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INFLUENCE OF HOST SIZE ON THE REPRODUCTIVE PERFORMANCE AND BIOMETRICAL CHARACTERS OF *NESOLYNX THYMUS* (GIRAULT) (HYMENOPTERA: EULOPHIDAE) AN ECTO-PUPAL PARASITOID OF UZI FLY, *EXORISTA BOMBYCIS* (LOUIS) (DIPTERA: TACHINIDAE)

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Abstract

Nesolynx thymus is an indigenous, gregarious, ecto-pupal parasitoid of the tachinid fly, *Exorista bombycis* (Louis) which is a serious pest of mulberry silkworm (*Bombyx mori* L.) and causes 10 – 20% reduction in cocoon yield. In the present investigation, 2-day-old mated females of the parasitoid were allowed to parasitize 2-day-old big and small pupae of *E. bombycis* for 2 days at a parasitoid host ratio of 1:5 at 25±5°C and 65-70%RH. The parameters like percent parasitization, developmental duration, brood allocation, progeny production, sex ratio and progeny female longevity were recorded and all the parameters showed significantly higher performance in the first generation when big pupae were offered for parasitization compared to small pupae. Similarly, the parasitoid biometrical characteristics such as body length, head width, and wingspan of male and female and abdomen width and length of female were significantly higher in the parasitoids that emerged from big pupae. Also, in the first generation parasitoid females emerging from big pupae, the female brood allocation, total brood allocation, female progeny production and total progeny production were recorded to be significantly higher. The results clearly demonstrated that, the size of the host has an influence on the progeny production in *N. thymus*.

Key words: Biometric characters, *Exorista bombycis*, host size, *Nesolynx thymus*, progeny production.

INTRODUCTION

Among the host-related factors, host size (host biomass) is one of the most important factors that a female parasitoid relies upon for oviposition/breeding. However, in a few cases, the presence of the host itself forms the major stimulus for oviposition. Irrespective of whether the host is a natural or a factitious one, the female parasitoid first analyses the size of the host (host resources) before adjusting the egg load (clutch size), with more eggs being laid in larger hosts than in smaller ones (Charnov *et al.*, 1981; Askew and Shaw, 1986; Jenner and Kuhlmann, 2006). Hence, the mechanism of estimating host size (resources) before allocating the progeny is realized to be a strategy to avoid competition among the developing individuals (Narendra Kumar, 2019). Such a behavior of the parasitoid female ensures acquisition of fitness traits in the progeny individuals. Fitness chiefly refers to the body size with which the desirable attributes such as, longevity (Hohmann *et al.*, 1988; Visser, 1994; Doyon and Boivin, 2005), dispersal and host searching ability (Visser, 1994), fecundity (Hohmann *et al.*, 1988; Visser, 1994; Doyon and Boivin, 2005), and parasitization potential (Sandlan, 1982) are associated. Therefore, fitness of a parasitoid is considered to be an important factor in the success of a biocontrol programme.

Nesolynx thymus is one among twenty hymenopteran parasitoids that have been reported to parasitize the tachinid fly, *Exorista bombycis* (Louis), popularly known as uzi fly in India (Narayanaswamy and Devaiah, 1998). In turn, *E. bombycis* is known to be a larval endo-parasitoid of the silkworm, *Bombyx mori* (L.) and causes a cocoon yield reduction of 10-20% in the premier silk producing states in India namely, Karnataka, Andhra Pradesh and Tamil Nadu (Kumar *et al.*, 1993; Manjunath, 2004). Preliminary studies have indicated that *Nesolynx thymus* possesses immense potential to parasitize the pupae of *E. bombycis*.

In the context of the above, the present investigation was undertaken to record the effect of host size (*E. bombycis*) on the reproductive performance of the parasitoid (*Nesolynx thymus*). An effort was also made to record the performance of first generation adults of the parasitoid to understand whether or not host size in parent generation had any influence on the parasitoid development.

METERIALS AND METHODS

To study the impact of host size on the reproductive performance of the parasitoid, 2 day-old host pupae were categorized into big and small based on their size (1.2 cm as big host and 0.8 cm as small host) and provided with 2 day-old *N. thymus* for parasitization at parasitoid host ratio of 1: 5 at room temperature for 2 days in glass vials (size 10x 2.5 cm). The ovipositing females were fed with 50% honey. Each treatment comprised 5 replications. Observations were recorded on per cent parasitization, developmental duration, progeny production, sex ratio, adult size and adult longevity at room temperature.

The longevity of *N. thymus* was studied by recording their survivability on daily basis by providing 50% honey, till mortality. With respect to biometrical parameters, five traits namely body length, wing span, head width of male & female, length and width of abdomen of the female were measured using ocular microscope at 18X. The parasitoid adults were anaesthetized using chloroform before recording biometric observations.

In order to understand whether the host size had any impact on the progeny of parent parasitoid, the first generation parasitoid females emerging from big and small pupae were allowed to oviposit in randomly selected pupae (of almost uniform size) of *E. bombycis* (1:5 Parasitoid : Host). Observations pertaining to all the developmental parameters were recorded. The data were analyzed statistically employing one-way ANOVA followed by DMRT using SPSS package (version 21) for testing the level of significance.

RESULTS

Reproductive performance of *Nesolynx thymus* on big and small pupae of *Exorista bombycis.*

The results pertaining to the reproductive performance of *Nesolynx thymus* on big and small pupae of *Exorista bombycis* are depicted at Table 1 and briefed below:

Per cent parasitization: Up on exposing big and small host pupae of *E. bombycis* independently to the female parasitoid, *N. thymus*, the per cent parasitization was recorded to be 92.00±4.90 and 88.00±4.90 respectively. However, the results showed non significant difference among the treatments.

Developmental duration: The duration for completion of life cycle by the parasitoid prolonged significantly ($P \leq 0.05$) when the parasitoid developed on big pupa (17.60±0.25 days) compared to small pupa (16.60±0.25 days).

Brood allocation

The results for the parasitoid male progeny allocated to each of big and small host pupae were 3.29±0.45 and 2.24±0.31 respectively and their variation was non significant among the treatments. However, the allocation of female progeny among the treatments was significantly higher ($P \leq 0.01$) when big pupa (57.10±3.79) was provided compared to small one (39.07±1.51). Further, the total progeny allocated to big host pupa (60.39±4.14) was significantly greater ($P \leq 0.01$) than that allocated to small pupa (41.31±1.48).

Progeny production

The parasitoid male progeny production was significantly higher ($P \leq 0.05$) when the parasitoid was exposed to big host pupa (14.80±1.39) compared to small one (9.60±0.93). The female progeny production was significantly high ($P \leq 0.01$) following the parasitoid exposure to big pupa (261.00±16.08) as against small pupa (171.60±10.20). Similarly, the total progeny was also significantly high ($P \leq 0.01$) on big pupa (275.80±16.49) compared to small pupa (181.20±9.43).

Sex ratio: The sex ratio of *N. thymus* in the progeny was non significant between the treatments involving big (1:18.11±1.76) and small (1:18.78±2.47) host pupae.

Female longevity: The parasitoid females that emerged from big pupae of *E. bombycis* (27.10±0.30 days) lived significantly longer ($P \leq 0.05$) than those developed in small pupae (24.58±0.87).

Effect of host size (*Exorista bombycis*) in parent generation on the biometrical traits of *Nesolynx thymus* progeny

The results with regard to the Effect of host size in parent generation on the biometrical traits of *Nesolynx thymus* progeny are depicted at Table 2 and briefed below:

Body length: The body length of the male parasitoids was significantly higher (P≤0.01) when they developed on big pupa (1.824±0.027 mm) compared to those developed in small pupa (1.632±0.020 mm). Similarly the body length of the females also showed highly significant difference when developed in big pupa (2.298±0.031mm) compared to small (1.998±0.018).

Head width: The parasitoid males developed in big and small pupa of *E. bombycis* had a head width of 0.528±0.008 mm and 0.468±0.012 mm respectively, revealing significantly greater difference (P≤0.01). Similarly, the head width of the parasitoid females developed on big (0.618±0.009) and small (0.564±0.010) pupae were also significant with each other (P≤0.01).

Wingspan: The wingspan of *N. thymus* male developed from big and small host pupa was recorded to be 3.216±0.029 mm and 3.006±0.034 mm respectively, and found to be significant among the treatments (P≤0.05). Similarly, wingspan of *N. thymus* female developed from big and small host pupa was recorded to be 3.522±0.018 mm and 3.246±0.023 mm respectively. However, the parasitoid female wingspan was significantly greater (P≤0.01) for the parasitoid females emerging from big and small pupae compared to males.

Female abdomen size: The abdomen length of the parasitoid female was significantly higher (P≤0.01) when they developed on big host (1.104±0.020) compared to small host (0.888±0.025 mm). Similarly, the abdomen width of the parasitoid showed significantly higher (P≤0.01) variation for the parasitoid females recovered from big host (0.720±0.013 mm) compared to that of small host (0.618±0.009 mm).

Impact of host size (*Exorista bombycis*) in parent generation on the reproductive performance of progeny females of *Nesolynx thymus*.

The results of the experiment on the impact of host size in parent generation on the reproductive performance of progeny females of *Nesolynx thymus* are depicted at Table 3 and briefed below:

Per cent parasitization: The percent parasitization by first generation parasitoid females (*N. thymus*) developed on big and small pupae of *E. bombycis* was recorded to be 92.00±4.90 and 88.00±4.90 respectively, without any significant difference among the treatments.

Developmental duration: No significant variation in the developmental duration of the parasitoid was observed when the parasitoid females emerging from host pupae of either sizes parasitized randomly selected pupae of *E. bombycis*. The values for the parameter in respect of the parasitoid emerging from big and small host pupae were 17.00±0.32 and 16.40±0.25 days, respectively.

Brood allocation: The results for the parasitoid male progeny ranged between 3.14±0.33 (big) and 2.50±0.21 (small) among the treatments which showed no significant variation. However, the recovery of female progeny of *N. thymus* from big and small host pupa was 55.21±3.13 and 36.87±2.84 respectively. Thus, the results for female progeny from big and small host pupae showed significantly higher (P≤0.01) variation among the treatments. In addition, the total brood allocation also showed significantly higher (P≤0.01) values for the parasitoids emerging from big host (58.35±3.24) compared to small host (39.37±2.88).

Progeny production: No variation among the mean values for *N. thymus* male progeny production was realized with the results between 13.60±1.16 (big) and 11.40±0.87 (small). However, the number of parasitoid female progeny produced was significantly higher (P≤0.01) in big pupa (240.80±9.81) compared to small host pupa (167.80±9.03). Also, the total parasitoid progeny production ranged between 254.40±9.54 (big host) and 179.20±9.01 (small host) and revealed a significantly higher variation (P≤0.01) among the treatments.

Sex ratio: With respect to sex ratio, the results indicated the values ranging between 1: 18.37±2.06 (big host) and 1:15.09±1.46 (small host) thereby indicating no significant difference among the treatments.

DISCUSSION

Parasitoids are known to exhibit a great deal of variation in their reproductive strategies depending on host and parasitoid related factors as well as environment associated factors. Many parasitoids prefer to attack only when hosts of certain age or size are available, although in most cases, their progeny can develop in all host (larval/pupal) ages and sizes (Nakamatsu and Tanaka, 2004; Li *et al.*, 2006; Aruna and Manjunath, 2006; Veena and Manjunath, 2007 a, b; Gangadhar and Manjunath, 2009, 2010; Naveed *et al.*, 2014; Broski and King, 2016; Li *et al.*, 2017, Narendra Kumar and Manjunath, 2018).

Many studies have been conducted to determine the impact of host size on the reproductive performance, fecundity, longevity and vigour of the parasitoids. Aruna and Manjunath (2010) in their study with *Nesolynx thymus* on *Musca domestica* revealed that reproductive parameters of females and total progeny production per female, sex ratio, and longevity increased significantly with host size. Besides, studies conducted by Senthoorraju *et al.*, (2020) and Qadir *et al.*, (2024) also proved that host size had significant effect on percent parasitization. In the study conducted by Narendra Kumar and Manjunath (2018) on *Trichomalopsis uziae*, when bigger and smaller host pupae were provided for parasitism, no significant variation in per cent parasitism, developmental duration, male progeny production, and longevity of female progeny was observed. However, the parameters such as female progenies, total progenies as also sex ratio were significantly higher when bigger host pupae were parasitized.

Host size also influences the sex ratio of parasitoids, such that a female biased sex ratio is produced on large hosts and male-biased sex ratio on small hosts which has been demonstrated in *Hyssopus thymus* Girault (Purrington and Uleman, 1972), *Ephedrus cerasicola* Stray (Hagvar and Hofsvang, 1986), *Cotesia flavipes* Ameron (Omwega and Overholt, 1997), *Pimpla parnorae* (Ueno, 1999), *Nesolynx thymus* (Aruna, 2007), *Trichopria sp*. (Veena, 2008), *Tetrastichus howardi* (Gangadhar, 2009) and *Trichomalopsis uziae* (Narendra Kumar (2019).

In the present study, the parameters like developmental duration, female & total brood allocation, progeny production and progeny female longevity showed significantly higher performance in the first generation females when big pupae were offered for parasitization. However, parameters such as per cent parasitization, male brood allocation and sex ratio showed non significant variation among the treatments.

The parent generation biometric parameters such as body length, wing span of males & females, head width of males, abdomen length of females increased significantly with the host size in the studies conducted by above authors. In the present study also, the parasitoid biometrical characteristics such as body length, head width, and wingspan of male and female and abdomen width and length of female were significantly higher when the parasitoid emerged from big pupae.

Further, with respect to performance of first generation adults, no impact of host size was observed in several studies involving various parasitoids (Aruna and Manjunath, 2010; Veena and Manjunath 2007a; Narendra Kumar and Manjunath, 2018). However, in the present study, the first generation adults emerging from big hosts showed significantly higher values for parameters such as female & total brood allocation, female & total progeny production. Whereas, per cent parasitization, developmental duration, male brood allocation, male progeny production and sex ratio were found to be non-significant between the females emerging from big and small hosts.

CONCLUSION

In the current investigation it was observed that the parasitoid *Nesolynx thymus* parasitized both big and small host pupae without any significant difference, however female & total brood allocation, progeny production, female longevity, and developmental duration were significantly higher in big sized hosts compared to small. Sex ratio was found to be non-significant between big and small hosts.

All the biometric traits studied for the progeny from parent generation such as body length, head width, wing span of both sexes and female abdomen size (length and width) were found to be on higher side for the progeny emerged from bigger host pupa compared to small host pupa.

With regard to reproductive performance of progeny females of parasitoids (F1 progeny), there was no significant difference in per cent parasitization, developmental duration, male brood allocation, male progeny production and sex ratio between parasitoids emerged from big and small hosts. However, for parameters such as female and total brood allocation, female and total progeny production the results were very much significant for the progeny obtained from big and small pupae. Hence it may be concluded that the parasitoid has preferred bigger host pupa over small pupa for its reproduction by way of allocating maximum brood and producing more progeny.

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Table-1: Reproductive performance of *Nesolynx thymus* on big and small pupae of *Exorista bombycis.*

Values given in the Table are the mean of 5 replications (Mean ± SE);
Mean values followed by the same superscript in columns are statistically not significant;
@ - Out of 5 pupae provided for parasitization;

Host size	Per cent parasitization@	Developmental duration (days)	Brood allocation (No.)			Progeny production (No.)			Sex ratio (M:F)	Progeny female longevity (days)
			Male	Female	Total	Male	Female	Total		
Big	92.00±4.90	17.60±0.25	3.29±0.45	57.10±3.80	60.39±4.14	14.80±1.39	261.00±16.08	275.80±16.49	1:18.11±1.76	27.10±0.30
Small	88.00±4.90	16.60±0.25	2.24±0.31	39.07±1.51	41.31±1.48	9.60±0.93	171.60±10.20	181.20±9.43	1:18.78±2.47	24.58±0.87
F value	0.333 NS	8.333 *	3.707 NS	19.471 **	18.803 **	9.657 *	22.038 **	24.805 **	0.049 NS	7.547 *

** - Significant at 1 %; * - Significant at 5%;
NS – Nonsignificant;

Table- 2: Effect of host size (*Exorista bombycis*) in parent generation on the biometrical traits of *Nesolynx thymus* progeny.

Host size in parent generation	Body length (mm)		Head width (mm)		Wingspan (mm)		Female abdomen Size (mm)	
	Male	Female	Male	Female	Male	Female	Length	Width
Big	1.824±0.027	2.298±0.031	0.528±0.008	0.618±0.009	3.216±0.029	3.522±0.018	1.104±0.020	0.720±0.013
Small	1.632±0.020	1.998±0.018	0.468±0.012	0.564±0.010	3.006±0.034	3.246±0.023	0.888±0.025	0.618±0.009
F value	32.914 **	69.876 **	17.308 **	16.200 **	22.363 **	90.686 **	44.862 **	42.639 **

Values given in the Table are the mean of 10 replications (Mean ± SE);
Mean values followed by the same superscript in columns are statistically not significant;
** - Significant at 1 %;

Table-3: Impact of host size (*Exorista bombycis*) in parent generation on the reproductive performance of progeny females of *Nesolynx thymus*.

Values given in the Table are the mean of 5 replications (Mean ± SE);
Mean values followed by the same superscript in columns are statistically not significant;
@ - Out of 5 pupae *Exorista bombycis* were provided for parasitization;

Host size in parent generation	Per cent parasitization@	Developmental duration (days)	Brood allocation (No.)			Progeny production (No.)			Sex ratio (M:F)
			Male	Female	Total	Male	Female	Total	
Big	92.00±4.90	17.00±0.32	3.14±0.33	55.21±3.13	58.35±3.24	13.60±1.17	240.80±9.81	254.40±9.54	1:18.37±2.06
Small	88.00±4.90	16.40±0.25	2.50±0.21	36.87±2.84	39.37±2.88	11.40±0.87	167.80±9.03	179.20±9.01	1:15.09±1.46
F value	0.333 NS	2.250 NS	2.702 NS	18.794 **	19.137 **	2.283 NS	29.992 **	32.840 **	1.693 NS

** - Significant at 1 %; NS – Nonsignificant;