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REPRODUCTIVE EFFICIENCY OF *TETRASTICHUS HOWARDI* (OLLIFF) (HYMENOPTERA: EULOPHIDAE) ON SOME LEPIDOPTERAN INSECT/HOST SPECIES

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ABSTRACT

Laboratory investigations were undertaken at the Department of Studies in Sericulture Science, University of Mysore, Manasagangotri, Mysuru, at temperature ranging between 23 – 28ºC and 65 – 85 % Relative humidity, to understand the effect of lepidopteran insect/host species on its reproductive performance of progenies of an indigenous endo-pupal parasitoid, *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae). For experimentation, 2-day-old pupae of lepidopteran insect/host species were exposed to parasitism by 2-day-old *T. howardi* for 2 days at a host-parasitoid ratio of 1:1. After development of the parasitoid progenies, observations were recorded on the parasitoid developmental duration, progeny production (male and female), sex ratio, progeny female longevity.

The results revealed that, reproductive efficiency of the parasitoid *Tetrastichus howardi* showed significant variation among the selected lepidopteran insect/host species. Emergence in insect/host species were greatly influenced on the progeny production of *T. howardi.* Among the insect/host species, *H. armigera* (120.80±4.54) and *S. c. ricini* (111.20±5.09) were recorded a highest number of progenies in compression to other insect/host species.

Key words: Lepidopteran insects, progeny production, reproductive efficiency, *Tetrastichus howardi*.

INTRODUCTION

Tetrastichus howardi (Olliff) (Hymenoptera: Eulopidae), *is* a gregarious endo-pupal parasitoid under the Chalcidoidea superfamily has been observed to be both as a primary parasitoid as well as a facultative hyperparasitoid. It is known to parasitize the pupal stage of various lepidopteran families that includes Noctuidae, Crambidae and Plutellidae (Kfir *et al*., 1993). In India, attempts have also been made to use it as a bio-control agent against sugarcane borers (Baitha *et al*., 2016) and spotted stem borer, *Chilo partellus* (Kfir *et al*., 1993).

Research on the effectiveness of biological control programs emphasizes the importance of mass rearing parasitoids. This requires an understanding of the parasitoid reproductive potential, life cycle, parasitisation capacity, and sensitivity to environmental factors. These factors are critical to developing cost-effective mass rearing techniques for *T. howardi*. (Thangjam, 2012).

The focus on biological interaction between parasitoids and their hosts is crucial because it directly affects the efficiency and sustainability of these programs. When developing mass-rearing techniques, factors such as reproductive potential, host suitability, and environmental conditions (e.g., temperature, light, and humidity) are pivotal.

Further research on these parameters would help optimize rearing practices and enhance the cost-effectiveness of parasitoid production. In particular, balancing the sex ratio and maximizing parasitisation capacity can contribute significantly to the overall success of these control programs.

T. howardi, a biocontrol agent for managing sugarcane internode borers. The use of *T. howardi* has been promoted in South India's sugar industry as an effective method for controlling these pests. It's great that mass rearing technology has been standardized using the pupae of *Samia cynthia ricini* (Eri silkworm) and *Bombyx mori* (Mulberry silkworm), as these species are readily available for large-scale production. The ability of a single *B. mori* pupa to produce 115 offspring of *T. howardi* is particularly impressive, as it shows the potential for significant pest control with minimal resources. The adaptability of *T. howardi* to both laboratory and field conditions makes it a promising option for integrated pest management (IPM), especially for lepidopteran pests. Therefore, the parasitisation ability of *T. howardi* on lepidopteran pests, with the goal of improving mass production methods for better pest control (Sankar and Rao 2016).

T. howardi is a vital component of IPM against leaf roller, *Diaphania pulverulentalis* Hampson, a serious defoliator of mulberry (*Morus* spp.), the exclusive food plant of the silkworm, *Bombyx mori* L.

MATERIALS AND METHODS

Host collection and culture:

The host insects were collected from the field and reared on their host plant leaves in the laboratory to obtain the pupae used for screening.

Wherever the cultures of some of these insects was available in some research institutes like Central Sericultural Research & Training Institute (CSR&TI), National Bureau of Agricultural Insect Resources (NBAIR) and Department of Studies in Sericulture Science the same was procured from there either in egg, larval, or pupal stages depending on the availability of these stages. The host cultures were maintained at 25-28°C and 60-80% RH in the laboratory at the Department of Studies in Sericulture, University of Mysore. The following lepidopterans in their pupal stage was screened to find they would serve as hosts or not based on successful parasitism, *i.e.*, based on the emergence of the adults of *Tetrastichus howardi:*

Sl. No.	Host pupae (Family)	Order	Host emergence (Yes/No)	Successful parasitism (Yes/No)
1.	*Amata passalis*, Sandalwood defoliator (Erebidae)	Lepidoptera	Yes	No
2.	*Amsacta albistriga*, red hairy caterpillar (Erebidae)	Lepidoptera	Yes	No
3.	*Amsacta moorei*, Tiger moth (Arctiidae)	Lepidoptera	Yes	No
4.	*Archips micaceana*, Soyabean leafroller (Tortricidae)	Lepidoptera	No	Yes
5.	*Bombyx mori*, Mulberry Silk moth (Bombycidae)	Lepidoptera	No	Yes
6.	*Corcyra cephalonica*, Rice moth (Pyralidae)	Lepidoptera	No	Yes
7.	*Diaphania pulverulentalis*, Leaf roller (Pyralidae)	Lepidoptera	No	Yes
8.	*Ergolis merione*, Castor spiny caterpillar (Nymphalidae)	Lepidoptera	No	Yes
9.	*Euproctis fraterna*, Coffee hairy caterpillar (Erebidae)	Lepidoptera	Yes	No
10.	*Eupterote mollifera*, Hairy caterpillar (Eupterotidae)	Lepidoptera	Yes	No
11.	*Exorista bombycis*, Indian uzi fly (Tachinidae)	Diptera	No	Yes
12.	*Glyphodes negatalis*, karanj defoliator (Crambidae)	Lepidoptera	No	Yes

13.	*Graphium agamemnon*, Tailed jay butterfly (Papilionidae)	Lepidoptera	No	Yes
14.	*Haritalodes derogata*, Cotton leaf roller (Crambidae)	Lepidoptera	No	Yes
15.	*Hasora chromus*, Common banded awl (Hesperiidae)	Lepidoptera	Yes	No
16.	*Helicoverpa armigera*, Cotton bollworm (Noctuidae)	Lepidoptera	No	Yes
17.	*Plutella xylostella*, Diamondback moth (Plutellidae)	Lepidoptera	No	Yes
18.	*Samia cynthia ricini*, Eri silkworm (Saturniidae)	Lepidoptera	No	Yes
19.	*Spilosoma obliqua*, Bihar hairy caterpillar (Erebidae)	Lepidoptera	Yes	No
20.	*Spodoptera frugiperda*, Fall armyworm (Noctuidae)	Lepidoptera	No	Yes
21.	*Spodoptera litura*, Cutworm (Noctuidae)	Lepidoptera	No	Yes

Parasitoid culture: Nucleus cultures of *T. howardi* were procured from the insectary of Pest Management Laboratory (PML) of the Central Sericultural Research and Training Institute (CSR & TI), Mysuru, and maintained on the pupae of *Samia cynthia ricini* at 25-28^{o}C and 60-80% RH in the laboratory at the Department of Studies in Sericulture, University of Mysore, Manasagangotri, Mysuru. The adults of the parasitoid were fed on aqueous honey at 50%.

In this experiment, 2-day-old gravid females of the parasitoid *Tetrastichus howardi* were allowed to parasitize 2–3-day-old of selected host insect species at a host-parasitoid ratio of 1:1 in a test tube (15 x 1.5 cm) plugged with cotton, with ten replications. The parasitoids adults were fed 50% aqueous honey solution and were allowed to parasitize the host pupae for a period of 2 days. Thereafter, they were separated from the host pupae and were kept for parasitoid emergence (first generation). After the emergence of the parasitoid adults, parameters such as developmental duration (days), progeny production (male, female, and total) (No.), sex ratio (Females/male), progeny female longevity (days) were recorded. The longevity of parasitoid adult females was determined by maintaining 10 replication each with 10 adults that were fed with 50% aqueous honey solution.

The accrued data was analyzed employing Analysis of Variance (ANOVA) (F-test) followed by Duncan Multiple Range Test (DMRT) the level of significance. Statistical package for Social Sciences (SPSS), Version 21.0.

RESULTS & DISCUSSION

In the present study, all lepidopteran insects / host species were selected to get their appropriate host for mass multiplication of *T. howardi*. Results showed that selected lepidopteran insects were initiate suitable to performed as a host for *T. howardi.*

The results are presented in Table 1. The developmental duration of parasitoids developed from the insect/host species pupae significantly more in *S. litura* (22.40±0.56 days) and less in *S. frugiperda* (14.40±0.16 days) followed by *P. xylostella* (14.50±0.42 days). Lucchetta *et al*. (2022) also found somewhat similar results with host, *S. frugiperda* in which *T. howardi* had the shortest life cycle, from egg to adult, during the prepupal stage of *S. frugiperda*, with a duration of 20.10 ± 0.22 days. It raises questions about the adaptability and flexibility of *T. howardi* in responding to different host environments.

The average number of the male parasitoids was more numbers in *H. armigera* (32.60±1.28) pupae, less numbers in *D. pulverulentalis* (4.60±0.67) followed by *P. xylostella* (4.70±0.65) and *G. negatalis* (5.00±1.09) pupae. The average number of the female parasitoids was more numbers in *S. c. ricini* (100.1±4.55) followed by *G. agamemnon* (90.00±3.64) pupae and less numbers in *D. pulverulentalis* (22.80±1.77) followed by *E. bombycis* (26.20±1.80) pupae.

Out of the total number of parasitoids was significantly highest numbers in *H. armigera* (120.80±4.54) followed by *S. c. ricini* (111.20±5.09) pupae and lowest numbers in *D. pulverulentalis* (27.40±1.80) followed by *E. bombycis* (32.00±2.68). Baitha *et al.* (2021) in their study also found out that the emergence of parasitoids was observed more on initial few days of emergence.

The sex ratio (Females/male) of parasitoids was significantly higher in *S. c. ricini* (9.27±0.50) followed by *G. agamemnon* (9.27±0.39) and *G. negatalis* (7.99±1.98), lesser in *H. armigera* (2.70±0.23) followed by *P. xylostella* (2.98±0.33). Offspring females' longevity of parasitoids developed from the insect/host species pupae more in *S. litura* (20.50±0.63 days) followed by *S. frugiperda* (19.60±0.22 days) and *S. c. ricini* (19.40±0.73 days) less in *H. derogata* (12.40±0.24 days).

The information on the custom of *S. c. ricini* 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 *S. c. ricini* in comparison to another insect host.

Host culture of *T.howardi*

***T.howardi* egg laying on the host/insect pupae**

Development of *T.howardi* inside the host/insect pupae (Pre pupal stage)

Emerged *T.howardi* on the host/insect pupae

Female and male adult *T.howardi* under the microscope

Plate 1: Developmental stages of *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae) on lepidopteran insect/host species

Table 1: Impact of insect/host species screened for parasitism by *Tetrastichus howardi*

Sl. No.	Host/Insect	Dev. duration (days)	Progeny production (No.)			Sex ratio (Females/ male)	Progeny female longevity (days)
			Male	Female	Total		
1.	*Archips micaceana*	17.80±0.20^{d}	9.00±1.14^{cd}	29.80±2.33^{e}	38.80±1.62^{f}	3.58±0.57^{fg}	15.40±0.67^{cde}
2.	*Bombyx mori*	17.40±0.01^{d}	11.30±0.70^{bc}	65.30±4.25^{c}	76.60±4.62^{d}	5.88±0.40^{cd}	14.30±0.73^{ef}
3.	*Corcyra cephalonica*	13.70±0.21^{f}	7.90±0.72^{de}	29.90±2.46^{e}	37.80±2.86^{f}	3.96±0.39^{efg}	17.15±0.65^{b}
4.	*Diaphania pulverulentalis*	17.60±0.24^{d}	4.60±0.67^{g}	22.80±1.77^{f}	27.40±1.80^{g}	5.34±0.73^{de}	16.00±0.54^{bcd}
5.	*Ergolis merione*	17.80±0.37^{d}	9.80±1.06^{bcd}	71.00±3.72^{c}	80.80±3.27^{d}	7.62±1.19^{b}	13.60±0.50^{fg}
6.	*Exorista bombycis*	18.20±0.20^{cd}	5.80±0.91^{fg}	26.20±1.80^{ef}	32.00±2.68^{fg}	4.78±0.42^{def}	16.20±0.58^{bc}
7.	*Glyphodes negatalis*	16.20±0.37^{e}	5.00±1.09^{g}	31.60±0.92^{e}	36.40±1.80^{f}	7.99±1.98^{ab}	14.60±0.40^{def}
8.	*Graphium agamemnon*	17.80±0.20^{d}	9.80±0.66^{bcd}	90.00±3.64^{ab}	99.80±4.20^{bc}	9.27±0.39^{a}	15.00±0.31^{cdef}
9.	*Haritalodes derogata*	15.40±0.24^{e}	7.80±1.01^{de}	40.80±2.85^{d}	48.60±3.74^{e}	5.46±0.49^{de}	12.40±0.24^{g}
10.	*Helicoverpa armigera*	18.80±0.48^{bc}	32.60±1.28^{a}	88.20±5.31^{b}	120.80±4.54^{a}	2.70±0.23^{g}	17.20±0.96^{b}
11.	*Plutella xylostella*	14.50±0.42^{f}	4.70±0.65^{g}	12.40±0.84^{g}	17.10±1.27^{h}	2.98±0.33^{g}	9.50±0.40^{h}
12.	*Samia cynthia ricini*	19.20±0.44^{b}	11.10±0.79^{bc}	100.1±4.55^{a}	111.20±5.09^{ab}	9.27±0.50^{a}	19.40±0.73^{a}
13.	*Spodoptera frugiperda*	14.40±0.16^{f}	11.70±0.70^{b}	82.30±3.94^{b}	94.40±4.38^{c}	7.07±0.40^{bc}	19.60±0.22^{a}
14.	*Spodoptera litura*	22.40±0.56^{a}	6.90±0.93^{ef}	43.80±4.23^{d}	50.70±5.10^{e}	7.03±0.69^{bc}	20.50±0.63^{a}
F value		48.08**	47.84**	63.82**	65.85**	11.31**	28.10**

@ Based on one host pupae provided for parasitism

Values given in the Table are the means of 10 replications (Mean±SE)

**$p \leq 0.01$ *$p \leq 0.05$ NS: Non-significant

Mean values followed by the same superscript in columns are statistically not significant

CONCLUSION

Reproductive efficiency of the parasitoid *Tetrastichus howardi* exposed significant variation among the host pupae of selected lepidopteran insect/host species. Emergence in lepidopteran insect/host species were greatly influenced on the progeny production of *T. howardi.* Among the lepidopteran insect/host species, *H. armigera* and *S. c. ricini* were recorded a higher number of progenies in compression to other insect/host species.

This investigation leads to identification two or more suitable hosts based on the acquisition of reproductive efficiency. The host species thus identified and used for the development of package for mass production of *T. howardi.*

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