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EGG LAYING PATTERNS OF THE UZI FLY, *EXORISTA SORBILLANS* (WIEDEMANN) ON THE LARVAE OF THE SILKWORM, *BOMBYX MORI* L.

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ABSTRACT
Knowledge on the egg laying patterns of the uzi fly, *Exorista sorbillans* (Wiedemann) on the larvae of the silkworm, *Bombyx mori* L. forms important base for silkworm cocoon crop protection strategies. Experiments were conducted to study the egg laying patterns, considering five important parameters, of uzi fly on the mulberry silkworm larvae *viz*., a. quantum of eggs laid by an individual uzi fly, b. egg laying span, in days of uzi fly, c. preference of silkworm larval instars for uzi fly egg laying, d. preference of silkworm larval body surface for uzi fly for egg laying and e. number of eggs laid by uzi fly on individual silkworm larva. Results indicated that the uzi fly, *Exorista sorbillans* lays up to 800 number of eggs, in a span of 10 days following the parabolic type of distribution, preferring later (fourth and fifth) instar silkworm larvae, again preferring dorsal surface of intersegmental region of the silkworm larva and lays one egg on one individual silkworm larva.

KEY WORDS: Uzi fly, *Exorista sorbillans*, egg laying patterns, silkworm, *Bombyx mori*.

INTRODUCTION

Silkworm rearing in India has long history. Sericulture, an agro-based industry is supporting many farmers in India in general and in South India in particular. The industry flourished well up to 1980. However there was a threat from the diseases alone causing a moderate to complete cocoon crop loss. Further, a new threat was encountered during 1980 in the form of a pest which was later recognized as uzi fly (Anonymous, 1980). Since then, uzi fly has remained a major silkworm pest (Narayanaswamy *et al*., 1994a). Uzi fly, *Exorista sorbillans* is an endo-larval parasitoid on silkworm, *Bombyx mori* L. (Narayanaswamy *et al*., 1994a) causing considerable damage to silkworm rearing in several silk producing countries including India. In spite of adopting several control measures, uzi infestation recorded a loss of 20-30 % cocoon production. Since its appearance in Karnataka (Anonymous, 1980), the pest remained as a major threat to the silkworm. The fly was first recorded in Bailanarasapura village of Hosakote Taluk of Bangalore District, Karnataka during May, 1980. Prior to this, it was confined to the North-Eastern sericultural regions of India, especially Bengal and Assam. The pest was introduced through Nistari seed cocoons brought from West Bengal by unscrupulous seed preparers (Mahadevappa, 1992). The first survey by Jolly (1987) revealed the pest spread to nearly 170 villages, covering 400 km and 4000 sericulture farmers in the traditional sericulture areas of Karnataka. Attracted by its economic importance, various researchers published on different aspects of uzi fly including integrated pest management. Works on uzi fly include its fertility, fecundity, induction of sterility and control measures (Isarangkul and Scinchaisri, 1971; Sriharan *et al*., 1971; Datta and Mukherjee, 1978; Kumar *et al*., 1985; Jolly *et al*., 1991). Available literature says that female of *E. sorbillans* laid eggs on silkworm that hatched in 2 to 3 days; the hatched out uzi larvae penetrates into its host (silkworm larva), and come out by killing the host within 6 to 8 days (Narayaswamy *et al*., 1994a). They (Narayaswamy *et al*., 1994a) reported pupal period to be 10 to 12 days and the total developmental period from 17 to 22 days (Sriharan *et al*., 1971; Datta and Mukharji, 1978). Uzi fly prefers to deposit eggs on older silkworm larvae (late age), particularly the fourth and fifth instar silkworm (Siddappaji, 1985). The fly travels for more than 2.5 km in search of host (Narayanaswamy *et al*., 1994b).

A single mated female can lay eggs about 300 to 1000 depending upon season (Sengupta *et al.*, 1990; Chamundeswari, 1994), for a period of 9 to 25 days (Sengupta *et al.*, 1990), the fertilized eggs are laid throughout the life span of female (Sengupta *et al.*, 1990), uzi fly can lay its eggs on all the silkworm instar larvae, but prefers fourth and fifth instar silkworm larvae (Sengupta *et al.*, 1990; Siddappaji, 1985; Chamundeswari, 1994). Sengupta *et al.* (1990) have given general and important, but incomplete aspects of uzi fly egg laying patterns. Thus, important aspect of egg laying patterns of the uzi fly *Exorista sorbillans* on the silkworm *Bombyx mori* are dealt with in the present communication.

MATERIALS & METHODS

DFLs (disease free layings) of popular multivoltine x bivoltine silkworm hybrid, PM x CSR_2 of the mulberry silkworm, *Bombyx mori* were procured from the Silkworm Seed Production Centre (SSPC), National Silkworm Seed Organization (NSSO), Central Silk Board (CSB), Hindupur, Anantapur District, Andhra Pradesh, India and reared according to Krishnaswami (1986). Hatched out

larvae from DFLs, collected into pre-disinfected rearing trays were fed daily four times (06.00, 10.00, 16.00 and 22.00 h) on fresh mulberry (*Morus* sp. V1 variety) at a temperature of 25 ± 1 °C, and relative humidity (RH) of 80 ± 5%. The silkworm larvae, at different instars, were used for uzi fly egg laying studies.

Fresh maggots of the uzi fly, *Exorista sorbillans* were collected from the Government Cocoon Market, Department of Sericulture, Hindupur, Anantapur District, Andhra Pradesh, India and allowed to pupate in dark by keeping the maggots in an enamel tray (6" x 9") covered with black paper. After 5-6 days, the trays were transferred to the wire mesh cages of 24" x 24" x 24" dimension. The emerged uzi flies were fed with sugar cubes and 10% glucose solution soaked in cotton (Sriharan *et al*., 1980). The flies were allowed to mate feely for 24 hours and the gravid females were separated and kept in different cages for further use for egg laying patterns on silkworm larvae.

Fifth instar fifth day silkworm larvae were utilized for the purpose. Five hundred number of larvae were taken in a plastic rearing tray (2' x 3'), kept in an appropriate sized wire meshed cage in order to avoid the escape of introduced uzi fly and also to restrict the entry of other uzi fly(ies). One number of gravid uzi fly was introduced at 06.00 h, allowed to lay eggs on the silkworm up to 06.00 h next day. The silkworm larvae, along with the tray were removed from the cage and introduced a fresh rearing tray with 500 fresh silkworm larvae (fifth age fifth day) for furthering the studies on quantum and span of egg laying of uzi fly. The process was repeated till the uzi fly exhausted its egg laying. The silkworm larvae were scanned under magnifying lens and counted for a) total number of uzi eggs laid on the entire 500 number of silkworm, b) number of uzi fly eggs per individual silkworm larva and c) quantum of uzi fly eggs on different body surface areas of silkworm larva. The data thus recorded were used for calculating a) total number and b) span of eggs laying by an individual uzi fly, c) number of uzi fly eggs on different surfaces (intersegmental, intrasegmental, ventral) of silkworm larval body and d) number of uzi fly eggs on silkworm larva.

Similarly, 500 number of silkworm larvae of different instars (1^{st} to 5^{th}) were separately taken into plastic rearing trays of 2' x 3' dimension kept in a wire meshed cages. One number of 5 days old uzi fly was introduced at 06.00 h. The uzi fly was allowed to lay eggs on the silkworm larvae up to 06.00 h next day. The silkworm larvae, along with the tray were removed from the cage and introduced a fresh rearing tray with 500 silkworm larvae (fifth age fifth day silkworm larvae) for furthering the studies on quantum and span of egg laying of uzi fly. The silkworm larvae were scanned under magnifying lens and counted for total number of uzi eggs. Data thus collected were used for calculating percentage of uzi egg laid on silkworm larvae.

In total, 5 replications were maintained per each treatment and all the experiments were repeated for five times. Macroscopic data were analyzed microscopically to obtain the targeted parameters and the data were statistically (ANOVA) treated.

RESULTS

The egg laying of uzi fly, *Exorista sorbillans* on the silkworm, *Bombyx mori* has been studied under five patterns; a. the quantum of eggs laid by an individual uzi fly, b. uzi fly egg laying span on silkworm, c. preference of silkworm larval instars for uzi fly egg laying, d. preference of silkworm larval body surface for uzi fly egg laying and e. number of eggs laid by uzi fly on individual silkworm.

a. quantum of eggs laid by an individual uzi fly on the silkworm larvae: The total number of egg laid by individual uzi fly, *Exorista sorbillans* on the silkworm, *Bombyx mori* larvae from the initiation day to the day to the completion day is depicted in figure 1. As seen from the graph (Fig. 1) it is clear that variations do occur between individual uzi flies with regards to total number of eggs laid during their egg laying span. The average number of eggs laid by uzi fly was 751 eggs (minimum of 680 eggs and maximum of 820 eggs). Differences in the total number of eggs laid by individual uzi fly were statistically significant at 5% level ($p < 0.05$), indicating that there exists differences among the individual uzi flies in terms of quantum of eggs laid.

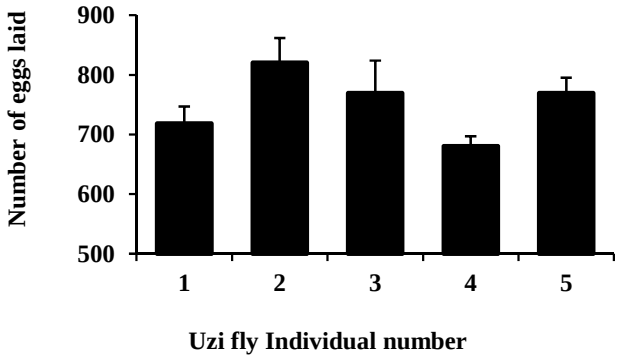

FIGURE 1: Total number of eggs laid (± SD) by individual uzi fly, *Exorista sorbillans* on the silkworm, *Bombyx mori* during its egg laying span (initiation of egg laying to completion of egg laying). Note existence of individual variations in the total number of eggs laid among the individual uzi flies. The variations are statistically significant at 5% level ($p < 0.05$).

b. uzi fly egg laying span on silkworm: The results on the number of days taken by individual adult female uzi fly, *Exorista sorbillans*, after mating, on the silkworm, *Bombyx mori* and number of eggs laid on each day is presented in figure 2. The fly continues its egg laying process up to ten days. The egg laying process started at lower rate on first few days (day 1 to day 3), ranging from 10 eggs on the first day to 25 eggs on the third day. The fly increased its quantum of egg laying till 7th day. Uzi fly laid highest eggs on 5th and 6th day. However, the peak of egg laying was on 5th day and slightly diminished on 6th day. The difference between the number of eggs laid by uzi fly on 5th day and 6th day was marginal and not significant. The egg laying trend of uzi fly from day 8 onwards declined and on day 10, it touched the platue level. Thus, the adult female uzi fly took a maximum of 10 days to complete its egg laying process on silkworm larvae. It is also clear that the egg laying pattern, upon graphic representation, followed the parabola curve pattern. In other wards the quantum of eggs laid during the initial three days was minimum; it reached to the higher magnitude levels later up to the day 6th and from day 7, the number of eggs laid reduced to touch the platue level on the day 10 where egg laying process has been completed.

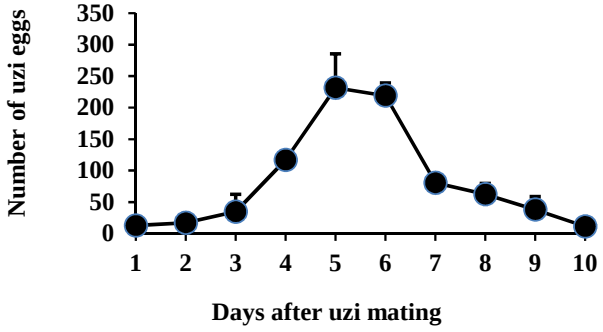

FIGURE 2: Number of egg layed (± SD) by uzi fly, *Exorista sorbillans* on the silkworm, *Bombyx mori* from the day 1 (initiation of egg laying) today 10 (completion of egg laying). Note less number of eggs laid on the first three days and last three days. Also note increase in number of eggs laid from day 4 to day 6 with peak of egg laying on day 5. The variations are statistically significant at 5% level ($p < 0.05$).

c. preference of silkworm larval instars for uzi fly egg laying: The results on uzi incidence at all instars (I to V) of the silkworm, *B.* mori larvae are depicted in figure 3. Obviously, no incidence of uzi eggs on the body surface of the larvae was observed during I instar. Surprisingly, the incidence of uzi has been noticed during the II instar period of the silkworm, however, with less percentage (2%). The uzi incidence continued increasing from the III instar larval period of the silkworm to the V instar. Incidentally, the percentage of uzi infestation was high (16.8%) during V instar period of the silkworm larvae followed by IV (7.00%) and III (3.80%) instar periods.

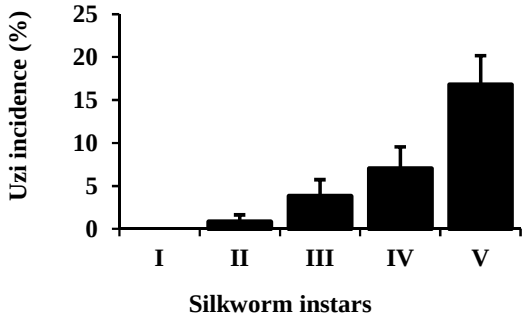

FIGURE 3: Percentage of infested silkworm larvae by uzi fly, *Exorista sorbillans* observed (± SD) during different larval instars periods of the silkworm, *Bombyx mori* . Note no incidence of uzi during the I instar laeval period. Incidence was negligible during the II instar. The intensity of infestation increased from the III instar and reached its maximum during the V instar. The observations are statistically significant at 1% level ($p < 0.01$).

d. preference of silkworm larval body surface for uzi fly egg laying: Upon scanning for uzi fly eggs, only in three surfaces of silkworm larval body *viz*., intersegmental, intrasegmental and ventral regions only were found affected. Data on number of larvae with uzi eggs on the above three surfaces were recorded and converted in to percentage. The data thus converted in to percentage on the three body surface regions of the silkworm are presented in figure 4. It is clear that majority (over 95%) of the silkworm larvae had received uzi eggs in the intersegmental surface. A meager percentage of silkworm larvae were found with uzi eggs on the surface of intrasegmental and abdominal region. Up on the statistical treatment, the observed data are highly significant at 1% level ($p < 0.01$).

FIGURE 4: Percentage of silkworm larvae infested by uzi fly, *Exorista sorbillans* observed (± SD) on three body surface areas of larva *viz.*, dorsal intersegmental, dorsal intrasegmental and ventral abdomen. Note mejority of larvae were infested by uzi fly (over 95%) on the dorsal intersegmental region and the limited larvae were infested on either dorsal intrasegmental or ventral abdominal regions. The observations are statistically significant at 1% level ($p < 0.01$).

e. number of eggs laid by uzi fly on individual silkworm larva: The results on the number of eggs laid by the uzi fly on individual silkworm larvae are presented in figure 5. From the figure it is clear that the majority of silkworm larvae (over 80%) were found with only one egg of uzi fly on their body surface. Individual silkworm that had more than one egg was also noticed in the batch. Thus around 4% of silkworm larvae received uzi eggs of 2 or 3 per larva and a meager amount of larvae received uzi eggs of 4 and above.

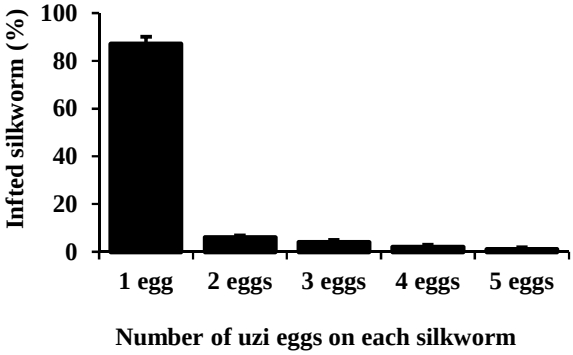

FIGURE 5: Number of eggs of uzi fly, *Exorista sorbillans* observed (± SD) on individual silkworm, *Bombyx mori* larvae on the day 5 of fifth instar period. Note majority of silkworm (over 80%) silkworm larvae were infested with single egg of uzi fly. Also note very less percentage of silkworm larvae (less than 6%) were infested with more than one number of uzi eggs. The observations are statistically significant at 5% level ($p < 0.05$).

DISCUSSION

The uzi fly, *Exorista sorbillans* was first detected in south India, in Bailanarasapura village of Hosakote Taluk of Bangalore District, Karnataka during May, 1980 (Anonymous, 1980) and later evoked much interest on the pest as it caused severe damage to the silkworm cocoon crop (Jolly, 1987), with a loss to the extent of 20-30 percent cocoon production. Studying the flight range of uzi fly, Narayanaswamy *et al.* (1994b) reported that the uzi fly can travel a distance of 2.7 km for effective parasitization of silkworm. Prasad and Reddy (2009) studied the spectral sensitivity of uzi fly during egg laying period and reported that uzi fly prefers light to detect silkworm and lay eggs on it. Sinchaisri *et al.* (1972) reported that uzi prefers silkworm hybrids rather than pure breeds for egg laying. Narayanaswamy *et al.* (1994a) reported that uzi fly prefers multivoltine races. The above reports are more important ones in uzi fly egg laying patterns and are conclusive. Therefore, these aspects are not covered in the present studies. The quantum of eggs laid by uzi fly on silkworm is an important aspect in the egg laying patterns. Sengupta *et al.* (1990) viewed that uzi fly lays about 300 to 1000 eggs. Chamundeswari (1994) reported that uzi fly lays 94 to 399 eggs depending on the season. The recorded maximum number of eggs was 1182 (Chamundeswari, 1994). Sinchaisri *et al.* (1972) and Narayanaswamy *et al.* (1994a) reported that uzi fly has its preference of silkworm for egg laying, certain silkworm hybrids and multivoltine breeds are much preferred and therefore, the number of eggs laid are differed. Sengupta *et al.* (1990) again reported that the number of eggs laid by uzi fly differs from season to season. In the present study, the range of uzi fly egg laying was from 718 to 820 number of eggs (Fig. 1). Large numbers of eggs laid by uzi fly hints that the fly thrives for continuation of progeny. The egg laying pattern of uzi from day to day is also an important aspect. In the present study, the egg laying pattern compared to day to day oviposition has recorded a perfect parabola, with less number of eggs laid on the initial days, increased egg laying during the middle days and again decreased egg laying activity towards the end of

the egg laying period (Fig. 2.). There are clear cut reports that uzi fly lays eggs in fewer number during the initial period of egg laying span, increases to its maximum in the middle part of the span and again decrease to the platue level during the later part of egg laying span (Sengupta *et al.*, 1990). Therefore, the observed patters of egg laying in uzi fly against egg laying span is amply been supported. There are variations in the duration of uzi fly egg laying span. Sengupta *et al.* (1990) reported that the egg laying span ranged from 9 to 25 days, depending up on season. Siddappaji (1985) reported that uzi fly can potentially infest 200 to 300 silkworms over a period of 7 to 10 days. Available reports irrevocably agree that uzi fly lay eggs throughout the egg laying span (adult female life span). In the present study, the uzi fly egg laying span was 10 days (Fig 2). It is generalized that the egg laying of uzi fly followed a parabola curvilinear pattern, with an egg laying duration of 10 days, in the present study. The instars periods of silkworm that were preferred of uzi fly for egg laying is again an interesting one. There are 5 different larval instars in the life cycle of the silkworm. In the present study (Fig. 3.), no uzi fly infestation was noticed in the first larval instar of silkworm. Infestation started from the second instar and reached to its maximum in the fifth instar silkworm larval period. The infestation during the second and third instar larval period was negligible (0.8 and 3.8%). However, infestation started reaching climbing from the fourth instar (7.8%) and reached peak during fifth silkworm larval instar period (16.8%). Sengupta *et al.* (1990) reported that uzi fly approaches the host larva and after repeated survey, it lays eggs. This indicates that uzi needs sufficient space for its posture on the silkworm to successfully complete egg laying. The initial silkworm larval instars with less size and surface does not support the uzi requirements to lay eggs on the surface of the host. However, the later silkworm instar larvae, with higher size and greater surfaces are much preferred by uzi for successful egg laying. LiJiSheng (2006) reported that *E. sorbillans* eggs were usually laid on the back of the silkworm, from 3 to 5 metamere, parasitic parts were in the intersegmental membrane. In the present study also, uzi fly laid most of its eggs (96%, Fig. 4) on the dorsal intersegmental region and less percentage of eggs on dorsal intrasegmental and ventral regions (2% each). This observation demonstrates that uzi fly prefers to lay its eggs on the dorsal surface of the silkworm larvae and in the intersegmental region, perhaps to protect uzi eggs laid to be intact for continuation of its progeny. In the similar lines, uzi preferred to lay a single egg on one silkworm larva (Fig. 5.). The silkworm larvae that were having one egg each on their surface was 87%. Data were also recorded with two uzi eggs per silkworm larva to the tune of 6%. Silkworm with 3 eggs and more were very meager. The reports of Sengupta *et al.* (1990) that uzi fly survey and lays eggs suggests that before laying egg on the body of silkworm larva, uzi fly confirms that no earlier uzi fly egg exists. The observation stresses that uzi fly prefers and plans for successful completion of its life cycle and continuation of progeny assured.

CONCLUSION

Thus, the uzi fly, *E. sorbillans* lays up to 800 number of eggs, in a span of 10 days following the parabolic type of distribution, preferring later (fourth and fifth) instars of silkworm larvae, again preferring intersegmental dorsal surface of the silkworm larva and lays one egg on one silkworm larva.

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