

Review Article

Advancing Sustainable Sericulture: A Review on Biological Control Agents in Managing Pests and Diseases of Mulberry and Silkworms

ABSTRACT

Sericulture, the culture of rearing of silkworms (*Bombyx mori* L.) for silk production, is significantly impacted by pests and pathogens that affect silkworms and mulberry plants which is primary food source for these insects. Traditional chemical pesticides, though effective, pose risks including environmental pollution and harm to non-target organisms. To address these issues, the sericulture industry is increasingly adopting biological control methods, which utilize natural enemies such as parasitoids, predators and pathogens to manage pest populations in an eco-friendly manner. This approach offers several advantages: it minimizes environmental pollution, protects beneficial organisms and promotes sustainability by leveraging natural pest regulation mechanisms. Key biological control agents in sericulture include parasitoids like *Acerophagus papayae* and *Trichogramma chilonis*, predators such as ladybird beetles, and pathogens including fungal and bacterial species. Despite its benefits, biological control faces challenges such as slower action and environmental dependencies. Effective implementation requires careful planning, integration with other pest management strategies and ongoing monitoring. Overall, biological control represents a significant advancement towards more sustainable and resilient sericulture practices.

Keywords: [Sericulture, Biological Control, Parasitoids, Predators, Pathogens, Sustainable Agriculture]

1. INTRODUCTION

Sericulture, relies heavily on the health and productivity of mulberry plants, the sole food source for these insects. However, both mulberry plants and silkworms are vulnerable to a variety of pests and diseases, which can significantly reduce leaf quality and yield. Infestations from pests and diseases can result in an estimated 25% reduction in mulberry foliage, adversely impacting the nutritional value of the leaves and, consequently, the growth and silk production of silkworms (Rajadurai and Thiagarajan, 2003). Historically, chemical pesticides have been the conventional method for controlling these pest and disease threats. While effective in the short period, the use of chemicals has led to significant unintended consequences, including environmental pollution, health risks to humans and the disruption of beneficial insect populations (Nordlund, 1984). These negative impacts highlight the limitations of chemical control and underscore the need for more sustainable pest management solutions. In response to these challenges, the sericulture industry has increasingly explored biological control methods. This approach employs natural enemies such as parasitoids, predators and pathogens to manage pest populations in an environmentally friendly and sustainable manner (Van Lenteren, 1986). Biological control offers a viable alternative by leveraging natural mechanisms to regulate pest populations,

thereby reducing depending on harmful chemical pesticides, (Singh *et al.*, 1994). By integrating these methods, sericulture can enhance both the health of mulberry plants and also productivity of silkworms while minimizing adverse environmental and health effects. The adoption of biological control represents a significant step towards achieving more sustainable and resilient sericulture practices, (Doutt, 1964).

Biological Control Agents in Sericulture

Biological control involves the use of natural enemies, such as parasitoids, predators and pathogens to control pest populations. This approach offers a promising solution by targeting specific pests in a manner that minimizes environmental impact and promotes long-term pest management sustainability (Singh *et al.*, 1995; 1999 and Hagen *et al.*, 1976).

Parasitoids

Parasitoids are organisms that spend a significant period of their life cycle attached to or within a host organism, eventually killing it. They offer high specificity and effectiveness in pest control due to their targeted nature. In sericulture, several parasitoids have demonstrated efficacy against pests affecting mulberry and silkworms.

➤ *Acerophagus papaya*

Acerophagus papayae is a parasitoid effective against the papaya mealybug (*Paracoccus marginatus*), a significant pest of mulberry. This parasitoid targets the early nymphal stages of the mealybug, making it highly specific to its host. Recommended release practices involve inoculating 100 adults per acre as soon as the pest is detected. The use of *Acerophagus papayae* has been shown to significantly reduce mealybug populations, thereby protecting mulberry plants and ensuring better leaf quality, (Narendra Kumar *et al.*, 2011).

➤ *Trichogramma* Species

Trichogramma chilonis is a well-documented egg parasitoid used extensively to control a range of lepidopteran pests. This tiny parasitoid targets the eggs of various moths and butterflies that infest mulberry plants. The recommended release rate is 100,000 adults per acre in split doses. *Trichogramma chilonis* has been particularly effective in managing pests such as leaf webbers and wasp moths, leading to improved crop health and yield (Singh *et al.*, 1994). Similarly, *Trichogramma embryophagum* has shown promise in controlling other pest species through egg parasitism, (Narendra Kumar *et al.*, 2003).

➤ *Nesolynx thymus*

The uzi fly (*Exorista bombycis*) is a significant parasitoid of silkworms, causing substantial damage. *Nesolynx thymus*, a hymenopteran parasitoid, targets this fly and has proven effective in managing its populations. To optimize its impact, *Nesolynx thymus* should be released in coordination with the silkworm rearing stages. This timing ensures that the parasitoid effectively controls the uzi fly, reducing its detrimental effects on silk production (Singh *et al.*, 1995 and Devaiah *et al.*, 1992).

Predators

Predators are organisms that consume multiple prey items throughout their lifetime for survival, playing a crucial role in managing pest populations. In sericulture, several key predators have been utilized effectively, (Hassell, 1978).

Ladybird Beetles

Ladybird beetles, such as *Cryptolaemus montrouzieri* and *Scymnus coccivora*, are effective predators of the pink mealybug *Pseudococcus longispinus*. Both species consume various life stages of mealybugs, including eggs, nymphs and adults. For optimal control, it is recommended to release 250 beetles per acre per year, split into two doses (Singh *et al.*, 1994; 1995). Careful timing and monitoring of beetle releases are essential to maximizing their impact (Singh *et al.*, 1994; 1995 and Mani *et al.*, 2013). Regular assessments of mealybug populations and beetle activity can enhance the effectiveness of this biocontrol strategy.

Other Predatory Insects

In addition to ladybird beetles, other predatory insects have shown potential in sericulture. For instance, the predatory bug *Orius insidiosus* has been reported to effectively manage pest populations of thrips and other small pests in mulberry and silkworm habitats. The integration of these predators into pest management strategies can enhance overall effectiveness. (Rajadurai *et al.*, 2003 and Bhattacharjee *et al.*, 1994).

Case Studies and Recommendations

Several case studies illustrate the successful application of biological control agents in sericulture.

Ladybird Beetles Against Pink Mealybug

The use of ladybird beetles, such as *Cryptolaemus montrouzieri* and *Scymnus coccivora*, has proven highly effective in controlling pink mealybug populations. Careful timing and monitoring of beetle releases are essential to maximizing their impact (Singh *et al.*, 1995; 1999 and Mani *et al.*, 2013). Regular assessments of mealybug populations and beetle activity can enhance the effectiveness of this biocontrol strategy.

***Trichogramma chilonis* Against Lepidopteran Pests**

Trichogramma chilonis, a tiny parasitoid targeting the eggs of various moths and butterflies, has been successful in reducing pest populations in infested crop fields. For optimal results, *Trichogramma chilonis* should be used in conjunction with other pest management strategies to achieve comprehensive control (Singh *et al.*, 1994 and Jalali *et al.*, 2003).

***Nesolynx thymus* Against Uzi Fly**

Nesolynx thymus, a hymenopteran parasitoid, has effectively managed uzi fly populations affecting silkworms, (Datta *et al.*, 1978). The timing of its release, aligned with the silkworm rearing stages, is crucial for maximizing its impact on the uzi fly (Singh *et al.*, 1995). Regular monitoring and adjustment of release strategies can improve outcomes, (Ram Kishore and Kumar, 1990).

Pathogens

Pathogens used in biological control include bacteria, fungi and viruses that specifically target pests. Although their application is less widespread compared to parasitoids and predators, they can be effective under certain conditions.

➤ Fungal Pathogens

Fungal pathogens such as *Beauveria bassiana* and *Metarhizium anisopliae* have been utilized to control various pests affecting mulberry plants. These fungi infect and kill pests through direct contact and are particularly effective against insect pests, (De Leij *et al.*, 1991). *Beauveria bassiana*, for example, has been shown to control whiteflies and aphids that infest mulberry.

➤ Bacterial Pathogens

Bacterial pathogens, such as *Bacillus thuringiensis* (Bt), are well-known for their efficacy against certain pests. Bt produces toxins that specifically target the larvae of insects like leaf rollers and caterpillars. The application of Bt in sericulture can help manage these pests while minimizing harm to beneficial organisms.

Antagonistic Microorganisms

Trichoderma Species

Trichoderma harzianum and *Trichoderma viride* are antagonistic microorganisms effective against various fungal pathogens affecting mulberry, (Latha *et al.*, 1993 and Banerjee *et al.*, 2016). These fungi work by outcompeting pathogens for resources and producing antagonistic compounds that inhibit pathogen growth (Dhahira Beevi and Qadri, 2010). Their application can significantly reduce disease incidence and support healthier mulberry plants, (Nordlund, 1984 and Shivapratpet *et al.*, 1996).

Plant Extracts

Natural plant extracts, such as garlic, neem and tulsi, have demonstrated efficacy against fungal diseases like *Aspergilliosis* and *muscardine*. Extracts of garlic and datura have been particularly effective, reducing disease incidence without negatively impacting commercial silk production. Incorporating these natural remedies, (Krishna Prasad *et al.*, 1979).

Advantages and Limitations of Biological Control

Biological control offers several promising advantages over traditional chemical methods:

Pollution-Free

Biological control agents do not harm to air, soil or water pollution, making them an environmentally friendly alternative to chemical pesticides. This advantage aligns with the growing emphasis on sustainable agricultural practices (Pritam Singh *et al.*, 1980).

Safe for Non-Target Organisms

Biological control agents typically target specific to pests, leaving other organisms unharmed. This specificity helps maintain ecological balance and supports biodiversity within the sericulture environment (Van Lenteren, 1983).

Sustainable

Biological control agents can perpetuate themselves as long as the pest populations persist, offering a form of long-term pest management. This sustainability is beneficial for maintaining healthy sericulture ecosystems over time (Rajadurai, 2005).

Despite these advantages, biological control also has some limitations:

Slower Process

Biological control methods often take longer to achieve observable results compared to chemical treatments. The gradual nature of biological control can be a drawback in cases requiring immediate pest suppression, (Sathyaprasad *et al.*, 2005).

Limited Scope

Some biological control agents may not be effective against all types of pests or in all environmental conditions. This limitation necessitates careful selection and application based on the specific pest and environmental context.

Dependency on Environmental Conditions

The effectiveness of biological control agents can be depended by various environmental factors, such as the presence of alternate hosts or hyper-parasites. These factors can impact the success of biological control strategies and require ongoing monitoring. (Van Lenteren *et al.*, 2006).

Conclusion

Biological control represents a highly promising and environmentally friendly alternative to traditional chemical pest management in sericulture. By harnessing natural enemies such as parasitoids, predators and pathogens, the sericulture industry can effectively manage pests and diseases while reducing reliance on harmful chemicals. This approach not only mitigates environmental and health risks but also promotes more sustainable practices within the industry. Despite its potential, biological control does come with challenges, including slower action times and limitations in its effectiveness across all pest types and environmental conditions. However, its significant benefits-such as minimizing pollution, protecting non-target organisms, and offering long-term pest management solutions-make it an invaluable component of integrated pest management strategies. To maximize the effectiveness of biological control, careful planning and ongoing research are essential. This includes optimizing the release rates and timing of biocontrol agents, integrating biological control with other pest management practices, and continually monitoring and evaluating their impact. As the sericulture industry continues to evolve towards more sustainable practices,

biological control will undoubtedly play a crucial role in ensuring its future resilience and success.

CONSENT (WHERE EVER APPLICABLE)

Authors may use the following wordings for this section: "All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal.'"

ETHICAL APPROVAL

This article does not contain any studies with human participants or animals performed by any of the authors

REFERENCES

- Banerjee S, Pal S, Mukherjee S, Podder D, Mukherjee A, Nandi A, Debnath P, Sur PK, Ghosh SK. Cellular abnormalities induced by *Trichoderma* spp. during in vitro interaction and control of white muscardine (*Beauveria bassiana*) and green muscardine (*Metarhizium anisopliae*) diseases of silkworm *Bombyx mori*. *Journal of Biopesticides*. 2016;9(2):104-112.
- Bhattacharjee SS, Chakraborty N, Kumar CA, Sahakundu AK. Control of white powdery mildew, *Phyllactiniacorylea* (pers) KARST. with the ladybird beetle, *Illeis indica* Timb. (Coccinellidae: Coleoptera). *Sericologia: An International Journal of Sericulture and Silk Production*. 1994; 34:485-491.
- Datta RK, Mukherjee PK. Life history of *Tricholygabombycis* (Diptera: Tachnidae) a parasite of *Bombyx mori* L. (Lepidoptera: Bombycidae). *Annals of the Entomological Society of America*. 1978; 71:767-770.
- De leij, F.A.A.M, Kerry BR. The Nematophagous fungus *Verticillium chlamydosporium* as a potential biological control agent against *Meloidogyne arenaria*. *Revue de Nematologie*. 1991; 14:157-164.
- Devaiah MC, Govindan R, Narayanaswamy KC. Life cycle of uzi fly *Exoristabombycis*, in *Recent Advances in Uzi Fly Research*. 1992; pp.1-12, Karnataka State Sericulture Development Institute, Bangalore, India.
- Dhahira Beevi N, Qadri SMH. Biological control of Mulberry root rot diseases (*Fusarium* spp.) with antagonistic microorganisms. *Journal of biopesticides*. 2010;3(1):90-92.
- Doutt RL. Biological characteristics of entomophagous adults; in *Biological control of insect pests and weeds*. DeBach, P. (ed.). 1964; pp. 145-167. Reinhold, New York.

- Hagen KS, Bombosch S, Mc Murthy JA. The biology and impact of predators; in Theory and practices of biological control. Huffaker, C. B. and P. S. Messenger (eds.). 1976; pp. 93-142, Academic Press. New York.
- Hassell MP. The dynamics of arthropod predator-prey systems. Princeton University press. 1978; New York.
- Jalali SK, Rabindra J, Rao NS, Dasan CB. Mass production of *trichogrammatids* and chrysopids. Project Directorate of Biological control, Bangalore, India. Technical Bulletin No. 2003;33.
- Krishna Prasad KS, Siddaramaiah AH, Ligaraju S. Possible control of muscardine disease of silkworm by using few plant extracts. Current research. 1979;8(5):79-80.
- Latha J, Govindaiah, Datta RK. In vitro toxic effect of culture filtrate of *Trichoderma* species against *Fusarium pallidroseum* causing leaf blight in Mulberry. Indian Journal of Sericulture. 1993; 32:121-123.
- Mani M, Krishnamoorthy A, Shivaraju C. A wonderful predator (*Cryptolaemus*). Lap Lambert Academic Publishing. 2013; p. 232.
- Narendra Kumar JB, Gopinath OK, Sreenivas BT, Divya SH, Shylesha AN, Vinod Kumar, Shekhar MA, Qadri SMH. Mass production of *Acerophagus papayae* to contain papaya mealybug. Indian Silk: A Journal of Sericulture. 2011;2(1):4-6.
- Narendra Kumar JB, Magadum SB, Kamble CK. Mass Production technique of *Trichogramma*– An egg parasitoid of mulberry leaf roller. Indian Silk: A Journal of Sericulture. 2003;41(10):12-14.
- Nordlund DA. Biological control with entomophagous insects. Journal Georgan Entomological society (2nd supp.).1984;14-27.
- Pritam Singh, Moore RF. Handbook of Insect Rearing, Vol. I & II. Elsevier Science Publishers, Amsterdam;1980.
- Rajadurai S, Thiagarajan V. Mulberry sap sucking pests. Indian silk. 2003;42 (4):5-8.
- Rajadurai S. Mass production technology of predators and parasitoids recommended in IPM practices and of mulberry pests with their insectary models and their requirements. In: Mulberry Crop Protection (Edt. by Govindaiah et al.), CSB publication. 2005;431-459.
- Ram Kishore, Kumar P. Parasitoid of uzi fly *Exoristasorbillans*wiedmann (Diptera: Tachinidae) XII. Biology of *Trichopria* sp. (Hymenoptera :Diapriidae);1990.
- Sathyaprasad K, Manjunath D, Ashwani Kumar C. Insectary facilities and mass production of parasitoids. In: Silkworm Crop Protection (Edt. By Govindaiah et al.) CSB publication. 2005;387-394.

- Shivapratp HR, Philip T, Sharma DD. In vitro antagonism of *Trichoderma* species against Mulberry leaf spot pathogen, *Cercosporamoricola*. Indian Journal of Sericulture. 1996; 35:107-110.
- Singh RN, Sinha BRRP, Sinha SS. Host discrimination between parasitised and unparasitised uzi fly pupae by females of *Trichomalopsisapanteloctena* Crawford (Hymenoptera: Pteromalidae). Trends Life Sci. 1994; 9:27-32.
- Singh RN, Thangavelu K. First record of *Trichomalopsisapanteloctena* on the uzi fly to its parasitoid. Indian Journal of Sericulture. 1995;34:164-165.
- Singh RN, Thangavelu K. Interference among females of *Trichomalopsisapanteloctena* (Hymenoptera: Pteromalidae) and its effect on progeny production Journal of Insect Science. 1999; 12:77-78.
- Van Lenteren JC. Biological Pest Control: Passing fashion of here to stay. Organorama: A Journal of Organismic and Evolutionary Biology. 1983;20:3-9.
- Van Lenteren JC. Evaluation, mass production, quality control and release of entomophagous insects; in Biological Plant and Health Protection. Frang, J. M. (ed.); 1986: pp. 31- 58, Fisher Verlag, Stutt.