***Review Article***

# A Comprehensive Review of Insect Pest Management in Muga Silkworm (*Antheraea assamensis* Helfer): Current Scenario and Future Prospects

**Abstract**:

Muga silkworm (*Antheraea assamensis* Helfer), renowned for its natural production of prized golden silk, is native to Assam and adjacent regions in North-Eastern India. However, outdoor rearing of Muga silkworms exposes them to environmental fluctuations year-round, resulting in significant crop losses due to insect pests. Notably, pre-seed crops (Aherua and Jarua) and seed crops (Chotua and Bhodia) experience significantly higher losses compare to commercial crops (Jethua and Kotia). This paper presents a thorough analysis of insect pests impacting Muga silkworm rearing, classified according to activity periods and intensity of attacks. Primary insect pests include *Exoristasorbillans* (uzifly), *Apantelesglomeratus* (brachonid fly), ants and wasp. Uzifly inflicts damage during winter (November to February), primarily affecting 4th and 5th instar Muga larvae, leading to substantial losses during cocoon harvest in March-April, jeopardizing seed production for subsequent Jethua (April-May) commercial crops. *Apantelesglomeratus* and ants pose threats during summer. *Vespa orientalis* (wasp) causes damage to late instars from April to September. Chemical control methods are discouraged due to their adverse effects on silkworms. Therefore, urgent research into environmentally sustainable pest management strategies tailored to Muga rearing's specific needs and limitations are warranted. This review synthesizes detailed descriptions of identified pests, challenges in insect pest management, and discusses various mitigation strategies, offering insights into the biology of major insect pests affecting Muga silkworms and evaluating the effectiveness of different pest management approaches.

**Keywords**: Muga silkworm, Insect pests,Integrated pest management.

## Introduction:

Muga silkworm, scientifically known as *Antheraea assamensis* Helfer, is a holometabolous, multivoltine, and oligophagous lepidopteran insect with significant economic importance. In poikilothermic insects such as the Muga silkworm, growth and development are greatly influenced by abiotic factors such as temperature, humidity, rainfall, and light [Sarkar*et al*., 2022]. However, rearing Muga silkworms outdoors exposes these valuable insects to a multitude of environmental fluctuations year-round, which can result in disease outbreaks and insect pests infestations, consequently affecting productivity [Srilaxmi, K. and Paul, R. 2010]. Predators in the rearing fields pose a notable threat, causing crop losses of up to 20-25% [Singh et al., 1992]. Muga silkworms primarily feed on the leaves of Som (*Perseabombycina*) and Soalu (*Litseamonopetela*) [Kumar *et al*, 2022]. The rearing cycle encompasses six distinct periods throughout the year, namely Jarua (December-January), Chotua (February-March), Jethua (April-May), Aherua (June-July), Bhodia (August-September), and Kotia (October-November)[Sarkar et al., 2022]. It is worth noting that insect pest infestations on Muga crops can vary based on meteorological and geographical conditions [Chaudhury, 1981; Thangavelu et al., 1988; Singh & Das, 1996]. While the insect pest complex of the Muga ecosystem has been thoroughly researched, the only reported endoparasitoid to date is *Exoristasorbillans*, which inflicts significant damage (15 to 20%) during the Jarua (December-January) and Chotua (February-March) crops [Subharani& Jayaprakash, 2015]. During the Aherua (pre-seed) and Bhodia (seed) crops in the summer season, abiotic factors such as temperature, humidity, rainfall, along with diseases like flacherie and cytoplasmic polyhedrosis (CPV), contribute to significant losses of silkworms during rearing [Singh *et al*., 2022]. Extreme weather fluctuations, early-stage rainfall or hailstorms, and late-stage disease and predator incidences drastically reduce the percentage of effective rearing rates (ERR). A comprehensive understanding of the pest complex within specific agro-climatic conditions is crucial for developing successful pest management strategies[Srilaxmi, K. and Paul, R. 2010]. Several authors have reported that insect pest infestations in Muga crops vary from place to place. Furthermore, Muga silkworms face different insect pests in various regions of the country and abroad (Chaudhury, 1981; Thangavelu et al., 1988; Singh & Das, 1996). The utilization of chemical insecticides for pest control in sericulture is frequently deemed impractical and undesirable. Hence, there is a critical necessity for alternative approaches that can complement and partially substitute chemical-based pest management in sericultur[Singh &Saratchandra, 2008]. Considering the crucial significance of Muga culture and the scarcity of information concerning the diversity of insect pests throughout different growth phases of the silkworm, this comprehensive study was conducted to bridge these knowledge gaps and facilitate the formulation of appropriate pest management strategies for Muga silkworm rearing.

**Current Scenario of Insect Pests in Muga Silkworm:**

The insect pests infesting muga silkworms belong to various families, including Tachnidae, Braconidae, Formicidae, Pentatomidae, Vespidae, and Mantidae. Singh & Das (1996) documented 39 insect specimens from twenty-five families infesting primary muga food plants and muga silkworms (Antheraea assamensis) in RMRS, Boko, Assam. Muga Silkworm faces attacks from various parasitoids (such as *Exoristasorbillans* and *Apanteles sp*.) and predators (including ants, wasps, birds, etc.). Among these, *E. Sorbillans* is identified as a significant larval endoparasitoid of the silkworm, inflicting extensive damage to the sericulture industry. Particularly during the Jarua (December-January) and Chotua (February-March) crop seasons, it has been reported to cause losses ranging from 20% to 90% during winter and the post-winter period (December-March) [Singh *et al*., 2022] and 50-70% cocoon rejection during February-March [Baruah & Kalita, 2020]. The mature maggots emerge from the larvae/pupae and undergo pupation either in the rearing field or in the grainage hall. Muga silkworms infested by uzi die during the larval or pupal stage. Additionally, this parasitoid has been reported in 95 species of insects across 20 families of Lepidoptera and one family of Hymenoptera worldwide, even in the absence of silkworms [Singh *et al*., 2022]. [Thangavelu and Sahu, 1986] reported that the maggots of the Uzi fly display significant variation in body size, with maggots developing within *Bombyx mori*larvae generally being smaller compared to those developing within *A. assamensis* larvae, which are comparatively larger. It was also observed that the larger size of the muga silkworm might offer a more suitable environment for the uzi fly maggot compared to the smaller silkworm. Recent survey results indicate that the highest infestation of uzi fly was recorded during the Chotua crop (March-April 2010), with 43.0% infestation occurring in the 5th instar larvae and 35.0% at the cocoon harvesting stage. This was followed by the Jarua crop in

December 2009-January 2010, with 19.0% infestation at the larval stage and 27.50% at the cocoon harvesting stage, as reported in upper Assam [Reddy, 2011].*A.glomeratus* and ants pose threats during the summer season. *V.orientalis*(wasp) causes 20% damage to late instars larva from April to September [Subharani& Jayaprakash, 2015]. The muga cocoons are also infested by yellow flyThe fly completely fed on the head region of the pupae and emerged from the same by making a hole that is about 1cm in diameter" suggested[Singh *et al.,* 2022]. Instances of a pupal parasitoid Ichneumon wasp (Xanthopimplapedator) on muga silkworm have been reported for the first time from various muga growing locales in West Garo Hills, Meghalaya, during various muga summer crops [Majumdar *et al*., 2021].

**TABLE 1. Majour Insect Pests Infesting Muga Silkworm**[Subharani& Jayaprakash, 2015].

| **Sl. N o.** | **Commom Name** | **Scientific Name** | **Order** | **Family** | **Type** | Rearing loss (%) | **Status** |
|---|---|---|---|---|---|---|---|
| 1 | Uzifly | *Exoristasorbillans* | Diptera | Tachinidae | Parasitoid | 20-45 % | Major |
| 2 | Apanteles | *Apantelesglomeratus* | Hymenoptera | Braconidae | Parasitoid | 7-10 % | Major |
| **3** | Red Ant | *Oecophyllasmangoline* | Hymenoptera | Formicidae | Predator | 12-18% | Major |
| **4** | Canthecona Bug | *Eocantheconafurcellata* | Hemiptera | Pentatomidae | Predator | 3-5% | Minor |
| 5 | Reduvid bug | *Sycanuscollaris* | Hemiptera | Pentatomid | Predator | 2-4% | Minor |
| 6 | Wasps | *Vespa orientalis* | Hymenoptera | Vespidae | Predator | 10-15 % | Minor |
| | | *Xanthopimplapedator* | Hymenoptera | Ichneumonidae | Parasitoid | 1-2% | Minor |
| **7** | Praying Mantis | *Heirodula westwoodi* | Mantoidea | Mantoidae | Predator | 1-3% | Minor |

**Insect Pest Profiles and Management Strategies:**

**1. Uzifly: *Exoristasorbillans***

Uzifly predominantly attacks 4th and 5th instar larvae, causing considerable damage. These flies lay their eggs directly on the intersegmental regions of the larvae. Upon hatching, the maggots penetrate the larval body, consuming inner tissues and fat bodies before undergoing pupation in the soil. Infestations during the early stages result in larval mortality before the spinning phase, while those occurring in later stages lead to the production of cocoons of inferior quality, thereby diminish their suitability for reeling and decreasing their market worth. The peak activity of Exoristasorbillans is observed during the Chotua (February-March) and Baisakhi (April-May) crop seasons, resulting in losses ranging from 20 to 25%. To effectively manage this pest, integrated practices are recommended.

**The Life cycle of uzi fly**

Uzi fly completes their life cycles in four stages, viz egg, maggot pupa, and adult.

**Egg:**The eggs of Uzifly are creamy white in color, measuring approximately 0.45-0.56 mm in length and 0.25-0.30 mm in width. They exhibit an oblong shape and typically hatch within 2-5 days after being laid. Upon hatching, the maggot penetrates into the body of the muga silkworm. [Goswami *et al*., 2011].

**Maggot:**In the second stage of the Uzifly life cycle, the maggot undergoes three instars. The newly hatched maggot emerges from the eggshell through the operculum, typically positioned towards the silkworm's body. Upon hatching, the maggots penetrate the larval body and commence feeding on the tissues of the worms [Narayanaswamy and Devaiah, 1998]. During the first two instars, Uzifly larvae develop just beneath the host body, and in the final instar, they migrate from this location into the body cavity. These larvae are yellowish-white in color and typically measure 1.3-1.6 cm in length. With eleven body segments, they feed on various tissues within the silkworm's body. When mature, the maggots exit the host body by piercing the integument using their thoracic hooks [Baruah & Kalita, 2020].

**Pupa:**The pupae of Uzifly exhibit an oblong shape with a rounded posterior end. They range in color from light reddish-brown to dark reddish-brown. The pupal body comprises 11 segments and measures between 0.9 to 1.2 cm in length and 0.4 to 0.6 cm in lateral width. Adults typically emerge approximately 10-12 days after pupation[Thangavelu & Sahu, 1986].

**Adult:**Adult Uziflies are characterized by a blackish-grey coloration, with males typically longer than females. Their heads exhibit a triangular shape, while the dorsal side of the thorax displays four longitudinal black bands. The abdomen is conical in form, with the first segment being black and the subsequent segments appearing grayish-yellow. The lifespan of adult flies varies depending on sex and season [Reddy, 2011]. Male typically have a lifespan of around 10-18 days, while females generally live 2-3 days longer than males. Survival periods are shorter during the summer months. [Baruah & Kalita, 2020].

fig 1 :Uzi fly infected Muga silkworm larva fig 2 : Uzi fly infested damaged silkworm cocoons

**Integrated management practices to be followed for Exoristasorbillans**

The severe damage inflicted upon silkworm crops by the Uzifly menace in sericulture has created a dire situation, significantly impacting the foundation of sericulture in India. Consequently, the threat posed by these notorious fly pests has become a grave concern, exacerbated by the lack of known preventive/control measures to effectively curb Uzifly infestations. Addressing the control of both the Indian Uzifly and non-mulberry Uzifly has garnered the attention of numerous researchers in the past. Various approaches, including preventive measures such as employing mosquito nets and trapping female Uziflies, have been suggested as potential strategies. [Baruah & Kalita, 2020]. .

**1) Mechanical methods**:To mitigate Uzifly infestations during the peak period (December to March), it's recommended to rear silkworms under a nylon mosquito net, which has been shown to provide 80-90% control. When transferring late-stage worms, it's essential to carefully remove any fly eggs from the integument of the silkworm larvae using forceps. Additionally, it's advised to collect and dispose of any Uzifly maggots emerging from the cocoons three days after spinning in a designated container (Jali/montage). Installing electricity-operated stifling chambers for cocoons can effectively prevent the emergence of Uzifly maggots from infested cocoons within 3-5 days after spinning [Reddy, 2011].

**2) Cultural methods ▪**To combat Uzifly infestations effectively, it's advisable to plow or dig the soil in rearing plots, exposing maggots and pupae to predators or intense sunlight, thereby reducing their numbers. Maintaining cleanliness in the rearing field is crucial, and dusting with bleaching powder during rearing can help to deter infestations. It's also recommended to avoid continuous rearing of muga silkworms (monocropping) from December to April, as this practice can minimize the risk of Uzifly infestation [Bindroo*et al*., 2008].

**3) Biological methods ▪***Nesolynx thymus* is a parasitic insect that preys on uzi flies during their ecto-pupal stage. Typically, around 40-60 parasitoids develop within each uzi fly pupa. N. thymus is cultivated on house fly pupae, with 50 milliliters of parasitoid pupae being packaged in a nylon net pouch, priced at Rs 50 per pouch. Approximately 10,000 N. thymus adults emerge from each pouch. For effective release, it's recommended to distribute N. thymus between the 3rd and 5th day of the 5th instar stage, at a rate of 2 pouches per 100 developing uzi flies. Once spinning worms begin to mount, they should be transferred near the areas of infestation. After the cocoons are harvested, the same pouches can be placed near manure pits for further use [Baruah & Kalita, 2020].

**4) Quarantine method:**To mitigate infestation, it's advisable to impose restrictions on the transportation of seed cocoons between different locations and states. Private cocoon markets, grainages, and reeling units should be subjected to regular surveillance and monitoring[Reddy, 2011].

**2. Apanteles: *Apantelesglomeratus***

*Apantelesglomeratus* exhibits heightened prevalence during the summer and winter months, aligning with favorable environmental conditions for its lifecycle. This period corresponds to increased incidences of infestation in early-stage silkworms, highlighting the importance of understanding its seasonal dynamics. Adult flies of *Apantelesglomeratus* deposit eggs inside silkworm larvae, initiating a parasitic lifecycle. Upon hatching, maggots feed on silkworm tissues, leading to tissue damage and compromised larval health. The emergence of maggots through tubercles results in the formation of fuzzy white cocoons externally, contributing to rearing losses estimated at 10-15%[Subharani& Jayaprakash, 2015].

fig 3 : Larvae infested by *A. glomeratus**fig 4 :* *A. glomeratus*adult fly

**To mitigate *Apantelesglomeratus* infestation:** Employing a nylon mosquito net during silkworm rearing stands out as an effective preventive measure against infestations. Keeping the rearing area clean and applying bleaching powder are essential practices for controlling infestations. Additionally, it is imperative to diligently collect and dispose of maggots, pupae, and any silkworm larvae affected by infestation to prevent further spread.

**3. *Ants:*** *Oecophyllasmangoline*,*Componotus*sp., *Solenopsis*sp.

Ant species like red, black, and carpenter ants pose a threat to muga silkworm larvae, causing significant rearing losses of 12-18%, especially during summer. Their predatory behavior involves carrying larvae to nests and consuming appendages through mandibular biting, leading to larval immobilization. Understanding these behaviors is crucial for devising effective management strategies to protect silkworms and sustain silk production. [Subharani& Jayaprakash, 2015].


Fig 5 :Ants infected Muga silkworm larva

**To manage ant's infestations:**

**1. Mechanical methods:**Ensuring the removal of ant nests from plants before brushing silkworms is critical to prevent disruptions during the rearing process. Additionally, maintaining regular inspections and cleanings of the rearing environment helps to eliminate any debris or food particles that might attract ants, thus safeguarding the silkworms from potential infestations and ensuring their healthy development.

**2. Physical methods:**Applying grease or yellow sticky traps on tree trunks effectively prevents ants from climbing trees, safeguarding against their predatory threat.

**3. Cultural methods:**Maintaining cleanliness in the rearing field and applying lime and bleaching powder before commencing rearing proves beneficial. Adopting good sanitation practices involves the removal of fallen leaves, deceased silkworms, and other organic debris that might lure ants. Additionally, it's advisable to refrain from planting ant-attracting flora near the rearing vicinity. Rotating silkworm rearing sites periodically can disrupt ant colonies and gradually diminish their population.

**4. Bug: *Eocantheconafurcellata* (Wolff.*)***Eocantheconafurcellata*, also known as the sting bug, feeds on silkworm larvae by piercing them with a long proboscis. It primarily attacks early instar larvae, causing significant damage [Subharani& Jayaprakash, 2015].

**To manage bug infestations:** Rearing silkworms under a nylon net and utilizing mechanical control methods are highly recommended strategies. Additionally, the introduction of *Psixstriaticeps*, a parasitoid, can effectively serve as a biological control agent against the stink bug. These measures collectively contribute to a comprehensive approach in managing pests and ensuring the healthy development of silkworms.

**Fig 6 :*Eocantheconafurcellata* (Wolff.)**

**5. Reduvid Bug: *Sycanuscollaris***:

*Sycanuscollaris* is an additional predator known for sucking the haemolymph of silkworm larvae, with a preference for targeting early instar larvae [Subharani& Jayaprakash, 2015].

**To manage reduviid bug infestations:**Rearing silkworms under a nylon net and employing mechanical control methods represent the sole available options.

**6. Praying Mantis: *Heirodula westwoodii***

Praying mantises are large insects with raptorial forelegs. Nymphs and adults carry away early instar larvae, making them easy prey. They can also injure late instar larvae [Subharani& Jayaprakash, 2015]..

**To minimize praying mantis predation:**Removing egg masses from the rearing field and eliminating the adult mantises is recommended.

**7. Wasps:*Vespa orientalis***

During early instar rearing and pupal stages, wasps, notably the *Vespa orientalis* and *Xanthopimpla predator* pose a significant threat to silkworm larvae. They seize tiny larvae and fatally injure them. Wasps typically use their stingers to inject venom, incapacitating the larvae before consuming them, causing substantial damage to silk production[Majumdar *et al*., 2021].

**To manage wasp infestations:** Rearing silkworms under a nylon net and utilizing mechanical control methods stand as the primary preventive measures. Additionally, managing insects that produce honeydew, such as aphids, can indirectly decrease wasp attraction.

Fig 7 :Pest Management for Muga Silkworms

**Future Prospects in Pest Management for Muga Silkworms**

The future of managing insect pests in Muga silkworms necessitates a shift towards sustainable and eco-friendly approaches. Research endeavors focusing on novel biopesticides, enhancing host plant resistance, and genetically fortifying silkworms for pest resilience offer promising avenues to combat pest challenges effectively. Additionally, leveraging advancements in digital technologies, such as precision agriculture and remote sensing, can revolutionize pest monitoring and facilitate informed management decisions.Collaborative efforts among researchers, farmers, and policymakers are paramount for translating scientific breakthroughs into practical solutions. Given the substantial challenges posed by insect pests in Muga silkworm rearing, urgent attention is imperative. The unsuitability of chemical insecticides underscores the urgency to embrace environmentally friendly pest management strategies.

**Conclusion:**

This paper presents a comprehensive overview of the primary insect pests impacting Muga silkworms and proposes a repertoire of cultural, biological, and integrated pest management strategies to mitigate their detrimental effects. It is imperative to develop and adopt these sustainable practices to safeguard the invaluable Muga culture in the region and ensure its continuity for generations to come.

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