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Does adult nutrition affect parasitizing efficiency of *Tetrastichus howardi* (Eulophidae: Hymenoptera) on pupae of sugarcane stalk borer, *Chilo auricilius* Dudgeon?

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ABSTRACT: The parasitizing efficiency of *Tetrastichus howardi* (Olliff) (Eulophidae: Hymenoptera) was studied at 26 ± 2^{0}C and 65 ± 5% relative humidity in the laboratory on pupae of sugarcane stalk borer, *Chilo auricilius* Dudgeon (Crambidae: Lepidoptera) on different nutrients regimes. The number of progeny emerged from each pupa varied from 35.20 to 56.20 in different nutrition regimes. The provision of supplementary food (vit C) appeared to be an important factor for higher adult emergence. The percentage female emergence was maximum (90.66) in honey- water solution which is at par with vitamin E (87.88) and vitamin C (87.74) followed by solutions of stalk borer (85.48) and silkworm (82.24). The significantly higher percentage of female progeny was produced as compared to males in all nutrients tested. The availability of silkworm solution as a food source increased more male emergence (17.24) than other nutrients (10.34 to 14.52%). Providing the right nutrition from honey-water solution and vitamin C for *T.howardi* will enhance their biological activities during mass rearing and their efficiency throughout field release.

Key words: Pupa, parasitoid, biology, nutrient, sugarcane borer. *Stenobracon nicevillae*

Introduction

Bio-agents are important organisms in both natural and human-modified environments. They form important components of ecological food webs in the agro ecosystem, and in agriculture they can be

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used as bio-agents against a number of crop pests of economic importance. Adult female parasitoids have to decide how to allocate their time, mainly dedicated to host or food foraging, to minimize energy waste (Benelli *et al.,* 2017). Food foraging is usually mediated by the exploitation of visual and olfactory cues, which can cover innately attractive stimuli (Waeckers, 1994) as well as learned ones (Giunti *et al.*, 2015). Both play a important role in minimizing costs associated with food-searching activities and on adaptation to spatial and temporal variation of food availability (Giunti *et al.,* 2015). The food-foraging behaviour has a key role for biological control since nutrition affects the parasitoid reproductive attributes (Jervis and Kidd, 1986; Tena *et al.*, 2015).

Tetrastichus howardi (Hymenoptera: Eulophidae) is a gregarious pupal parasitoid with potential for use in bio-control of sugarcane borers (Cherian and Subramaniam, 1940; Alvarez *et al*., 2005; Sankar and Rao, 2016). The knowledge of biological attributes (sex ratio, reproductive potential, length of the life cycle, exposure periods and parasitoid sensitivity to abiotic factors i.e. temperature, light, and humidity) particularly on nutrition is of vital importance in the mass rearing of *T. howardi* on alternate hosts and developing strategies for their subsequent release in the field (Kfir, 1993; Favero *et al*., 2013; Kumar *et al*., 2018). Itdisplays adequate biological attributes when reared on the alternate hosts i.e., *Chilo partellus* (Swinhoe), *Sesamia inferens* Walker, *Scirpophaga excerptalis* (Walker), *Bombyx mori* F (Kumar, 2020).

The parasitizing efficiency of parasioid can be affected by the quality of the adult nutrition. They can rely on different hosts and non-host nutrient resources, such as sugar rich sources (floral nectar, honey dew and pollen) in the field as well as various artificial nutrients have been found to be a beneficial alternative food source for parasitoids in the laboratory (Zhang *et al*., 2004; Lee *et al*., 2006; Winkler *et al*., 2006; Tenna *et al.,* 2013; Kumar *et al*., 2016).

There is limited knowledge on host nutrients (stalk borer and silk worm as adult nutrition) as well as non-host nutrients (honey-water and vitamins) on biological attributes of *T. howardi*. Therefore, the present study was undertaken to evaluate the effect of feeding on these five nutrients on parasitising efficiency of *T.howardi*.

Materials & Methods

Sugarcane stalk borer, *Chilo auricilius* Dudgeon (Crambidae: Lepidoptera) is a specialized borer of sugarcane and it extensively damages the mature cane stalk. Thestalk borer pupae were used as host for evaluating the parasitising efficiency of *Tetrastichus howardi*. The pupae of stalk borer were collected after splitting the damaged shoots of sugarcane (collected from sugarcane fields at Research Farm, ICAR-IISR, Lucknow).Freshly formed pupa is thin, slender and yellowish-white or creamy yellow and as it matures the colour changes to light brown. The mulberry silk worm pupa was obtained from DSCL, Rupapur, Hardoi (U.P.).

The pupal parasitoid, *Tetrastichus howardi* was maintained on pupae of sugarcane stalk borer, *C.auricilius*. The pupae of stalk borer and mulberry silk worm were crushed and diluted with distilled waters separately as well as honey, vitamin E and vitamin C also diluted (1: 1 v/v). Newly emerged

mated females of *T. howardi* were kept singly in glass vials (15 x 2.5 cm). Each individual female parasitoid was provided with a pupa of stalk borer. The female was fed on solutions of Vit E (T_1); Vit C (T_2); Stalk borer (T_3); Mulberry silk worm (T_4) and Honey-water by making a fine streak on inner wall of glass vials and were plugged with cotton wool. The individual females were allowed 24h for parasitisation and then removed. The experiment was conducted at 26 ± 2^{0}C and 65 ± 5% relative humidity with five replications. The observations were taken after the emergence of parasitoid on the development period (egg to adult), the number of progeny emerged per pupa, female emergence and sex-ratio (M: F).The sex of adult parasitoids was determined by the morphological characters of their antennae and abdomen (LaSalle, 1994). The data (except sex ratio) were subjected to analysis of variance (ANOVA) at 5% probability.

Results and Discussion

The development period was observed as 17.2 and 18.4 days, respectively in honey- water and vitamin E solutions as compared to other nutrients (19.8 to 20.6 days) on *C.auricilius* (Table 1).The period of development of this parasitoid on different hosts is variable, but generally, the cycle lasts from 14 to 20 days (Puttarudriah and Sastry, 1958, Favero *et al*., 2013).

The number of progeny emerged from each pupa varied from 35.20 to 56.20 per pupa in different nutrients regimes (Table 1). Vitamin C supported maximum number ofprogeny followed by stalk borer solution. The provision of supplementary food (vit C) appeared to be an important factor for enhancing higher adult emergence. The nutrients necessary for parasitoid reproduction are partially acquired during the larval stages, and they may be allocated directly to egg production, but also stored as teneral reserves for adult maintenance and reproduction (Jervis *et al*., 2008).Nutrients stored in the fat body may subsequently be remobilized through metabolic costs, which are small in comparison to costs associated with egg resorption (Boggs, 1992). Overall, insects seem to use carbohydrates as their basic energy resource, while lipids function as long-term energy stores (Mondy *et al*., 2006).

Table 1.Effect of adult nutrition on the parasitizing efficiency of *T.howardi* on stalk borer pupa

Nutrition	Development period (days)	No of progeny/ pupa	Emergence (%)		Sex Ratio (M:F)
			Female	Male	
Vitamin E	18.40^a	40.0^b	87.9^b	12.12^a	1:7.80
Vitamin C	19.80^b	56.2^d	87.7^b	12.26^a	1:7.20
Stalk borer solution	20.60^b	45.4^c	85.5^a	14.52^a	1:5.80
Mulberry silk worm solution	20.20^b	35.2^a	82.2^a	17.24^b	1:5.40
Honey- water solution	17.20^a	40.8^b	90.7^b	10.34^a	1:9.80

The percentage female emergence was observed as maximum (90.66) in honey- water solution which is at par with vitamin E (87.88) and vitamin C (87.74) followed by solutions of stalk borer (85.48) and silkworm (82.24). The significantly higher percentage of female progeny was produced as compared to males in all nutrients tested. Commonly well fed female parasitoids alter the progeny sex ratio, producing a higher proportion of female offspring. The availability of silkworm solution as a food source increased more male emergence (17.24) than other nutrients (10.34 to 14.52%). The maximum sex ratio 1:9.80 (M:F) was observed in honey- water solution as compared to 1:7.80 in Vitamin C, 1:7.20 in Vitamin E, 1:5.80 in stalk borer solution and 1:5.40 in silkworm solution (Table 1). Host pupae (silk worm and stalk borer solutions) as food are reported detrimental to adult emergence but beneficial for male emergence compared to vit C and honey water solution.

The quality of the nutrition (as provided to adults) influenced the development, progeny and sex ratio of the parasitoid. Honey is well known for its high nutritional values containing amino acids, vitamins, minerals and others (Ajibola *et al*., 2012).Host pupae as food for parasitoids is essential to maximize female fecundity, but its contribution to reproduction varies from species to species.

Nutrition is the single most important factor influencing egg production and female fecundity; the amount of resources available to the female from her own larval and adult feeding largely determines her reproductive potential (Godfray, 1994; Quicke, 1997; Thompson, 1999; Papaj, 2000; Rivero *et al*. 2001). Chen (1962) reported that importance of arginine; cystine, tryptophan, tyrosine and phenyl alanine either for moulting differentiation, pupation or adult emergence and most of these were found to be present in favourable hosts. The differences in fecundity, sex ratio and development rate of parasitoids reared on different hosts were correlated with differences in the host's relative content of essential amino acids.

The present findings indicated that wasp nutrition could improve the parasitoid's quality attributes. Therefore, providing the right nutrition from honey- water solution and vitamin C for *T.howardi* will enhance their biological activities during mass rearing and their efficiency throughout field release. Further studies are required to ensure that other nutrients (sugar rich sources i.e., floral nectar and honey dew) available in natural field conditions that sustain their life and activity, are taken into consideration in formulating better conservation technology.

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