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Role of *Nesolynx thymus* (Girault) in sustainable management of Uzi Fly, *Exorista bombycis* (Louis) Infestations in sericulture

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Abstract

The Uzi fly, *Exorista bombycis* (Louis), is a destructive endoparasitoid that leads to considerable losses in silkworm crops, with damage levels reaching around 20% during the rainy season, 11-15% in winter, and 1-3% in summer. In sericulture, reducing chemical pesticide use is essential because even low levels of toxicity can harm silkworm health and lower silk yield. An eco-friendly alternative for managing this pest is the parasitoid *Nesolynx thymus* (Girault), a member of the family Eulophidae (order Hymenoptera). This species is known for its short life cycle, high parasitization capacity, efficient host detection, and ability to adapt well to both laboratory and field environments, making it suitable for large-scale production. *N. thymus* targets the pupae of nearly all Uzi fly species, including *Blepharipa zebina* and *Exorista phillipinensis*. Its mass production involves two steps: first rearing housefly (*Musca domestica*) pupae, followed by rearing *N. thymus* on these pupae. During parasitization, gravid females exhibit distinct behavioral patterns as they oviposit within the pupae of *E. bombycis*. Factors such as host pupal size, age, and exposure time greatly influence parasitoid development and efficiency. Optimizing these host-related parameters can improve the effectiveness of *N. thymus* in pest control programs and support its use as a sustainable management tool against the Uzi fly.

Keywords: Biological control, *Exorista bombycis*, *Nesolynx thymus*, *Musca domestica*, parasitoid, sustainable sericulture

Introduction

India ranks as the second-largest silk producer globally and is the only country that produces all five commercially known varieties of silk (Padaki *et al.*, 2015) ^[22]. The mulberry silkworm (*Bombyx mori* Linn.) is a domesticated species extensively cultivated for silk production (Giora *et al.*, 2022) ^[13]. Despite advancements in sericulture, significant crop losses continue to occur annually due to various factors, with pest infestations being a major concern (Rahmathulla, 2012; Haripriya & Mamatha, 2023) ^[25, 14].

Among the insect pests affecting silkworms, the Uzi fly (*Exorista bombycis* Louis) is considered one of the most destructive. Other pests such as dermestid beetles, earwigs, and ants also contribute to crop damage (Belgumpe & Jadhav, 2017) ^[8]. The Uzi fly, a larval endoparasitoid belonging to the order Diptera and family Tachinidae (Singh *et al.*, 2024) ^[30], has been reported in several parts of Maharashtra (Jadhav & Sathe, 2016) ^[16]. Various species of Uzi flies attack silkworms, including the Japanese Uzi fly (*Crossocosmia sericariae* Rondani), Hime Uzi fly (*Ctenophorocera pavidus* Meigen), Tasar Uzi fly (*Blepharipa zebina* Walker), and the Indian Uzi fly (*Exorista bombycis* Louis) (Sowmya & Ranjitha, 2021) ^[34].

This pest is particularly problematic in the sericulture regions of Karnataka, Andhra Pradesh, Tamil Nadu, and West Bengal. Losses attributed to Uzi fly infestations range from 10-40%, with the highest damage occurring during the rainy season (over 20%), followed by winter (11-15%) and summer (1-3%) (Sakthivel *et al.*, 2012; Bari *et al.*, 2023) ^[27, 5]. Female flies lay 250-300 eggs on silkworms, preferring the 4th and 5th instar larvae. After hatching within three days, the maggots penetrate the host, feeding on its body fluids and leaving black scars. They continue feeding until the silkworm reaches the pupal stage, after which mature maggots emerge, rendering the cocoons unfit for reeling (Reddy *et al.*, 2015; Barsagade, 2017) ^[26, 6].

Infections during the 4th instar prevent cocoon formation, while infestations during the 5th instar result in unreelable cocoons. Maggots pupate in crevices and cracks within the rearing environment (Choudhury *et al.*, 2014)^[10].

Biological control using natural enemies has proven to be an effective, eco-friendly alternative to chemical pesticides (DeBach *et al.*, 1971)^[11]. These natural enemies include parasitoids, predators, entomopathogenic nematodes, and various microorganisms that suppress pest populations directly or indirectly (Khandagale *et al.*, 2023)^[18]. Several hymenopteran parasitoids are known to attack Uzi fly pupae, such as *Nesolynx thymus*, *Trichopria* sp., *Exoristobia philippiensis*, *Dirhinus* sp., *Brachymeria lugubris*, *Spalangia endius*, *Pachycrepoideus veerannai*, and *Spilomicrus karnatakensis* (Nirmala & Veeranna, 1998; Singh & Maheshwari, 2002; Singh & Saratchandra, 2003)^[20, 31, 33].

Chemical control methods, though effective against pests, pose serious risks to silkworms, farmers, and the surrounding ecosystem (Singh & Saratchandra, 2002)^[32]. Furthermore, even minimal chemical residues can negatively affect silkworm rearing and reduce raw silk quality (Karthik & Rathinamoorthy, 2017; Altman & Farrell, 2022)^[17, 1]. Therefore, biological control is increasingly being adopted as part of an eco-friendly integrated pest management (IPM) approach.

The pupal parasitoid *Nesolynx thymus* (Girault), belonging to the family Eulophidae, is recognized as a highly promising biocontrol agent against Uzi flies. It is characterized by its short life cycle, high parasitization potential, efficient host-searching ability, and suitability for mass production under laboratory and field conditions. *N. thymus* has been successfully used to control Uzi fly species such as *Exorista philippinensis* and *Blepharipa zebina* infesting muga silkworms (*Antheraea assamensis* Helfer) (Choudhury *et al.*, 2014)^[10]. The Central Sericultural Research and Training Institute (CSR&TI), Mysore, has identified this parasitoid as a key component of IPM strategies in sericulture (Hasan *et al.*, 2009; Gahukar, 2014)^[15, 12]. Large-scale releases of *N. thymus* have shown promising results in suppressing Uzi fly populations, making it a sustainable and environmentally safe solution.

This paper highlights the role of *Nesolynx thymus* as a biological control agent and discusses its mass production and application for effective management of Uzi fly infestations in sericulture.

Mass Production of *Nesolynx thymus*

Nesolynx thymus, a hymenopteran parasitoid, was first identified and utilized in 1985 to control the Uzi fly, *Exorista bombycis* (Aruna & Manjunath, 2010)^[2]. Since its discovery, it has been widely used in India, primarily reared on pupae of the housefly, *Musca domestica*. Studies have shown that the highest parasitization rates by *N. thymus* occur on one to two-day-old *E. bombycis* pupae (Belgumpe & Jadhav, 2017)^[8]. The large-scale production of this parasitoid involves two main steps: production of housefly pupae and rearing of *N. thymus* on these pupae.

(a) Production of Housefly Pupae

Housefly pupae are collected in cages and maintained at 25±2 °C temperature with 75±5% relative humidity (RH) until adult emergence (Kumar *et al.*, 2016)^[19]. Within 4-5 days, around 80% of adults emerge and are provided with a diet consisting of sugar and milk powder in a 1:1 ratio, along with water supplied through cotton swabs. The colony conditions are then altered to 28±2 °C and 90±5% RH before placing oviposition containers into the 4-5-day-old adult fly cages (Ortiz *et al.*, 2016)^[21].

Oviposition containers are prepared with a mixture of 5-10 g of milk powder and 5 g of yeast powder added to 100 g of used larval medium, wrapped in moistened black cloth. Eggs (around 20,000) are collected within 5-6 hours using a brush (Wilkes *et al.*, 1948; Pastor *et al.*, 2014)^[36, 23].

For larval rearing, a fresh diet is prepared using 1.2 kg wheat bran and 15 g dry yeast, with water added to reach a total weight of 5.5 kg. Housefly eggs (20,000-25,000) are placed on this diet and covered with cloth. They hatch within 24 hours, and larvae (maggots) begin feeding. When the larvae turn creamy white, they enter the pre-pupal stage. Pre-pupae are gently transferred to a wire mesh (10 mesh size) placed on a perforated tray above a non-perforated tray to allow them to drop through. A thin layer of sawdust is spread to facilitate pupation. The pre-pupae turn brown as they develop into pupae (Pastor *et al.*, 2014; Kumar *et al.*, 2016)^[23, 19]. The quantity of pupae is measured by volume, with 1 ml containing approximately 30-35 pupae.

(b) Rearing *N. thymus* on Housefly Pupae

Fresh housefly pupae (500 ml, approximately 20,000) are spread in a single layer on a 60 × 30 cm plastic tray. Strips of plastic coated with 50% honey solution are placed in the tray to feed adult parasitoids. Around 4,000-5,000 one-day-old *N. thymus* adults are released at a ratio of one female to four housefly pupae. Approximately 350 ml of parasitized pupae is adequate for the process. The tray is covered with white cloth and secured with an elastic band to prevent parasitoid escape (Kumar *et al.*, 2016)^[19].

After 4 days, parasitized pupae are collected and placed in an adult emergence cage to allow any remaining houseflies to emerge. Empty shells are removed by winnowing, and the parasitized pupae are collected for distribution. Mixing 7-10-day-old parasitized pupae in equal proportions ensures continuous emergence for a week. These are packed in nylon net pouches (10 × 10 cm), each containing 50 ml of pupae, from which around 10,000 adult parasitoids emerge. The pouches can be transported easily to end-users. If supply is delayed, 10-14-day-old parasitized pupae can be stored at 10±2 °C for up to one week without affecting parasitoid quality (Senthoorraja *et al.*, 2020)^[28].

N. thymus completes its life cycle within 10-12 days in Uzi fly hosts. Adults live for 6-8 days, mate within 8-10 hours of emergence, and can mate multiple times (Belgumpe & Jadhav, 2017)^[8]. Upon parasitization, the larvae of *N. thymus* consume the contents of the host pupae, developing rapidly until they reach maturity (Kumar *et al.*, 1986).

Ovipositional Behaviour of *Nesolynx thymus* on *Exorista bombycis* Pupae

Behavioural manipulation offers an innovative and sustainable approach to insect pest control, as it utilizes the insects' own behavioural patterns for effective management of agricultural pests and ecosystem conservation (Chandana and Nadagouda, 2023)^[9]. The gravid females of *Nesolynx thymus* exhibit a sequence of distinct actions during the parasitization of *Exorista bombycis* pupae (Siddaiah and Danagoudra, 2019)^[29].

The process begins with host detection. When a female parasitoid is introduced to the pupal host, it moves actively within the container searching for a suitable host. Upon locating the host, the female mounts it and inspects it by repeatedly touching with its antennae—a behaviour referred to as drumming. Following this, the insect taps the surface of the host with the downward-bent abdominal tip equipped with sensory hairs. Tapping is observed to occur more frequently than

drumming.

Once the host is confirmed through these assessments, the female positions its ovipositor perpendicularly on the identified site. Holding the host firmly, the parasitoid becomes motionless to stabilize the ovipositor for drilling. Drilling is accomplished through alternating clockwise and anticlockwise movements, enabling the insertion of the ovipositor into the pupal body. After complete penetration, the parasitoid deposits its eggs inside the host. Both the host and parasitoid remain still during this stage.

Following oviposition, the female engages in grooming, cleaning its antennae and thoracic regions. It also feeds on the host's haemolymph, which seeps from the drilled hole. Occasionally, abnormal behaviours may lead to rejection of the host (Siddaiah and Danagoudra, 2019) [29].

Host and Parasitoid Interactions

Various host characteristics such as pupal size, age, and the duration of exposure to parasitoids play a crucial role in determining parasitoid biology. The size of the parasitoid, an important trait for successful biological pest control, is directly influenced by the size of the host (Aruna & Manjunth, 2009) [3]. Larger pupae, with an average volume of 263.89 mm³, showed a higher parasitism rate (74%) when exposed to mated females of *Nesolynx thymus*.

Host age is another significant factor affecting mating behavior,

reproductive efficiency, and parasitism levels of parasitoids (Aruna & Manjunath, 2010) [2]. Maximum progeny production of *N. thymus* was observed in two- to four-day-old puparia of *Exorista sorbillans* (Hasan *et al.*, 2009) [15]. As the host ages, its nutritional quality deteriorates, leading to reduced parasitoid development. For instance, *Diadromus collaris*, a pupal parasitoid of *Plutella xylostella*, showed a preference for younger pupae due to their better nutritional value (Wang & Liu, 2002) [35]. Medium-aged pupae are generally more favorable for parasitoid development (Pfannenstiel *et al.*, 1996) [24].

Senthoorraja *et al.* (2020) [28] reported that *N. thymus* exhibited the highest parasitism (65%) on host pupae aged between 24-48 hours, with parasitism rates declining significantly after 72 hours. The duration of exposure also directly influences parasitism efficiency. Exposure periods of 48 hours resulted in higher parasitism rates and an increased proportion of female progeny (Senthoorraja *et al.*, 2020) [28]. However, prolonged exposure beyond 48 hours may cause superparasitism, reducing effectiveness. Similar observations were made with *Tetrastichus howardi* against *Chilo partellus*, where extended exposure led to increased superparasitism (Baitha *et al.*, 2004) [4].

Thus, selecting host pupae aged 24-48 hours and optimizing exposure duration can improve the efficiency, mass multiplication, and production of *N. thymus* for effective control of the Uzi fly.

Table 1: Some important parasitoids against Uzi fly pupae.

S. No.	Scientific name	Order	Family	Nature	Status
1	<i>Nesolynx thymus</i>	Hymenoptera	Eulophidae	Ecto-pupal parasitoid	Gregarious
2	<i>Trichopria sp.</i>	Hymenoptera	Diapriidae	Endo-larval pupal parasitoid	Gregarious
3	<i>Exoristobia philippiensis</i>	Hymenoptera	Encyrtidae	Endo-larval pupal parasitoid	Gregarious
4	<i>Dirhinus sp</i>	Hymenoptera	Chalcididae	Ecto-pupal parasitoid	Solitary
5	<i>Brachymeri alugubris</i>	Hymenoptera	Chalcididae	Ecto-pupal parasitoid	Solitary
6	<i>Spalangia aendius</i>	Hymenoptera	Pteromalidae	Endo-larval pupal parasitoid	Solitary
7	<i>Pachycrepoideus veerannai</i>	Hymenoptera	Pteromalidae	Endo-larval pupal parasitoid	Gregarious
8	<i>Spilomicrus karnatakensis</i>	Hymenoptera	Diapriidae	Ecto-pupal parasitoid	Solitary

Table 2: Parasitization rate of *N. thymus* to the host age of Uzi fly (Belgumpe & Jadhav 2017) [8].

S. No.	Age of <i>E. bombycis</i> (day)	Parasitism by <i>N. thymus</i> (%)
1	0	80
2	1	75
3	2	60
4	3	45
5	4	30
6	5	20
7	6	15
8	7	8

Conclusion

The pupal parasitoid *Nesolynx thymus* (Girault) has proven to be a highly efficient and eco-friendly biocontrol agent for managing *Exorista bombycis* infestations in sericulture. Its short life cycle, high parasitization capacity, strong host-searching ability, and adaptability to both laboratory and field conditions make it ideal for large-scale production and field release. Successful mass rearing on *Musca domestica* pupae and the optimization of key factors such as host age, size, and exposure duration significantly enhance its performance. By integrating *N. thymus* into pest management programs, sericulturists can substantially reduce Uzi fly damage, minimize pesticide use, and safeguard cocoon quality. The adoption of this sustainable approach not only preserves the health of silkworms but also

supports the long-term viability and profitability of the sericulture industry.

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