JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Bombyx mori L. : Acts as host for *Tetrastichus howardi* for mass multiplication and its utilization for controlling leaf roller in mulberry

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ABSTRACT

Mulberry leaf roller (*Diaphania pulverulentalis* Hampson) is a significant pest of mulberry, causing crop loss of about 12-15%. Generally, biological method is most preferred for controlling pest infestation in mulberry because the leaf is used as a nutritional diet for silkworm *Bombyx mori* L. *Tetrastichus howardi*, an ectopupal parasitoid, plays a crucial role in controlling leaf roller infestations by laying eggs inside the pupae of the leaf roller. However, the mass production of *T. howardi* is limited due to challenges in collecting suitable host i.e the pupa of the leaf roller as it pupates inside the soil. Hence, there is a great need to identify an alternative host for *T. howardi.* The present study was investigated to find the host specificity of *T. howardi* towards bivoltine silkworm pupae. Six bivoltine breeds *i.e.* CSR_2, CSR_4, CSR_6, CSR_{26}, CSR_{52}, and CSR_{57} were used to assess the oviposition response of *T. howardi*. The results demonstrated that silkworm pupae from all six breeds may serve as host for *T. howardi.* Specifically, CSR_6, CSR_{26} and CSR_{57} exhibited higher host specificity towards *T. howardi* in comparison to other breeds. Morphometric parameters (Body length, Wing span, Head length and Abdomen length & width) were registered higher in bivoltine breeds CSR_{57} and CSR6. With regards to the number of progeny, CSR_{57} recorded significantly higher followed by CSR_{26}. Results of the present study clearly indicated that bivoltine breeds of *Bombyx mori* L (CSR_{57} and CSR_6) pupae may serve as suitable alternate host for mass production of T. howardi.

Key words: *Tetrastichus howardi*, *Bombyx mori* L, Mulberry leaf roller, Biocontrol agents, Mass Multiplication

INTRODUCTION

India is the world's largest consumer and second-largest producer of silk. In 2023-24, India's raw silk production totalled 35,500 metric tons (MT), with the mulberry sector contributing 70% (24,850 MT) of the total output, as reported by the Central Silk Board (CSB) in its Annual Report for 2023-24. Due to increasing domestic silk demand, Central Silk Board is presently targeting to achieve sustainable growth in the silk industry. Mulberry is the sole food plant for silkworm *bombyx mori.*L. The leaf quality greatly determines the cocoon production and its quality.

Quality mulberry leaf production is influenced by various factors such as variety, spacing, management of water, nutrients, pests and diseases. The biotic and abiotic factors greatly affect the growth, yield and quality of mulberry leaf by about 20-25% (Philip, T., 1991). Mulberry is a perennial high-biomass producing plant that attracts the pest infestation that results in the loss of mulberry leaf both in terms of quantity & quality. Leaf roller (*Diaphania pulverulentalis Hampson*), Bihar hairy caterpillar (*Spilosoma oblique Walker*), Pink mealybug (*Maconellicoccus hirsutus Green*), Papaya mealy bug (*Paracoccus marginatus*), Cutworm (*Spodoptera litura*) are the major pests infecting mulberry. In Karnataka, the percentage of crop loss due to Leaf roller (12–15%), Pink mealy bug (10-15%), and Bihar hairy caterpillar (25–30%) was documented by Manjunath et.al, 2000. Govindaiah.et.al, 2005 reported crop loss of 17-18% by Thrips, 12.62% by whitefly, 9.08% by Jassid and 8.24% by scale insects in mulberry. Apart from qualitative damage, the pest infestation adversely alters the biochemical constituents in mulberry leaf ultimately affecting the growth and development of silkworms.

Leaf roller, *Diaphania pulverulentalis* (Lepidoptera: Pyralidae) is one of the major pest of mulberry in south India (Manjunath et al., 2000) which reduces the leaf yield by 20%. The infestation of the leaf roller occurs during June to February and its severity is higher during September to November. In general, leaf roller infests the apical portion of the mulberry shoot, where it binds the tender leaves by secreting a silky substance that allows the larvae to stay inside the curled leaves and then it starts defoliating from apical tender leaves to coarse leaves.

The chemical method is the most prominent way of controlling leaf roller in mulberry. However, intensive use of pesticides in mulberry is not advisable because the pesticide residues present in the leaf adversely affect the silkworm larvae. Hence, there is a great need to find an alternate method for controlling leaf roller in mulberry. In the part of integrated pest management, the biological method is well established technique for controlling pest infestation in crops by utilizing natural enemies (parasitoids, predators & pathogens). According to Van Lenteren (1983), the extent of insect pest suppression through natural enemies was around 82% by parasitoids, 17% by predators and 1% by pathogens.

Tetrastichus howardi is a gregarious ecto-pupal parasitoid and has a broad host spectrum with a distinct preference for Lepidopteron insects (Baitha *et al*., 2004). Apart from parasitizing the pupae, it can also destroy the eggs of Lepidopteron by host feeding which is an additional factor for reducing the pest population in crops. Moreover, *T.howardi* has high fecundity capacity which helps to increase the parasitoid population in the infested plot. This is an important attribute for controlling pest infestation through biological methods. Considering the effectiveness of controlling leaf roller by *T.howardi*, the CSRTI, Mysuru has already recommended *T.howardi* @ 50,000 adults/acre as a biological agent (natural enemy) for controlling leaf roller in mulberry. However, the suitable host for mass multiplying *T.howardi* for commercial purposes is very limited. Moreover, *T.howardi* has different reproductive potential with different hosts. It is hypothesized the that pupa of *Bombyx mori.* L. may also serve as an alternate host for the mass multiplication of *T.howardi*. Therefore, the present study was undertaken to find out the suitability of different bivoltine breeds of silkworm *Bombyx mori.* L as an alternate host for mass production of *T.howardi*.

MATERIALS ANDMETHODS

Parasitoid description:

Tetrastichus howardi is a gregarious larval and pupal parasitoid that belongs to the family Hymenoptera. It is a polyphagous parasitoid possesses significant potential to control the stem borer in sugarcane (La Salle and Polaszek 2007) and leaf roller in mulberry (Gangadhar, B. (2009)). *T.howardi* controls lepidopteran insects throughout the year and its effectiveness is significant during winter months. The mature wasp has a dark metallic blue thorax measuring 3 mm in length, and it has a black abdomen with a subtle metallic sheen. The total life period to complete its life cycle is around 17 days. This parasitoid is considered an effective biological control agent due to its high reproductive capacity and effective parasitization.

Host & Parasitoid culture

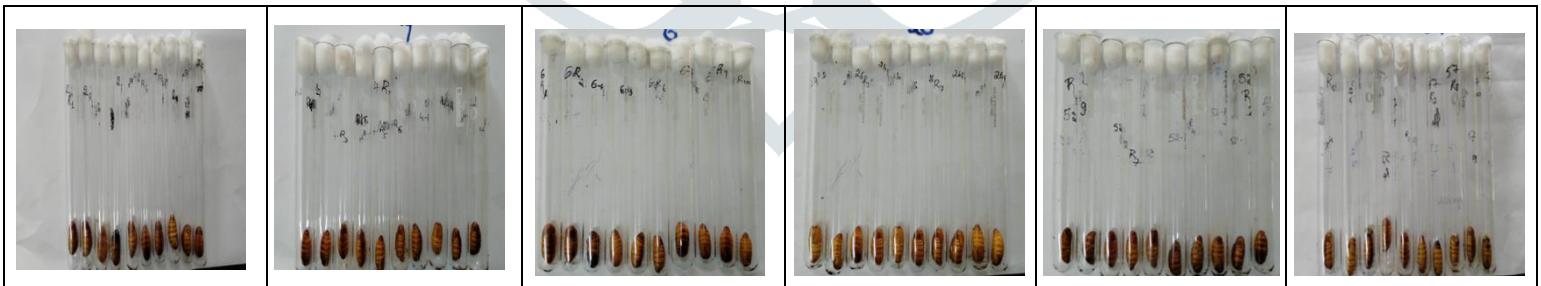
The study was carried out at the Department of Sericulture Science, University of Mysore, Manasagangotri, Mysuru during April - July 2022. Silkworm *Bombyx mori* L. pupae was utilized for the study as a host for *T.howardi.* The host culture was maintained at 25-28℃ and 60-80% RH. (Plate 1). The cultures of *T. howardi* was procured from the Pest Management Laboratory of the Central Sericultural Research and Training Institute (CSR & TI), Mysuru, and maintained on the pupae of *Samiacynthia ricini* at 25-28℃ and 60-80% RH in the laboratory at the Department of Studies in Sericulture, University of Mysore. The adults of the parasitoid were kept alive by feeding with 30% aqueous honey.

Oviposition of *T. howardi* on the host *Bombyx mori* L. pupae

Four days old (96 hrs) silkworm *Bombyx mori* L. pupae, with weight ranging from 0.84 to 0.95g (weight differs from breed to breed) were individualized with 24 hrs old *T. howardi* mated females at 1:1 ratio and kept in cotton sealed test tube (15 x 1.5 cm) for two days (48 h) under 25 ± 2 ºC, 60-80%, RH (Plate 2) and then *T. howardi* females alone were removed from the test tube after the parasitism exposure period. Whereas, *Bombyx mori* L. pupae was only allowed to stay in the test tube until the emergence of parasitoids offspring. After the emergence, of parasitoids from the host Silkworm *Bombyx mori* L. pupae, the data was recorded on developmental duration, progeny production (male, female, and total), sex ratio, progeny female longevity, parent female longevity and morphometric characters of progeny adults (body length, head width and wing span of male and female and abdominal length and width of female) (plate 3).

CSR_2	CSR_4	CSR_6	CSR_{26}	$CSR5_2$	CSR_{57}

Plate 1: Pupae of bivoltine breeds



CSR_2	CSR_4	CSR_6	CSR_{26}	$CSR5_2$	CSR_{57}

Plate2: Experimental set up for parasitization on the pupae of bivoltine breeds

				
***T.howardi* parasiting host**	**Emerged *T.howardi***	**Pre pupa**	**Female adults**	**Male adults**
Plate 3: *T.howardi* microscopic view				

RESULTS & DISCUSSION

The first information on the use of *Bombyx mori* L as a host for mass multiplication of *T.howardi* was reported by (Sankar et al. 2016) and their findings indicated that emergence of *T.howardi* was higher in *Bombyx mori* L in comparison to another insect host.

In the present study, the bivoltine breeds CSR_2, CSR_4, CSR_6, CSR_{26}, CSR_{52} and CSR_{57} were selected to see their suitability as host for mass multiplication of *T.howardi.* Results indicated that bivoltine breeds were found suitable to act as host for T. *howardi.* The average number of parasitoid that emerged from bivoltine breeds were 14 in CSR_2, 8 in CSR_4, 9 in CSR_6, 80 in CSR_{26}, 16 in CSR_{52} and 84 in CSR_{57}. Out of total emergence, the male and female sex ratios were 2.5 in CSR_2, 3 in CSR_4, 3 in CSR_6, 1.35 in CSR_{26}, 3 in CSR_{52} and 6.3 in CSR_{57}. Kfir et al. (1993) reported that the total life cycle of parasitoid was 20±1 days. A similar result was also observed in the present study (19±1 days). (Table 1 & Graph 1).

Morphometric characters of *T.howardi* were recorded during adult stage and significant difference was found among the host bivoltine breeds. In males, the morphometric characters were ranged from 1.16±0.1 to 1.86±0.05 body length, 0.3 ± 0.11 - 0.55 ± 0.02 body width, 0.7 ± 0.24 - 0.96 ± 0.02 wing span, 0.36 ± 0.02 - 0.49 ± 0.05 head width and 0.56 ± 0.16 L - 0.35 ± 0.07W to highest of 0.90± 0.09L – 0.52 ± 0.05W. Whereas in females, the morphometric characters were ranged from 1.77 ± 0.18 - 2.39± 0.15 body length, 0.43 ± 0.04 - 0.61 ± 0.04 body width, 1.04 ± 0.15 - 1.35 ± 0.1 wing span, 0.43 ± 0.07 - 0.62 ± 0.07 head width and 0.70 ± 0.31L – 0.53 ± 0.05W to 1.19± 0.07L – 0.79± 0.04W.

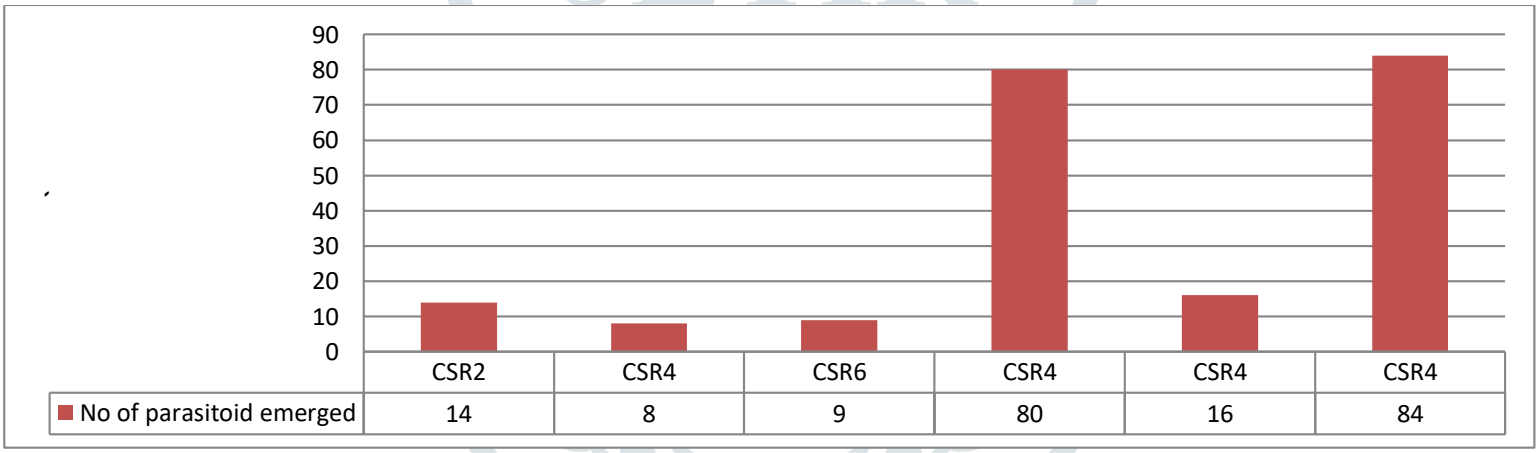
Among the host bivoltine breeds, CSR_6 [body length (1.86±0.05 mm in male and 2.06±0.02 mm in fermale), width (0.55±0.02 mm in male and 0.53±0.06 mm in female), wingspan(l) (0.96±0.02 mm in males and 1.2±0.04 mm in females), head width (0.47±0.02 mm in males & 1.2±0.04 mm in females), female abdomen measured (1.02±0.06 mm l & 0.51±0.06 mm w) and male (0.85±0.02mm l & 0.51±0.08 mm w)], CSR_{52} [body length (1.29±0.32 mm in male and 1.77 ± 0.18 mm in fermale), width (0.3±0.11 mm in male and 0.43±0.04 mm in female), wingspan(l) (0.7 ± 0.24mm in males and 1.04 ± 0.15mm in females), head width (0.36 ± 0.02mm in males & 0.43 ± 0.07 mm in females), female abdomen measured (0.70 ± 0.3 mm l & 0.53 ± 0.05mm w) and male (0.56 ± 0.16 mm l & 0.35 ± 0.07mm w)]. and CSR_{57} [body length (1.56±0.03 mm in male and 2.07±0.06 mm in fermale), width (0.37±0.07 mm in male and 0.61±0.04 mm in female), wingspan(l) (0.85 ± 0.09 mm in males and 1.24 ± 0.08 mm in females), head width (0.39 ± 0.04 mm in males & 0.53 ± 0.04 mm in females), female abdomen measured (1.14 ± 0.05 mm l & 0.66 ± 0.08 mm w) and male (0.76± 0.11mm l & 0.43 ± 0.03 mm w)]. Were registered significantly higher morphometric characteristics.

Host	Pupal weight (g)	Developmental duration (days)	Progeny production (No.)		Total Progeny production (No.)	Sex ratio (♀♀/♂)	Female longevity (days)	
			Male	Female			Progeny	Parent
CSR_2	0.92 ± 0.10	20±0	4±0	10±0	14±0	2.5±0	19±0	12.2 ± 1.78
CSR_4	0.95±0.14	22±0	6±0	2±0	8 ±0	3±0	19±0	11.2 ± 1.07
CSR_6	0.94±0.13	17±0	2±0	7±0	9 ±0	3±0	20±0	11.6 ± 1.5
CSR_{26}	0.84±0.05	17±0	34±0	46±0	80±0	1.35±0	19±0	11.4 ± 3.04
CSR_{52}	0.90±0.06	20±0	4±0	12±0	16 ±0	3±0	18±0	11 ± 1.20
CSR_{57}	0.85±0.08	20±0	11±0	70±0	84 ±0	6.3±0	19±0	12.6 ± 4.23

***** Data are the means of ten replications (Mean ± SD)**.**

Comparative reproduction performance of *Tetrastichus howardi* in of CSR_2, CSR_4, CSR_6, CSR_{26}, CSR_{52} and CSR_{57} breeds

Progeny production of *T.howardi* was significantly influenced by different bivoltine breeds in the present study (Table 1). Significantly higher progeny production was registered in CSR_{57} [84 as 11M & 70F] and in CSR_{26} [80 as 34M & 46F] in comparision to other bivoltine breeds such as CSR_2 [14 as 4M & 10F], CSR_4 [8 as 6M & 2F], CSR_6 [9 as 2M & 7F], CSR_{52} [16 as 4M & 12F].



Graph 1. Numbers of progeny produced by different bivoltine breeds of *Bombyx mori* L.

Table1. Effect of host (*Bombyx mori* L.) bivoltine breed on the progeny production of *Tetrastichus howardi*

Host breed	Body length (mm)		Body width (mm)		Wing span (mm)		Head width (mm)		Female abdomen (mm)		Male abdomen (mm)	
	Male	Female	Male	Female	Male	Female	Male	Female	Length	Width	Length	Width
CSR_2	1.16 ± 0.01	1.86 ± 0.02	0.45 ± 0.02	0.50 ± 0.04	0.86± 0.04	1.1 ± 0.02	0.43 ± 0.02	0.48± 0.16	1.03±0.04	0.50 ±0.06	0.81±0.02	0.49 ±0.08
CSR_4	1.81± 0.24	2.39± 0.15	0.38 ± 0.01	0.57± 0	0.8± 0.05	1.23± 0.13	0.41± 0.04	0.6± 0.04	1.19± 0.07	0.79± 0.04	0.90± 0.09	0.52± 0.05

CSR_6	1.86 ± 0.05	2.06 ± 0.02	0.55 ± 0.02	0.53 ± 0.06	0.96 ± 0.02	1.2 ± 0.04	0.47 ± 0.02	0.51 ± 0.16	1.02 ± 0.06	0.51 ± 0.06	0.85 ± 0.02	0.51 ± 0.08
CSR_{26}	1.77 ± 0.14	2.15 ± 0.12	0.43 ± 0.05	0.52 ± 0.1	1.13 ± 0.1	1.35 ± 0.1	0.49 ± 0.05	0.62 ± 0.07	0.8 ± 0.04	0.55 ± 0.06	0.7 ± 0.07	0.49 ± 0.03
CSR_{52}	1.29 ± 0.32	1.77 ± 0.18	0.3 ± 0.11	0.43 ± 0.04	0.7 ± 0.24	1.04 ± 0.15	0.36 ± 0.02	0.43 ± 0.07	0.70 ± 0.31	0.53 ± 0.05	0.56 ± 0.16	0.35 ± 0.07
CSR_{57}	1.56± 0.03	2.07 ± 0.06	0.37 ± 0.07	0.61 ± 0.04	0.85 ± 0.09	1.24 ± 0.08	0.39 ± 0.04	0.53 ± 0.04	1.14 ± 0.05	0.66 ± 0.08	0.76 ± 0.11	0.43 ± 0.04

Table 2. Influence of host (*Bombyx mori* L.) Bivoltine breed on the morphometric characteristics of *Tetrastichus howardi*

Conclusion

Results indicated that reproductive efficiency and progeny fitness of the parasitoid *Tetrastichus howardi* showed significant variation among the host pupae of different bivoltine breeds of *Bombyx mori* L. Emergence and morphometric variation in host breeds were greatly influenced on the progeny production and progeny fitness of *T. howardi*. *A*mong the bivoltine breeds, CSR_{57} and CSR_6 were registered a higher number of progenies in compression to other breeds. Therefore, it can be concluded that the pupae of bivoltine breeds i.e. CSR_{57} AND CSR_6 may be utilized as an alternate host for the mass production of *T. howardi*, an ectopupal parasitoid of leaf roller.

REFERENCES

Ana Laura Favoreto, Rafaela Freitas Pavani, Murilo Fonseca Ribeiro, Antonio Jose VinhaZanuncio, Marcus Alvarenga Soares, Jose Cola Zanuncio and Carlos FredericoWilcken(2020). *Tetrastichus howardi* (Hymenoptera: Eulophidae): first report of parasitism in *Oxydiavesulia* (Lepidoptera: Geometridae). *Braz. J. Biol.*,**81**(2): 406-410.

Anuj Kumar, Arun Baitha and Kumar A. (2021). Response of pupal weight of stalk borer, *Chiloauricilius* Dudgeon (Crambidae: Lepidoptera) on biology of *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae). *Insect Environment*,**24** (1):63-69.

Arun Baitha and Sinha O.K. (2004). Differential response of host pupae of sugarcane borers on the parasitisation and reproduction of *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae). *Indian journal of Sugarcane Technology*, **19** (1 & 2): 90-91.

Aruna AmbadahalliSiddaiah and Manjunath Danagoudra (2019). Oviposition behavior of an ectopupal parasitoid *Nesolynx thymus* (Hymenoptera: Eulophidae): A biocontrol agent of the Uzi fly *Exoristabombycis* (Diptera: Tachinidae). *Journal of Entomology and Zoology Studies;* **7**(1): 190-193.

Aruna, A.S. (2007). Developmental dynamics of an Eulophid ecto-pupal parasitoid (*Nesolynx thymus*) on some Dipteran hosts. *Ph. D. Thesis*, University of Mysore, Pp. 291.

Aruna, A.S. and Manjunath, D. (2019). Role of diet on longevity of an eulophid parasitoid *Nesolynx thymus*Girault. *Journal of Entomology and Zoology Studies*, **7**(1): 194-197.

Augusto Rodrigues, Fabricio Pereira, F., Paulo Barbosa, R.R., Christian Silva-Torres, S.A. and Jorge Torres, B. (2021). Parasitism Behavior of *Tetrastichus howardi* (Hymenoptera: Eulophidae) on Larvae and Pupae of Sugarcane Borers. *J Insect Behav*, **34**: 71–81.

Basavarajappa, S., Senthoorraja, R., Subaharan, K., Ankita Gupta, Lalitha, Y., Bakthavatsalam, N. and Chandran, K. P. (2020). Host factors influencing the parasitism by *Nesolynx thymus* (Girault) (Hymenoptera: Eulophidae) on housefly, *Musca domestica*L.*Journal of Biological Control*, **34**(3): 200-207.

Bellow, T. S. (1985). Effects of host and parasitoid age on search behaviour and oviposition rates in *LariophagusDistinguendus* Forster (Hymenoptera: Pteromalidae). *Res. Popul. Ecol.*, **27**: 65-76.

BethiaHurlbutt King (1987). Offspring sex ratios in parasitoid wasps. *The Quarterly Review of Biology*, **62**(4): 367-396.

Chapman, R.F. (1998). *The Insects: Structure and Function.* 4th ed. Cambridge University Press, U.K.

Charnov, E.L., Los-den Hartogh, R.L, Jones, W.T. and Van den Assem, J. (1981). Sex ratio evolution in a variable environment. Nature, **289:** 27–33.

Clausen, C.P. (1978). Introduced parasites and predators of arthropod pests and weeds: A world review. In *Agriculture Handbook No. 480, Washington D. C., US Department of Agriculture.*

Cruz, I., Redoan, A.C., de Silva, R. B., de Figueiredo, M.L.C. and Penteado-Dias, A.M. (2011). New record of *Tetrastichushowardi* (Olliff) as a parasitoid of *Diatraeasaccharalis* (Fabr.) on maize. *Sci. Agric*., **68**(2): 252-254.

Dandin, S. B. &Giridhar, K. (2010). *Hand Book of Sericulture Technologies.* Central Silk Board, Bangalore, Karnataka, India, 427 p.

Gangadhar, B. (2009). Biology and evaluation of *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae) with reference to some insect hosts. *Ph. D. Thesis*, University of Mysore, p. 251.

Gordh, G., Legner, E.F. and Caltagirone, L.E. (1999). Biology of parasitic Hymenoptera. In *Handbook of Biological Control* (T. S. Bellows and T. W. Fisher, Eds.), Academic Press, San Diego, California, USA, p. 355-385.

Govindaiah, Gupta, V.P., Sharma, D.D., Rajadurai, S. and Naik, V.N. (2005) Mulberry crop protection. Central Silk Board Publication, Bangalore.

Hai-Poong Lee, Il-Kwon Kim, and Ki-Sang Lee (1999). Morphology and Development of *Tetrastichus* sp. (Hymenoptera: Eulophidae), Parasitizing Fallwebworm Pupae, *Hyphantriacunea* Drury (Lepidoptera: Arctiidae). *Korean J. Biol. Sci.*,**3**: 369 -374.

Harley Nonato de Oliveira, Juliana Simonato, Daniele Fabiana Glaeser and Fabricio Fagundes Pereira (2016). Parasitism of *Helicoverpaarmigera* pupae (Lepidoptera: Noctuidae) by *Tetrastichus howardi* and *Trichospilusdiatraeae*(Hymenoptera: Eulophidae). *Semina: CienciasAgrarios Londrina,***37**(1):111-115.

Hu, Cui, Pedro Barbosa and Peter Martinat, J. (1986). Influence of age of female *Glyptapantelesflavicoxis* (Marsh) (Hymenoptera: Braconidae) and its periodicity of oviposition activity on levels of parasitism and reproductive output. *Annals of the Entomological Society of America,* **79**(2).

Jorge Felix Alvarez Gonzalez, Fernando Naranjo, M. de Oca and Horacio Grillo Ravelo (2003). Estudios bio-ecologicos the *Tetrastichus howardi* Olliff. (Hymenoptera: Eulophidae), parásito pupal the *Diatraeasaccharalis* (Fabr.) (Lepidoptera: Crambidae) in Cuba. (Primera parte). *Centro Agricola Ano*,**30**(2):38-41.

Katiyar, R.L., Vineet Kumar, Manjunath, D., Sen, A.K., Shekar, M.A. and Datta, R.K. (2000). Biology of *Anagyruskamali* (Moursi) (Hymenoptera: Encyrtidae) – A parasitoid of the Mealy bug, *Maconellicoccushirsutus* (Green), with a note on its incidence. *Int. J. Indust. Emtomol,* **1** (2): 143 –148.

Kfir, R., Gouws, J. and Moore, S.D. (1993). Biology of *Tetrastichushowardi* (Olliff) (Hymenoptera: Eulophidae): A facultative hyperparasitoid of stem borers. *Biocont. Sci. Tech*., **3**(2): 149-159.

Kishore, R., Kumar, P., Manjunath, D. and Datta, R.K. (1994). Effect of temperature on the developmental period, progeny production and longevity of *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae). *Journal of Biological Control*, **8:** 10-13.

Manjunath, D. (2004). Pests of mulberry and their management. In: Advances in disease and pest management in sericulture - lead paper (Govindan, R., Ramakrishna Naika and Sannappa, B. eds.). Seri Scientific Publishers, Bangalore, 31-39 PP.

Nakamatsu, Y. and Tanaka, T. (2004). Food resource use of hyperparasitoid *Trichomalopsisapanteloctena*, an idiobioticectoparasitoid. *Ann. Entomol. Soc. Am.*, **97**: 994 - 999.

Narendra Kumar, J.B. (2019). Biology and behavior of *Trichomalopsisuziae*Sureshan & Narendra Kumar, an ecto-pupal parasitoid, with reference to the uzi fly, *Exoristabombycis* (louis). *Ph. D. Thesis*, University of Mysore, pp. 266.

Narendra Kumar, J.B. and Manjunath, D. (2021). Comparative performance of *trichomalopsisuziae* a pupal parasitoid of the tachinid *Exoristabombycis.Indian Journal of Entomology*,**83:**1-6.