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Influence of Host Age on Development and Morphological Parameters of the Parasitoid *Nesolynx thymus* Girault (Hymenoptera: Eulophidae), An Ecto-Pupal Parasitoid of the Uzi Fly, *Exorista bombycis* (Louis) (Diptera: Tachinidae)

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The present investigation was conducted to know the effects of host age on development and morphological characteristics of *Nesolynx thymus*, a gregarious ecto-pupal parasitoid of the uzi fly, *Exorista bombycis*, a serious endo-larval parasitoid of the silkworm, *Bombyx mori* L. For experimentation, 3 – 11 day-old pupae of *E. bombycis* were exposed to 2 day-old adults of *N. thymus* at 25 ± 2°C and 60 ± 10% RH. A highly significant negative correlation between host age and the following development and morphological characteristics of the parasitoid was observed : number of pupae parasitised, total adult recovery, sex ratio and recovery, longevity, body length, wing span, abdomen length, and abdomen width of females. The findings of the present study clearly demonstrate that various development and morphological parameters of *N. thymus* are influenced by the age of *E. bombycis* pupae.

Key words: *Nesolynx thymus, Exorista bombycis*, Parasitoid, Development and Morphological characteristics, Host age

Introduction

Host suitability to insect parasitoids is governed by many factors such as age, size and nutritional quality of the host. A positive correlation between host size and parasitoid adult size in general was documented as early as 1940 by Salt. Subsequently, several workers have measured wing length and hind tibia length in *Trichogramma minutum* (Bourchier *et al.*, 1993), abdomen size in *T. minutum* (Greenberg *et al.*, 1998) and hind tibia length in *Psyttalia cosyrae* (Samira *et al.*, 2003) *vis-à-vis* host age and size which are used as indicators of parasitoid fitness. Depending on the parasitoid life histories, host factors influence the fitness of the developing parasitoids differently. In koinobionts (which allow the host to grow continuously after parasitism), host age at the time of oviposition has little effect on offspring size. Host age can have less effect on sex allocation in koinobionts than in idiobionts (which paralyze the host at the time of oviposition) because this parameter is less important to fitness of offspring of the female (King, 1987, 1989). Therefore, host age influences host preference in parasitoids through differential effects of host age on offspring fitness.

Perusal of literature reveals that parasitoid size is influenced by host size. However, the information on host age impact on parasitoid size is found wanting. The present investigation, therefore, is aimed at understanding the influence of host age on some development and morphological parameters of *Nesolynx thymus*, a gregarious ecto-pupal parasitoid of the tachinid (uzi) fly, *Exorista bombycis*, a serious endo-larval parasitoid of the silkworm, *Bombyx mori*, accounting for 10 – 20% damage to silkworm crops in the southern sericultural belt comprising Karnataka, Andhra Pradesh and Tamil Nadu in India. Insofar as our knowledge about the literature on the above aspects goes, this is the first comprehensive report on the influence of host age on certain development and morphological (fitness) characteristics of a parasitoid.

Materials and Methods

The host pupae (*E. bombycis*) were procured by allow-

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ing the post-parasitic maggots of *E. bombycis* collected from silkworm cocoon market to pupate at 25 ± 2°C and 60 ± 10% RH. The adults of *N. thymus* were obtained from the laboratory stock-cultures maintained on the pupae of *E. bombycis* as per the methods of Kumar *et al.* (1996).

In the experimentation, 3, 4, 5, 6, 7, 8, 9, 10 and 11 day-old pupae of *E. bombycis* were exposed to a pair of 2-day-old parasitoid adults (one each of male and female) in a test tube (12.5 × 1.5 cm) at a host - parasitoid ratio of 4 : 1. The parasitoid adults were fed with 50% aqueous honey solution and were allowed to parasitise the host pupae for a period of 3 days. Thereafter, they were separated from the host pupae and the latter were observed for recording/ calculating the number of pupae parasitised, development duration, adult recovery per pupa, sex ratio, female longevity and adult size (male and female).

The parasitoid adult female longevity was recorded by maintaining 10 replications, each with 10 adults that were fed with 50% aqueous honey solution. Observations on mortality of these adults were made at an interval of 24 hrs. To measure the adult size, 10 each of males and females were anaesthetized (using chloroform) and head width, body length and wing span for males and females and abdomen length and width for females were recorded.

Statistical analysis of the data was carried out employing Analysis of Variance (ANOVA) followed by Duncan Multiple Range Test (DMRT) for the test of significance. Karl Pearson's Correlation Co-efficients were also estimated to know the correlation between host age and development and morphological characteristics of *N. thymus* (Gomez and Gomez, 1984).

Results

The results are presented in Figs. 1 and 2. The details of statistical analysis of the results are furnished in Table 1.

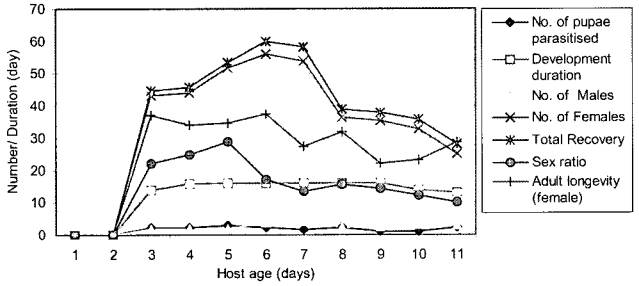

Fig. 1. Influence of host age on development parameters of *N. thymus*.

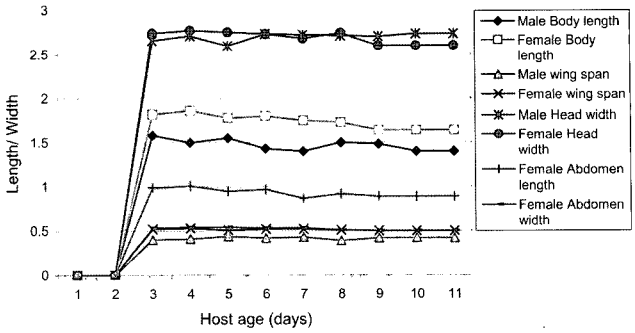

Fig. 2. Influence of host age on morphological parameters of *N. thymus*.

Table 1. Details of ANOVA and correlation analysis

Parameters	Correlation Coefficient	F- value for ANOVA
Development duration	0.15 NS	44.812**
Number of pupae parasitised	-0.350**	6.788**
Number of male	0.216NS	2.819**
Number of female	-0.396**	4.677**
Total	-0.351**	4.310**
Sex ratio	-0.587**	8.145**
Adult longevity (female)	-0.645**	10.250**
Male body length	-0.217NS	1.919**
Male wing span	0.274*	3.858**
Male head width	0.036 NS	1.387**
Female body length	-0.654**	14.238**
Female wing span	-0.437**	4.641**
Female head width	-0.035 NS	1.272**
Female abdomen length	-0.578**	7.711**
Female abdomen width	-0.332**	3.241**

** - Significant at 1% level ($P < 0.01$).
* - Significant at 5% level ($P < 0.05$).
NS - Non-significant.

Development duration

The adults of *N. thymus* parasitised 3-11 day-old pupae of *E. bombycis*. The mean development duration of the parasitoid ranged from 13 days (11 day-old pupae) to 16.1 days (6 day-old pupae). It was significantly ($P < 0.01$) longer for the parasitoid developing in 4 (15.89 ± 0.11 days) – 9 (16 days) day-old pupae when compared with 3 (14 days), 10 (14 ± 0.44 days) and 11 day-old treatments.

Number of pupae parasitised

The number of pupae parasitised by each of *N. thymus* adults ranged from 1.63 (7 day-old pupae) to 3.00 (5 day-old pupae). It was significantly higher ($P < 0.01$) in all but 7 (1.63), 9 (1.67) and 10 (1.67) day-old pupae. Correlation

analysis of the results revealed a highly significant negative correlation (–0.350).

Parasitoid recovery per pupa

The recovery of *N. thymus* adults per pupa was the lowest (28.09 ± 3.0) in 11 day-old pupae and the highest (59.85 ± 6.07) in 6 day-old pupae. Comparison of mean values showed significantly higher ($P < 0.01$) recovery when 6 and 7 day-old pupae were provided as opposed to 3, 4, 5, 8, 9, 10 and 11 day-old pupae.

With reference to sex-wise recovery, emergence of males progressively increased from 3 day-old pupae (2.03 ± 0.26) to a significant level in 7 day-old pupae (4.31 ± 0.64). Barring 7 day-old treatment, variations noticed for this parameter in all other treatments were not significant. Parasitoid female emergence too steadily increased from 3 (43.19 ± 4.39) up to 6 day-old (56.01 ± 5.57) pupae and the recovery in the latter and 7 day-old (54 ± 6.49) treatments was significantly ($P < 0.01$) higher than that in 8, 9, 10 and 11 day-old pupae with comparable values. A highly significant negative correlation for total (–0.351) and female (–0.396) parasitoid recovery was observed.

Sex ratio

The sex ratio (M: F) of *N. thymus* was the highest in 5 day-old pupae (1:28.83 ± 3.42) and the lowest in 11 day-old pupae (1: 10.04 ± 1.52) with values at 3, 4 and 5 day-old treatments being significantly higher. The parameter showed a highly significant negative correlation (–0.587).

Female longevity

N. thymus female longevity was significantly higher when it developed in 3 (37 ± 2.58 days), 4 (34 ± 2.72 days), 5 (34.7 ± 2.21 days) and 6 (37.5 ± 2.02 days) day-old pupae as compared to other treatments (except in 8 day-old treatment with 31.9 ± 1.07 days) where the values ranged from 22 ± 1.07 days (9 day-old) to 28.6 ± 0.81 days (11 day-old). A highly significant negative correlation (–0.645) was observed for this trait.

Parasitoid adult size

Body length: The body length of the emerging *N. thymus* adults ranged from 1.40 ± 0.01 mm (7, 10 and 11 day-old pupae) to 1.57 ± 0.05 mm (3 day-old pupae) in males and from 1.64 ± 0.01 mm (9, 10 and 11 day-old pupae) to 1.86 ± 0.01 mm (4 day-old pupae) in females. In both the sexes, it decreased with increase in age of pupae and the decrease was more consistent in females than males. While comparison of majority of mean values for females exhibited a highly significant variation.

Head width: The head width of *N. thymus* males varying from 0.39 ± 0.01 mm (8 day-old pupae) to 0.44 ± 0.01 mm (5 day-old pupae) and that of females fluctuating from 0.50 ± 0.01 mm (9, 10 and 11 day-old pupae) to 0.53mm (4 day-old pupae) revealed no significant difference.

Wing span: Except recording a significantly lower male wing span of 2.6 ± 0.04 mm (5 day-old pupae), the values in other treatments (2.66 ± 0.04 mm in 3 day-old –2.73 ± 0.01 mm in 6,10 and 11 day-old pupae) and those for females from 5-8 day-old pupae (2.68 ± 0.01 mm –2.77 ± 0.01 mm) were comparable. The parameter decreased significantly from 9 day-old treatment onwards for females.

Abdomen length and width: Abdomen length (L) and width (W) of *N. thymus* females decreased significantly when emerged from 9, 10 and 11 day-old pupae with an abdominal length of 0.89 ± 0.01 mm and a width of 0.49 ± 0.01 mm. However, the values in 3 (0.99 ± 0.01 mm L × 0.53 mm W) and 8 day -old (0.92 ± 0.01 mm L and 0.51 mm W) pupae exhibited greater similarity.

Among the parameters related to parasitoid size, body length, abdomen length, abdomen width and wing span of females exhibited a highly significant negative correlation, while male wing span revealed a significant positive correlation.

Discussion

Various development as well as morphological parameters of the parasitoid are reported to be influenced by a host of factors that chiefly include age, size and quality of host, age and size of parasitoid, etc. However, the investigations on these aspects employing ecto-pupal parasitoids are highly scanty and restricted to only *Nasonia vitripennis*. Hence, it would be worthwhile to extend such investigations to more and more ecto-pupal parasitoids that hold considerable promise in the biocontrol programme of pest insects.

In the present investigation too, the age of the host (*E. bombycis*) significantly influenced various biological parameters of the parasitoid (*N. thymus*) *viz.*, development duration, number of pupae parasitised, adult recovery (male and female), sex ratio (M: F), adult longevity (female) and adult size (male and female).

The distinct preference of the parasitoid for parasitising younger pupae (up to 6 days) could be explained based on the fact that the host nutrients were in easily usable form in these pupae compared to the older ones, as also attributed for *C. turionellae* (Sandlan, 1982) and *Galleria mellonella* (Ueno, 1997), thereby demonstrating the parasitoid's preference for the host age.

At 25 ± 2°C and 70 ± 10% RH, the development duration of *N. thymus* is reported to be 15 – 17 days. In the present investigation too, in majority of the treatments (4 – 9 day-old pupae), this parameter fell within the range indicated above. Though the parasitoid development duration reduced significantly in 3 day-old pupae, there was a definite trend for this duration reducing significantly in older pupae, especially those which were very close to adult eclosion (10 and 11 day-old) which usually takes place on 12^{th} or 13^{th} day, thus showing a significant negative correlation. The reasons for such a declining trend in parasitoid development duration, when older pupae were provided, might be due to reduced availability of food resources (energy) in usable form for the parasitoid, utilization of host food resources for host's own development and change in the nutritional composition of the host as stated by Sandlan (1982).

The positive correlation in the recovery of adult males with respect to age of the host might be a strategy employed by the ovipositing female to obviate the reduced host food resources in the older pupae as the development of males, unlike females, does not require increased supply of food resources (Visser and Alphen, 1987; Ueno, 1997).

A significantly higher negative correlation in sex ratio (M: F) (–0.587) *vis-à-vis* age of the host led to narrowing down of sex ratio of the parasitoid in older pupae as also reported by Islam (1995) and Ueno (1997). However, our findings differed from those of Wang *et al.* (1999) and Nakamura and Noda (2002) who reported that age of the host does not have significant influence on the sex ratio of the parasitoids.

Insofar as the impact of host age on various morphological characteristics was concerned, the decrease in female body size with increase in host age is obviously a reflection of decreased host food resources which might have happened due to utilization of food resources for development of host itself and exploitation of some part of the host resources by the developing parasitoid males, especially in older hosts.

Wylie (1963) reported a negative correlation between host age and parasitoid size in *N. vitripennis,* while Puttler (1961), Smilowitz and Iwantsch (1973) and Campbell and Duffy (1979) observed a positive correlation. The results of the present investigation with females agreed with those of Wylie (1963) and differed from the observations of Puttler (1961), Smilowitz and Iwantsch (1973) and Campbell and Duffy (1979). The reasons for positive correlation with male wing span remain obscure and no supportive evidences are available.

The findings of the present study clearly demonstrate that various development and morphological parameters of *N. thymus* are influenced by the age of *E. bombycis* pupae and provide appreciable biological information at a time when there is dearth in the literature on these aspects, especially with ecto-pupal parasitoids.

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