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The Uzi Fly Challenge: Biological Insights and Threats to Muga Silkworms

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Authors' contributions

This work was carried out in collaboration among all authors. Author RS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript and managed the analysis of the study with the help of author RBD. Author TN managed the literature searches along with authors BK and IG helped in measuring the dimensions as well as gave suggestions regarding the experiment. Author MS took part in the rearing of the muga silkworm in the experimental plot while author HS gave suggestions regarding the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

This study aims to thoroughly investigate the biology of a significant endo-larval parasitoid of muga silkworms, *Blepharipa* sp. (Walker). The research was conducted both in the field, where muga silkworms were reared under net conditions with temperature, humidity and rainfall levels ranging from 13.48℃-26.73℃, 77%-78.5% and 0mm-86mm and allowed to be infested by the uzi fly, and in the laboratory at room temperature and humidity. The findings revealed that the life cycle of *Blepharipa* sp. is completed in an average of 30 days for males and 33 days for females, with an incubation period of 2.40 days, a larval period of 6.20 days, a pupal period of 12.40 days, and adult longevity of 10.80 days for males and 12.00 days for females. Additional aspects such as peak infestation season and oviposition sites were also studied. The mortality rate due to uzi fly infestation was 100%, with worms dying either before the spinning stage or inside their cocoons, resulting in defective cocoons unsuitable for reeling. Given the severe economic losses and demotivation caused to farmers by this pest, a thorough understanding of its biology is of utmost importance.

Keywords: Antheraea assamensis; Blepharipa sp.; major pest; pest biology.

1. INTRODUCTION

India's diverse natural environment, conducive to the production of all four types of commercial silk, bestows upon it a distinctive presence in sericulture. Of them is the muga silkworm which, being multivoltine and endemic to Assam and some other north-eastern states, as typically reared outdoors, with cocoon spinning to seed production occurring indoors, rendering them vulnerable to pest infestations [1]. Among these pests, the uzi fly poses a significant threat, leading to yield reduction, particularly during the peak infestation period i.e. the chotua crop, a pivotal commercial seed crop within the muga cultivation. Locally, the fly is called "bor makhi" or "kunji makhi" by the farmers [2]. They cause a loss of silkworm crops which hampers the generation of future seed crops and hence disrupts the commercial seed crop production which ultimately causes loss in silk production [3]. The uzi fly is a member of the family Tachinidae, most of which are exclusive parasitoids, primarily targeting Lepidoptera but also known to attack different stages of other insects such as Heteroptera, Coleoptera and Symphyta of Hymenoptera [4]. The muga silkworm is known to be parasitized by two Tachinid species viz. *Exorista sorbillans* and *Blepharipa sp.* Among them, *B. sp.* is identified as the primary Tachinid fly that preys on muga silkworms where the peak period of attack occurs between December and April, with reported losses ranging from 48.7% to 80% in various seed areas across Assam [5]. The first report of *Blepharipa sp.* as a serious pest of muga silkworm was reported in the year 1989 by Goswami and Barah [6]. The infestation of the uzi fly is recognizable by the black scar where the attack occurred, and maggots emerging from the cocoon are evident through holes in it making them inappropriate for reeling. Muga silkworms, having six crops annually, are raised year-round. Due to their close synchronization with the uzi fly life cycle, it's challenging to rear them without infestation. Additionally, outdoor rearing increases the risk of crop loss due to other pests and diseases, compounded by different climatic conditions throughout the year. Managing the infestation involves employing nylon nets to cover the host plants, which is difficult because farmers typically don't prune their fields, resulting in large trees that cannot be completely covered by nets. The current study aims to thoroughly investigate the biology and damage symptoms of the endo-larval parasitoid *Blepharipa* sp. (Walker), a significant threat to the muga silkworm industry.Understanding the life cycle and infestation patterns of *Blepharipa* sp. is crucial for developing effective management strategies to mitigate its impact on the muga silkworm industry.

2. MATERIALS AND METHODS

The study of the uzi fly life cycle was conducted in field conditions at the experimental field of the Department of Sericulture, AAU, Jorhat, Assam (Lat 26.721544 ° , Long 94.196678 °) with temperature, humidity and rainfall levels ranging from 13.48℃-26.73℃, 77%-78.5% and 0mm-86mm. To calculate the oviposition and fecundity of the uzi fly, muga silkworm larvae were infested artificially by keeping them with mated female uzi fly in the field and were properly covered with a nylon net to prevent the uzi fly from flying out.

The later part of the study regarding pupal period and adult emergence was done in laboratory condition at room temperature and humidity by keeping the cocoons of infested muga silkworms separately in different plastic containers and was made sure to carry out everyday observation. The measurements of the dimensions of egg, maggot, pupa and adult were carried out with the help of a binocular stereoscope.

3. RESULTS

The female fly after copulation searches for a suitable host for oviposition which is found to be mostly the late instars of the muga silkworm i.e. 4th and 5th instars. They attach the eggs to the exposed integument of silkworm larvae mostly in the intersegmental region, although they were also found to lay eggs on exposed sides of prologs, near spiracles etc. With an average oviposition rate of 35.20 numbers per day (Table 3) during the experimental period, the female fly was spotted to lay 7-16 eggs per silkworm. The eggs were found to have hatched through chorion on the antero-ventral surface, with an observed hatching percentage of 84.48%, following an incubation period of 2-3 days (Table 2). The measurements of the egg, maggot, pupa and adult of *B. sp.* are depicted in Table 1.

3.1 Egg Stage of *Blepharipa sp.*

It was found that the eggs were ovoidshaped and of macro type (Fig.1). The surface of the egg was relatively flat ventrally with an opaque chorion and convex dorsally. Although the gravid adult female uzi flies appeared to lay their eggs anywhere on the larval body of the muga silkworm, it became apparent that the lateral region was the most desired location, subsequently followed by both ventral and dorsal site with percent infestation of 50.83%, 25.42% and 23.97% respectively exhibiting an incubation period of 2-3 days (Table 2) (Figs. 2-a,b,c) (Table 4). The egg hatches and enters the host larval body forming a black scar at the point of entrance (Fig. 9).

3.2 Larval Stage of *Blepharipa sp.*

With a nearly spherical posterior region and a tapered anterior region, the apodous and fusiform morphology of the maggots were typified by their curved hooked mouth part displaying a total of 12 body segmentations. The third instar matured maggots emerged from the host body to undergo pupation meanwhile completing all three larval instars inside the host body.

First instar maggot: The initial instar maggots (Fig. 3a) were minuscule, off white in appearance, and possessed two tiny, dot-like spiracles at posterior body region. They were linked to the respiratory funnel (Fig. 8) that had developed at the puncture site and did not move much, staying close to it and they do it by gathering a mass of fat bodies near the entrance point inside the infested silkworm larvae (Fig. 3b)

Second instar maggot: The maggots in their second instar (Fig. 4) had a gentle white appearance with two light brown spiracles at the posterior end. Additionally, they also exhibited sedentary behavior and remained close to the puncture site in the host larval body.

Third instar maggot: The maggots in their third instar were dirty white to yellowish white in colour (Fig. 5), having two noticeable spiracles with sclerotized peretreme. The third instar uzi maggots go throughout the entire host body, eating voraciously on the fat content of the host larva. They exited the host larval body by piercing the dead host's body wall at maturation. Such type of silkworms form flimsy or defective cocoons unsuitable for reeling (Fig. 10).

3.3 Pupal Stage of *Blepharipa sp.*

After emerging from the silkworm larval body, the mature uzi maggots searched for a suitable location to pupate. The maggots preferred to pupate in soil although they typically hunt for fissures and crevices in their surroundings. The freshly produced pupae had a light brown colour (Fig. 6a) that eventually grew darker with time (Fig. 6b). These coarctate pupae comprised 11 body segments. After the pupal stage, which lasted an average of 12.40 days (Table 2), the adult fly emerged from the pupa by breaking the predetermined line of weakness at the anterior region of the pupa. The adults appeared to emerge most often in the morning when the temperature appeared to be at its best. Temperature and rainfall had a significant impact on adult emergence; greater emergence was detected following rainy days and a greater infestation percentage was found in the Chotua crop of muga silkworm (Feb-Mar). With an average emergence percentage of 74.00, the emergence persisted for three to four days (Table 2).

Table 1. Measurement of different life stages of *Blepharipa sp.* (Walker)

Sl. No.	Life stages	Length(mm) Mean (±) SEm	Range	Width(mm) Mean (±) SEm	Range
1	Egg	0.80±0.09	0.7-0.9	0.38±0.07	0.3-0.5
2	Maggot				
	First instar	1.18±0.19	1-1.5	0.46±0.08	0.4-0.6
	Second instar	6.18±0.68	5-7	2.42±0.38	2-3
	Third instar	17.52±0.34	17-18	5.48±0.34	5-6
3	Pupa	11.32±0.68	10-12	5.34±0.68	4-6
4	Adult				
	Male	13.12±0.68	12-14	5.74±0.38	5-6
	Female	11.24±0.67	10-12	5.72±0.37	5-6
5	Wing span				
	Male	9.48±0.40	9-10	3.70±0.36	3-4
	Female	8.50±0.35	8-9	3.34±0.42	3-4

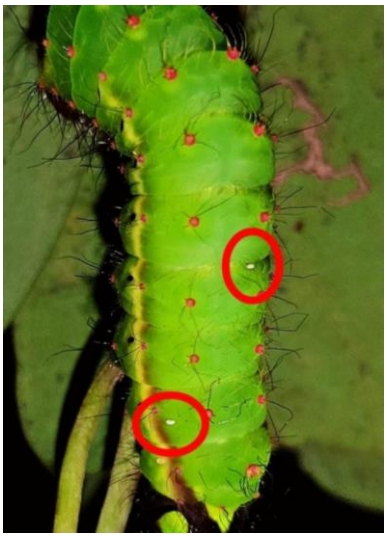
Table 2. Developmental parameters of uzi fly, *Blepharipa sp.* Walker in muga silkworm

Sl. No.	Parameter	Mean (±) SEm	Range
1	Incubation period (days)	2.40±0.48	2-3
2	Hatching percentage (%)	84.48±2.08	81.25-87.50
3	Larval period (days)	6.20±0.73	5-7
4	Pupal period (days)	12.40±0.78	11-13
5	Adult emergence (%)	74.00±2.45	70.00-76.67
6	Sex ratio (female:male)	2.84:1	-
7	Adult longevity (days)		
	Male	10.80±0.96	9-12
	Female	12.00±0.88	11-13

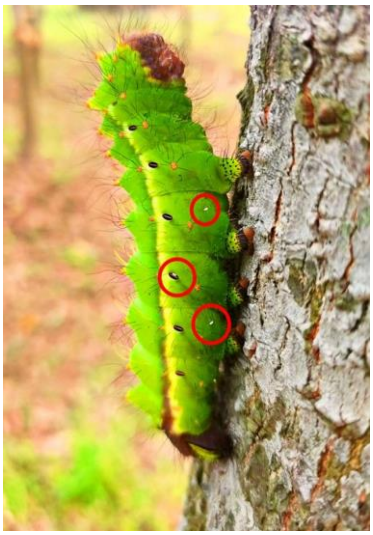
Table 3. Reproductive parameters of uzi fly, *Blepharipa sp.* infesting muga silkworm

Sl. No.	Parameter	Mean (±) SEm	Range
1	Pre-oviposition period (hours)	7.04±0.652	6-8
2	Oviposition period (days)	6.40±0.784	5-7
3	Rate of oviposition (no. of eggs/female/day)	35.20±4.487	27-41
4	Fecundity	219.00±17.188	186-237
5	Post-oviposition period (days)	4.40±0.48	4-5

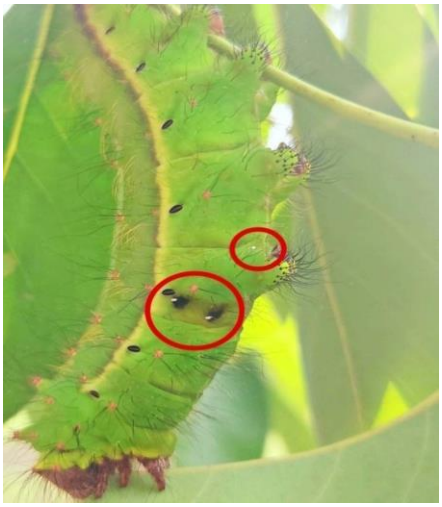
Fig. 1. Egg of Muga uzifly



a.



b.



c.

Fig. 2. Site of oviposition of Muga uzifly a. dorsal, b. lateral, c. ventral

Table 4. Site of oviposition of *Blepharipa sp.* on host body (*Antheraea assamensis* Helfer)

Site of oviposition on the host body	Mean (±) SEm	Percent infestation (%)
Dorsal	11.60±0.78	23.97
Lateral	24.60±0.99	50.83
Ventral	12.20±0.73	25.42

Fig. 3a. 1st instar maggot of Muga uzifly

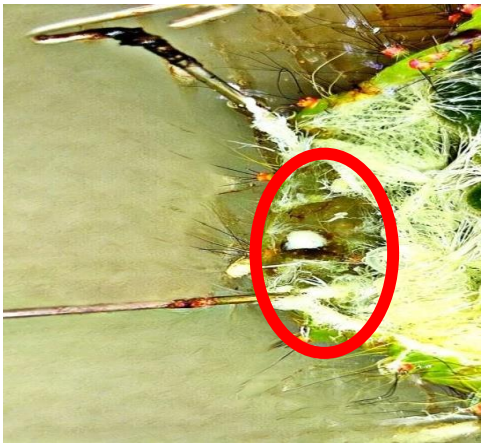


Fig. 3b. Fat mass of host larval body enclosing 1st instar maggot of Muga uzifly

Fig. 4. 2nd instar maggot of Muga uzifly

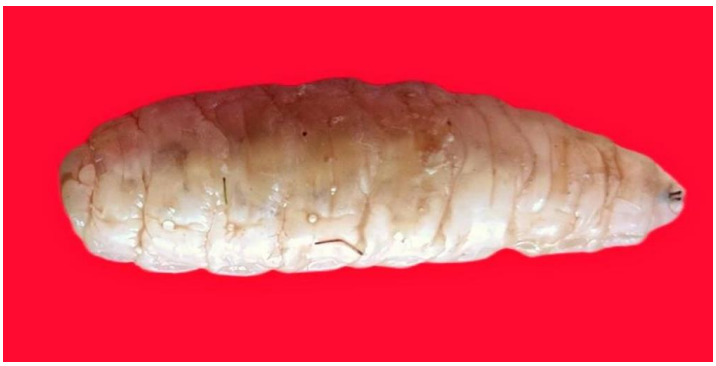


Fig. 5. 3rd instar maggot of Muga uzifly

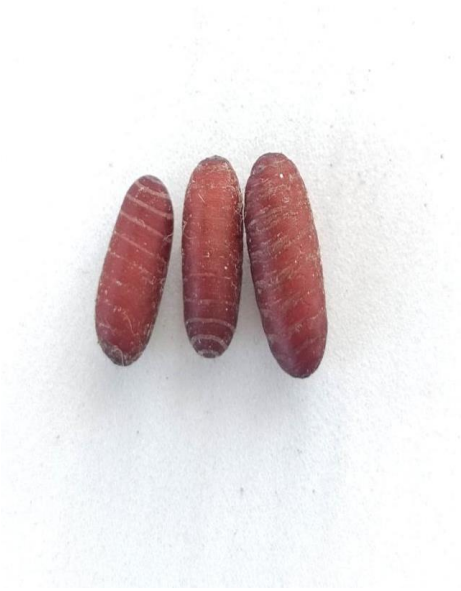


Fig. 6a. Freshly formed Muga uzifly pupa

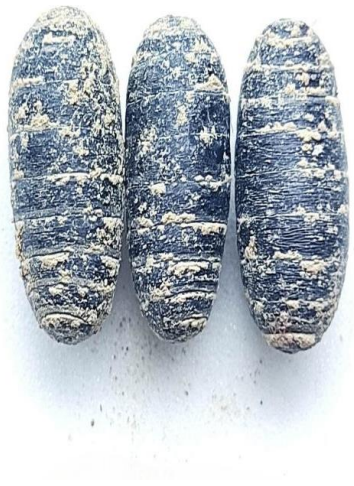


Fig. 6b. Muga uzifly pupa after they are dark in colour

Fig. 7. Adult Muga uzifly

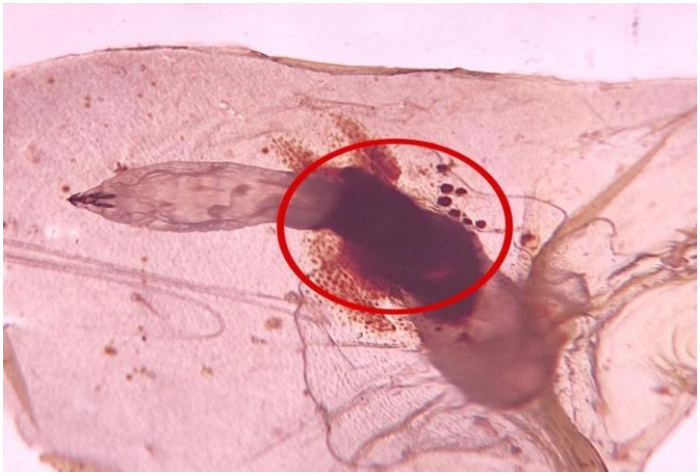


Fig. 8. Respiratory funnel formed by 1st instar maggot of Muga uzifly

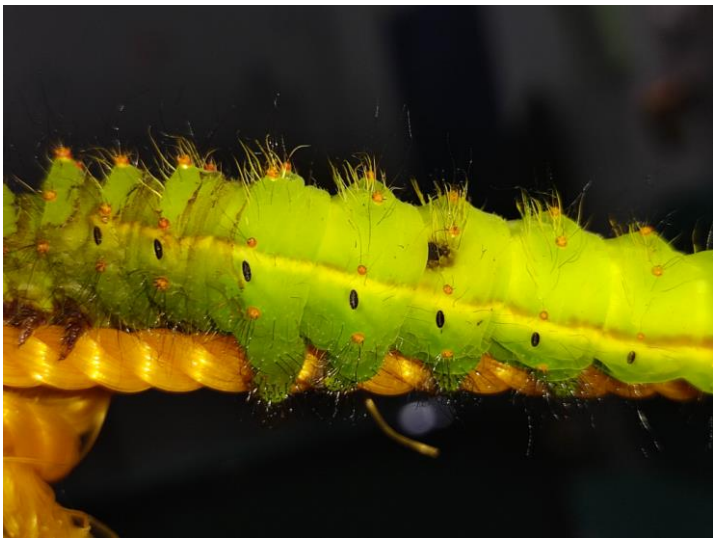


Fig. 9. Black scar formed after maggot penetration to larval body of muga

Fig. 10. Defective cocoon due to uzi infestation

3.4 Adult stage of *Blepharipa* sp.

The adult uzi flies had four longitudinal lines of bristles on the thoracic notum and long lateral bristles on the lateral abdominal area. They were blackish in appearance with an orange tinge at the dorso-lateral region of the abdomen. It was evident that the female was a bit bigger than the male. Mating mostly took place on the day of emergence (Fig. 7).

4. DISCUSSION

Blepharipa sp. is the most destructive pest resulting in significant losses in the muga industry among all the insect pests of muga silkworm in Assam and Meghalaya states of India [7]. Despite being the most destructive, there is little information accessible regarding the biology of the muga uzi fly. Reddy and Ranjan [8] reported higher infestation in the Chotua crop (43.0%) and the Jarua crop (19.0%) of muga silkworm in upper Assam. According to Manjunatha and Puttaraju [9], the eggs of uzi fly were also of macrotype, dull white, almost oval with a slightly pointed proximal region. Patil and Savanurmath [10] reported that usually the eggs of *B. sp.* hatched 3 days after oviposition and the hatching percentage was as high as 97.9% when observed under lab conditions. They also

revealed that the *B. sp.* preferred late instar worms of *Antheraea mylitta* D., mainly the 4th instar worms over the early instar worms. *B. sp.* was reported to infest hosts based on the host stage, vigour and health of the silkworm. Ramprakash and Kshirsagar [11] found that the maggot period of *Exorista bombycis* was found to be 5-7 days. The size of uzi flies attacking muga silkworms and mulberry silkworms also varies. Maggots of uzi flies targeting mulberry silkworms were smaller compared to those attacking muga silkworms and as reported these variations may stem from the larger body size of muga silkworm [12]. Thangavelu and Sahu [12] also stated that the pupa of the uzi fly were photonegative and undergo pupation mostly in soil but sometimes the pupation may occur inside the host larval cocoon. Goswami et al. [3] reported that the maggot of uzi fly infesting muga silkworm after maturation and coming out of the silkworm body pupates within 7-8 hours and the pupal period was found to be 10 days. Negi et al. [13] stated that the total life span of *B. sp.* was 48.1-64.1 days in an alternate host, *Cricula trifenestrata*.

5. CONCLUSION

Various reports regarding the infestation of a very destructive Tachinid pest of muga silkworm were recorded in Assam causing devastating economic loss. This study was done to provide a thorough study and familiarize the biology of the pest i.e. uzi fly. The uzi flies were found to mostly attack the muga silkworm during the Chotua crop (Feb-Mar) although the infestation occurs throughout the year. Starting from the egg stage to adult, the life cycle of the male uzi fly is 30 days long while the female has a longer life span of 33 days on average. The adult female finds the lateral region of the muga larva to be most favorable for egg laying which hatched within an incubation period of 2-3 days . Hatching of the egg is characterized by a black scar forming near the egg which occurred due to the puncture made by the maggot while entering the host larval body. The shorter egg incubation & larval period which is the destructive period makes it very difficult to control which is aided by the fact that they are endo-larval parasitoids, hence once the host is infested, they will surely die. Even if the host larvae managed to survive till cocoon spinning, those cocoons will be either flimsy, small, deformed or not fully formed. The resulting losses sometimes include the whole crop loss which renders the production of next generation progeny. Management strategies includes ploughing the rearing site to expose the puparium of the pests to sun, maintain proper cleaning schedule, biological method of releasing *Nesolynx thymus*, rearing of the muga silkworms under net etc. However to practice rearing under net condition in field, proper pruning schedule of the host plants should be maintained [14].

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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