaviour step was subjected to one-way ANOVA.

Table 15. 2. Relationship of weather factors and egg parasitoids

Per cent parasitism	Temperature (°C)		Humidity (%)		Rainfall	Sunshine
	Max	Min	Forenoon	Afternoon	(mm)	(hr)
Telenomus sp.	-0.39*	0.03	0.28	0.38*	0.35*	0.24
Chaetostricha sp.	0.11	-0.58**	-0.10	-0.18	-0.09	0.32*
E. helopeltidis	-0.22	-0.05	0.39*	0.26	0.30*	-0.23

**- Significant at 5% level   **- Significant at 1% level*

Table 15.3. Multiple regression analysis to predict *Telenomus* parasitism

Details	No of variables	No. of observations	R^2 Value	F value
Weather parameters	6	36	0.38	2.48

F value is not significant at 5 % level

15.3.1. Behaviours of *Telenomus* sp.

Five different kinds of behaviour of *Telenomus* sp. female were observed: drumming, ovipositor insertion, marking, walking and resting. Drumming was characterized by moving the antennae up and down over the exposed surface of the eggs, the female remaining still or walking over the eggs (Figure 15.2). During drumming, the females did not seem to follow a definite direction, returning to the same egg many times. Subsequently, the female would pause so that the egg was behind her, incline her body and insert the ovipositor in the part of the egg when drumming stopped. From this moment on, she would remain still, with no antennae movement and directing towards base, wings parallel to the body and hind legs firmly holding the extra chorionic process of host egg (Figure 15.3).

15.3.2. Biological traits

After retreating the ovipositor, the female would move backwards, the posterior region of her abdomen swinging laterally, 'brushing' along the surface of the egg, and evidencing a marking behaviour. Walking was characteristic of when there was lack of interest for the eggs by the female, which marched on top of the eggs but with no drumming. Immobility was characteristic of the resting step, also with immobile antennae, and again either on top of the eggs or at any point of the glass beaker. The average time spent on the each kind of oviposition behaviour was 4.25 ± 0.45 min for drumming, 17.63 ± 2.49 min for ovipositor insertion and 0.95 ± 0.25 min for marking *i.e.* the mean time spent on oviposition was 22.83 ± 2.24 minutes per egg (N = 102) (Table 15.4).

Figure 15.3. Ovipositor insertion behaviour of *Telenomus* sp.

On dissection, the *Telenomus* parasitized eggs showed initially dark colouration progressing from proximal end to distal end of the egg while unparasitized egg was reddish with advanced embryonic growth. The developmental period of *Telenomus* was 20.6 ± 1.13 days with range of 18 to 30 days. The male and female longevity was 2.83 ± 0.16 and 4.52 ± 0.11 days, respectively (Table 15.5). *Telenomus* sp. emerging from *H. antonii* egg is portrayed in Figure 15.4.

Table 15.4. Mean duration, in minutes, of the three steps of oviposition behaviour of *Telenomus* sp. on eggs of *H. antonii*

Behaviour	By egg	
	Mean ± SE	Range
Drumming (>24 h old egg)	4.25 ± 0.45	2 - 6
Ovipositor- insertion	17.63 ± 2.49	11- 30
Marking	0.95 ± 0.25	0 - 2
CD (P <0.05)	4.42	-
Total	22.83 ± 2.24	17 - 35.6

Table 15.5. Biological parameters observed of *Telenomus* sp. on *H. antonii* eggs

Telenomus sp. biological parameters	Mean (d)	Range (d)
Developmental period	20.6 ± 1.13	18 - 30
Longevity		
Male	2.83 ± 0.16	2 - 4
Female	4.52 ± 0.11	3 - 6
Sex ratio (F:M)	1: 0.85	

Figure 15.4. *Telenomus* **sp. emerging from** *H. antonii* **egg**

The behaviour observed for *Telenomus* sp. females (drumming, ovipositor insertion, marking, walking and resting) are common to many species in the Platygastridae family, for example, *Gryon gallardoi* (Wiedemann et al., 2003), *Telenomus nakagawai* Watanabe (Hokyo and Kiritani, 1966), *T. sphingis* Ashmead (Rabb and Bradley, 1970), *T. heliothidis* Ashmead (Strand and Vinson, 1983) and *T. triptus* Nixon (Higuchi and Suzuki, 1996). The time spent on each kind of behaviour by *Telenomus* sp. was higher to observations on *Gryon gallardoi* (Wiedemann et al., 2003). *Telenomus* sp. had shown prolonged period of emergence of up to 30 days from parasitised eggs, whereas unparasitised eggs emerge within 6 to 10 days (Srikumar and Bhat, 2012). Such phenomenon of prolonged developmental period of parasitoid over host insect is a well-adapted host-parasite relationship. This might ensure the continued availability of hosts and thus, the survival of the parasites (Campbell et al., 1974). At the same time when the pest density has reached a certain high level, it is unlikely that its equilibrium population size can be lowered by egg parasitoid activity alone (Newton, 1988). As the success was limited in earlier attempts on biological control of TMB, the high levels of parasitism recorded in the present study warrants further investigations.

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