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Reproductive biology of *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae): a gregarious pupal parasitoid

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ABSTRACT

The reproductive biology of *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae), a gregarious pupal parasitoid of several lepidopterous stem borers was studied in the laboratory at 28 ± 2^{0}C and 65 ± 5% relative humidity on field collected vs. laboratory reared and female vs. male pupa of *Chilo auricilius* and also under fed and unfed condition. The honey-water solution provided as a food supplement increased the survival and as well as life time offspring production over unfed females of *T.howardi*. Honey-water solution might suppress the parasitoid's tendency to engage in host-feeding, thereby increasing the offspring production. The number of progeny emerged from each laboratory reared *C. auricilius* pupa was more (75.6) than the field collected ones (66.5). The female biased sex ratio was found both in laboratory reared and field collected pupae. Larger pupae yielded higher progeny than the smaller ones. Due to limitation of space and deficiency of food material in smaller pupa, the result is either lowering of fecundity of females or greater mortality among immature stages or both. Female biased sex ratio in *T. howardi* was found with high degree of inbreeding.

Key words: Pupal parasitoid, *Tetrastichus howardi*, *Chilo auricilius*, nutrition, sugarcane borer

In their evolutionary game of hide and seek with natural enemies, some herbivores may have adapted a concealed life style such as borers of sugarcane. Feeding inside plant tissue make it more difficult for enemies to locate and attack potential hosts (Askew and Shaw 1986; Hawkins 1994). However, being part of the evolutionary game, some parasitoids have developed behavioural and morphological characteristics allowing them to utilize hosts with these concealed style.

Tetrastichus howardi (Olliff) (Hymenoptera: Eulophidae), a gregarious polyphagous pupal endoparasitoid with wide host range (Cherian and Subramaniam 1940; Puttarudriah and Sastry 1958; Boucek 1988; Baitha 2007; Prasad *et al.* 2007; Lasalle and Polaszek 2007; Alvarez *et al*. 2007; Cruz *et al.* 2011) is distributed widely in India (Uttar Pradesh, Bihar, Haryana, Punjab, Andhra Pradesh, Karnataka, Tamil Nadu and Odisha). It is basically a primary parasitoid associated with lepidopterous stem borers of concealed habitat and its unique adaptation for host searching through strategy of penetrating tunnel excavated by stem borers opens a new perspective in suppression of sugarcane stalk borer, *Chilo auricilius* Dudgeon.

The knowledge of characteristics of reproductive biology particularly on host size, host quality, adult nutrition, etc. is of vital importance in the mass multiplication of *T. howardi* on alternate hosts and developing strategies for their subsequent release in the field. The potential impact of a parasitoid on the population of its host depends, among other factors, on the parasitoid's longevity, its fecundity and the efficiency with which it locates its hosts. Each of these fitness parameters are directly linked to the number of hosts a parasitoid can attack. Hosts may be attacked, not because they are preferred, but because they are accessible in a particular habitat (Townes 1962; Vinson 1984).

The aim of this investigation was to ascertain the progeny allocation by *T. howardi* on field collected vs. laboratory reared, female vs. male pupae of *Chilo auricilius* and also the effect of adult nutrition on some biological attributes of the parasitoid.

MATERIALS AND METHODS

The experiments were conducted with *T. howardi* initially received from PDBC, Bangalore and later maintained on the pupae of sugarcane stalk borer *Chilo auricilius* Dudgeon reared on artificial diet (Varma *et al*. 1975), in the laboratory at 28 ± 2^{0}C and 65 ± 5% relative humidity during 2006-2007. Three experiments were conducted.

In the first experiment, 24 hr old ten mated females of *T. howardi* in two separate sets were individually placed into glass vials (15 x 2.5 cm). Fine streaks of honey-water solution (1:1 v/v) as adult food were provided in the first while the other set of ten females was kept without food (unfed). Laboratory reared two days old *C. auricilius* pupae, one each in every glass vial harbouring *T. howardi* female, was provided for parasitisation. The parasitized pupae were replaced with fresh ones daily and kept separately in similar glass vials till host/parasitoid emergence. After emergence, parasitoid were

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sexed, counted and the data on the survival (days), number of progeny emerged and the female ratio were recorded.

In the second experiment, twenty pupae each of *C. auricilius* reared in the laboratory and field collected pupae placed individually in glass vials (15 x 2.5 cm) were exposed to mated female (24 hr. old) of *T. howardi*. Adult food through fine streaks of honey-water solution (1:1 v/v) in this case was provided to all the glass vials. All other procedures and observations adopted were similar to that of the first experiment.

In the third experiment, the effect of pupae size (female and male) of *C. auricilius* on the number of adult progeny and female ratio of *T. howardi* in ten replications was evaluated. The methodology was similar to the one used in the previous experiment. The data were analysed by Paired T-test.

RESULTS AND DISCUSSION

The survival of female was 10.5 and 6.0 days in fed and unfed condition, respectively (Table 1). The availability of honey-water solution as a food source increased the survival of *T. howardi* females. It was found that females fed on honey-water solution, survived longer (4 to 32 days) than those without feeding for 6 to 8 days (Puttarudriah and Sastry 1958; Jervis and Kidd 1993; Baitha and Sinha 2005). The female parasitoids with a short life expectancy invest more foraging time on each host encountered because of getting less opportunity in finding out other unexploited host during their life time (Roitberg *et al.* 1992).

Table 1 Effect of adult nutrition on biological attributes of *T. howardi*

Parameter	Mean ± SD	
	Fed	Unfed
Survival (days)	10.5 ± 1.26 a	6.0 ± 0.816 b
No. of adult emergence	69.80 ± 1.75 a	59.30 ± 2.49 b
Female emergence (%)	92.26 ± 1.148 a	85.39 ± 3.12 b

Means followed by different letters in a row are significantly (P<0.05) different by Paired T-test

The longevity of *T. howardi* under unfed condition was found to be affected more probably because of female's tendency to spend more energy in searching the hosts and in their egg laying which affects longevity. Female progeny (96.26%) was significantly more in fed than the unfed ones (85.39%). The parasitoid sex ratio left a major impact upon its population dynamics. Female biased ratio in fed condition is very relevant to their use as biological control agents, and can assist in improving mass rearing programme (Waage and Ming 1984). Nutrition is one of the important factors governing the success of mass production of parasites in the laboratory and also their performance in the field.

The number of progeny emerged from each *C. auricilius* pupa were 75.6 and 66.5 on laboratory reared and field collected pupae, respectively (Fig 1). A female parasitoid with a wide host range sometimes prefers the host species from which it has been reared (Jackson 1973; Oghushi 1960; Vinson 1976).

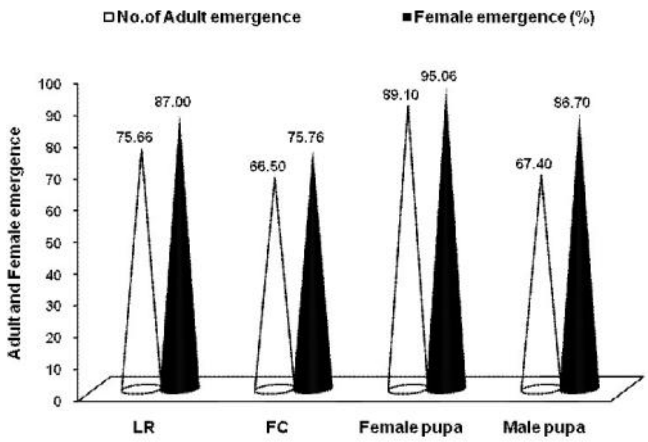

Fig 1 Response of laboratory reared vs. field collected and female vs. male pupa of *Chilo auricilius* on biological attributes of *Tetrastichus howardi*

The percentage female emergence on laboratory reared and field collected pupae were 87.00 and 75.74, respectively. The female biased sex ratio was found both in laboratory and field collected pupae. Males of *T. howardi* emerge first and stay close to the host pupa waiting the emergence of the females to mate (Gonzalez *et al.* 2003). Moore and Kfir (1995) observed that 35.3% of emerged females which were separated from males at emergence still produced both male and female offspring, indicating mating inside the host pupae before the female emerged. Preponderance of females over males in *T. howardi* was also observed (Cherian and Subramaniam 1940; Puttarudriah and Sastry 1958; Jalali and Singh 2001; Moore and Kfir 1995; Alvarez *et al.* 2005; Baitha *et al.* 2011; Cruz *et al.* 2011).

The number of progeny emerged from female *C. auricilius* pupa [18.2 ± 0.58 mm x 2.16 ± 0.03 mm] was more (89.10) than from male pupa [14.9 ± 0.19 mm x 1.87 ± 0.24 mm] (67.40) (Fig 1). The smaller host pupae gave rise to small number of parasitoids where as larger ones supported development of more parasitoids (Kfir 1993; Baitha and Sinha 2004). This may be attributed to the limitation of space and deficiency of food material in smaller pupa resulting in either lowering the fecundity of females or greater mortality among immature stages or both.

The female emergence (%) on female and male pupa was 95.06 and 86.70, respectively (Fig 1).The number and sex ratio of adult progeny emerging out of a host pupa depend on the size. Female biased sex ratio has been reported in *T. howardi* on other host pupae with high degree of inbreeding (Puttarudriah and Sastry 1958; Hamilton 1967). The large host size is more beneficial to the fitness of daughters than to sons and selection would then favour wasps to lay more daughters in large hosts and more sons in small hosts (Assem Van Den 1971). Host size effects are common in many wasp species (Clausen 1939). In general, large hosts are expected to be more advantageous in terms of offspring fitness than the small ones because of the former containing greater quantity of resources (Harvey *et al.* 2004).

In the light of the above findings, it can thus be concluded that the rearing system needs interventions to incorporate feeding for realization of their enhanced reproductive efforts. Laboratory reared large sized pupae yielding higher mean number of progenies (75-80) with 85-90% females proved suitable for mass rearing of *T. howardi* in the laboratory. It appears that *T. howardi* can reproduce at a higher rate than the host and can maintain numerically high number.

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