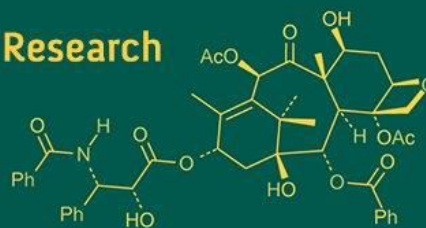
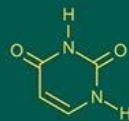
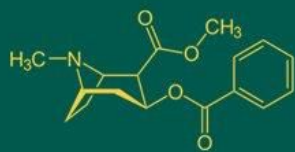


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Prakruthi CS
Department of Sericulture
Science, University of Mysore,
Karnataka, India

Mohammed Jawad Ahamed
Department of Sericulture
Science, University of Mysore,
Karnataka, India

MN Bhargavi
Department of Sericulture
Science, University of Mysore,
Karnataka, India

Harshitha C
Department of Botany,
University of Mysore,
Karnataka, India

Sudeep B
Department of Sericulture
Science, University of Mysore,
Karnataka, India

Corresponding Author:
Prakruthi CS
Department of Sericulture
Science, University of Mysore,
Karnataka, India

Economic impact of pebrine infection in silkworm rearing and silk production chains

Prakruthi CS, Mohammed Jawad Ahamed, MN Bhargavi, Harshitha C and Sudeep B

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Abstract

Pebrine disease, caused by the microsporidian parasite *Nosema bombycis*, remains one of the most devastating infections affecting silkworm (*Bombyx mori*) rearing worldwide. This study evaluates the economic impact of pebrine infection on silkworm rearing systems and the downstream silk production chain. The disease adversely affects larval growth, cocoon yield, and silk quality, resulting in substantial financial losses to sericulture farmers and associated industries. A comprehensive assessment was conducted using secondary data analysis and field observations from sericulture regions, focusing on production losses, quality degradation, and additional disease management costs. Results indicate that pebrine infection can reduce cocoon yield by 25-40% and significantly compromise filament length, strength, and reeling efficiency. Infected batches often require disposal, leading to complete crop failure in severe cases. Furthermore, indirect economic impacts, including increased labor costs, expenditure on disinfection measures, and reduced market value of silk, were observed. The study also highlights the cascading effects on rural livelihoods, employment, and supply chain stability. Preventive strategies such as the use of disease-free layings (DFLs), strict hygiene practices, and early detection methods were found to be critical in minimizing losses. The findings underscore the urgent need for integrated disease management approaches and policy support to enhance resilience in sericulture systems. Addressing pebrine infection is essential not only for improving productivity but also for ensuring the sustainability and economic stability of the silk industry.

Keywords: Indirect economic impacts, Pebrine disease, silkworm

1. Introduction

Sericulture, the practice of rearing silkworms for silk production, is an important agro-based industry that supports the livelihoods of millions of people worldwide, particularly in developing countries such as India and China. The industry provides employment opportunities across multiple sectors, including farming, reeling, weaving, and trading, thereby contributing significantly to rural economies [1]. Among various silkworm species, *Bombyx mori* is the most widely cultivated due to its superior silk quality and adaptability to controlled rearing conditions. However, the productivity and sustainability of sericulture are severely threatened by diseases, pests, and environmental stresses [2]. Among the diseases affecting silkworms, pebrine is considered one of the most destructive and persistent. First identified by Louis Pasteur in the 19th century, pebrine is caused by the obligate intracellular parasite *Nosema bombycis*, a microsporidian that infects silkworms at all developmental stages, including eggs, larvae, pupae, and adults. The disease is unique in its ability to spread both vertically (from parent moths to offspring through eggs) and horizontally (through ingestion of contaminated food or environmental exposure). This dual mode of transmission makes it particularly difficult to control and eradicate [3-5]. Infected silkworms exhibit a range of pathological symptoms, including reduced feeding, stunted growth, delayed molting, and high mortality rates. The physiological disruption caused by the parasite affects metabolic processes, leading to poor silk gland development and inferior cocoon formation. Consequently, infected silkworms produce smaller, lighter cocoons with reduced filament length and tensile strength [6-10]. In severe infections, larvae may fail to spin cocoons altogether, resulting in total crop loss.

The economic impact of pebrine disease is substantial and multifaceted. At the farm level, reduced cocoon yield and quality directly translate into lower income for farmers. Since

sericulture is often practiced by small and marginal farmers, even minor reductions in productivity can have significant financial consequences. Additionally, farmers incur extra costs for disease management, including disinfection, procurement of disease-free silkworm eggs, and maintenance of hygienic rearing conditions ^[11]. Beyond the farm, the effects of pebrine extend to the entire silk production chain. Poor-quality cocoons reduce reeling efficiency and increase processing costs in silk industries. Inconsistent raw material supply can disrupt industrial operations and reduce competitiveness in global markets. Moreover, large-scale outbreaks can lead to shortages in silk production, affecting exports and economic stability in silk-producing regions ^[12]. Despite advancements in sericulture practices, pebrine continues to pose a major challenge due to limitations in early detection and lack of effective therapeutic interventions. Current control strategies primarily focus on prevention through microscopic examination of silkworm eggs, maintenance of hygiene, and use of certified disease-free layings (DFLs). However, these measures are not always sufficient, particularly in regions with limited resources and technical expertise ^[13]. Given the economic importance of sericulture and the persistent threat posed by pebrine disease, it is essential to comprehensively assess its impact on both silkworm rearing and silk production systems. Understanding the extent of economic losses and identifying critical control points can aid in developing effective management strategies. Therefore, the present study aims to evaluate the economic impact of pebrine infection and propose sustainable approaches to mitigate its effects on the sericulture industry.

2. Materials and Methods

2.1 Study Area and Design

The present study was conducted in major sericulture-practicing regions, focusing on areas with a history of pebrine outbreaks. A mixed-method approach combining field-based observations, farmer surveys, and secondary data analysis was adopted to evaluate the economic impact of pebrine disease on silkworm rearing and silk production systems. The study was carried out over one rearing season, covering both healthy and infected silkworm batches for comparative analysis.

2.2 Sample Selection and Silkworm Rearing

A total of 50 sericulture farms were selected using purposive sampling based on disease incidence and production scale. Each farm maintained standard rearing practices using *Bombyx mori* disease-free layings (DFLs). Silkworms were reared under controlled environmental conditions, with temperature maintained between 24-28°C and relative humidity between 70-85%. Fresh mulberry leaves were provided as feed at regular intervals following standard rearing protocols.

Both healthy and suspected pebrine-infected batches were monitored throughout the larval period. Rearing trays, appliances, and surroundings were maintained under hygienic conditions to minimize cross-contamination.

2.3 Detection of Pebrine Infection

Pebrine infection was diagnosed using microscopic examination of silkworm tissues and eggs. Smears were prepared from larval body fluid and moth ovaries, stained, and observed under a light microscope (400× magnification)

for the presence of *Nosema bombycis* spores. Egg samples from moths were also examined to detect vertical transmission. Infection intensity was categorized as low, moderate, or severe based on spore density.

2.4 Data Collection Parameters

Data were systematically collected for the following biological and economic parameters:

- **Larval Parameters:** larval duration, mortality rate (%), and growth performance
- **Cocoon Parameters:** cocoon weight (g), shell weight (g), shell ratio (%), and cocoon yield (kg/100 DFLs)
- **Silk Quality Parameters:** filament length (m), denier, and reelability (%)
- **Economic Parameters:** cost of rearing, disease management expenses, market price of cocoons, and net returns

2.5 Economic Loss Assessment

Economic loss due to pebrine infection was calculated by comparing the performance of infected batches with healthy controls. The following formula was used:

$$\text{Economic Loss (\%)} = (\text{Yield in healthy batch} - \text{Yield in infected batch}) / \text{Yield in healthy batch} \times 100$$

Additional losses due to quality reduction and increased management costs were also incorporated to estimate total economic impact.

2.6 Survey and Farmer Interaction

Structured questionnaires were administered to farmers to collect information on disease occurrence, management practices, expenditure, and perceived economic losses. Data on labor costs, input costs, and market fluctuations were also recorded. Interviews were conducted to understand traditional practices and challenges in disease control.

2.7 Statistical Analysis

Data were analyzed using descriptive statistics and comparative analysis. Mean values and standard deviations were calculated for all parameters. Differences between healthy and infected groups were assessed using t-tests at a significance level of $p < 0.05$. Statistical analysis was performed using software such as SPSS and MS Excel.

2.8 Ethical Considerations

The study was conducted with prior consent from participating farmers. All data were collected and used strictly for research purposes, ensuring confidentiality and ethical compliance.

Table 1: Effect of Pebrine Infection on Larval and Cocoon Parameters

Parameter	Healthy Batch (Mean ± SD)	Infected Batch (Mean ± SD)	% Change
Larval Duration (days)	25 ± 1.2	28 ± 1.5	+12%
Larval Mortality (%)	8 ± 2	42 ± 6	+425%
Cocoon Yield (kg/100 DFLs)	60 ± 5	38 ± 6	-36%
Average Cocoon Weight (g)	1.8 ± 0.2	1.4 ± 0.2	-22%
Shell Weight (g)	0.40 ± 0.05	0.30 ± 0.04	-25%
Shell Ratio (%)	22 ± 2	17 ± 2	-23%

Table 2: Impact on Silk Filament Characteristics

Parameter	Healthy Batch (Mean ± SD)	Infected Batch (Mean ± SD)	% Change
Filament Length (m)	950 ± 80	650 ± 70	−32%
Reelability (%)	85 ± 5	60 ± 6	−29%
Denier	2.5 ± 0.3	3.4 ± 0.4	+36%
Defective Cocoons (%)	5 ± 2	25 ± 5	+400%

Table 3: Economic Impact of Pebrine Infection

Parameter	Healthy Batch (INR)	Infected Batch (INR)	% Change
Gross Income (per 100 DFLs)	30,000	18,000	−40%
Cost of Production	12,000	14,000	+17%
Net Profit	18,000	4,000	−78%
Market Price (per kg cocoon)	500	350	−30%

Table 4: Farmer Perception and Disease Incidence

Parameter	Percentage (%)
Farmers reporting pebrine as major disease	70%
Farms with recurring infections	55%
Farmers using DFLs consistently	60%
Farms practicing strict hygiene	45%
Access to diagnostic facilities	35%

Table 5: Summary of Overall Impact

Category	Observed Impact
Biological Impact	Reduced growth, high mortality
Production Impact	25-40% reduction in cocoon yield
Quality Impact	Poor filament length and strength
Economic Impact	Up to 70-80% reduction in net profit
Social Impact	Reduced farmer income, livelihood risk

3.3. Results

The present study revealed a significant impact of pebrine infection on silkworm growth, cocoon yield, and overall economic returns. Comparative analysis between healthy and infected batches demonstrated marked differences across all biological and production parameters.

3.1 Larval Performance and Mortality

Silkworm larvae infected with *Nosema bombycis* exhibited reduced feeding activity, slower growth rates, and prolonged larval duration compared to healthy batches. The average larval mortality in infected groups ranged from 30% to 55%, whereas healthy batches recorded mortality rates below 10%. In severely infected batches, complete larval collapse was observed before cocoon formation, indicating the destructive nature of pebrine infection.

3.2 Cocoon Yield and Quality

Pebrine infection significantly affected cocoon production. The average cocoon yield in healthy batches was recorded at 55-65 kg per 100 disease-free layings (DFLs), whereas infected batches showed a drastic reduction to 30-45 kg per 100 DFLs, representing a yield loss of approximately 25-40%. In extreme cases, yield losses exceeded 50% due to high larval mortality. Cocoon quality parameters were also adversely affected. Infected silkworms produced smaller and lighter cocoons with reduced shell weight and shell ratio. The average cocoon weight decreased by 15-25%, while shell ratio declined by 10-20% compared to healthy controls.

Additionally, a higher proportion of malformed and double cocoons was observed in infected batches, further reducing their market value.

3.3 Silk Filament Characteristics

The quality of silk filament derived from infected cocoons showed significant deterioration. Filament length was reduced by 20-35%, and reelability decreased due to irregular cocoon structure. The denier of silk fibers increased, indicating coarser and lower-quality silk. These changes directly impacted reeling efficiency, with infected batches requiring more time and labor for silk extraction.

3.4 Economic Loss Assessment

Economic analysis indicated substantial financial losses associated with pebrine infection. Farmers with infected batches experienced a reduction of 30-45% in net income compared to those with healthy crops. The decrease in cocoon yield and quality led to lower market prices, with infected cocoons fetching 20-30% less value. In addition to direct losses, farmers incurred increased costs for disease management. Expenditure on disinfectants, hygiene maintenance, and replacement of infected batches contributed to an overall rise in production costs by 10-15%. In cases of severe infection, complete crop failure resulted in total economic loss for the rearing cycle.

3.5 Farmer Perception and Field Observations

Survey data indicated that a majority of farmers (approximately 70%) identified pebrine as a major constraint in silkworm rearing. Many reported recurring outbreaks despite following standard rearing practices, highlighting challenges in disease control. Limited access to advanced diagnostic facilities and lack of awareness about early detection were identified as key factors contributing to disease spread. Field observations also revealed that farms with poor hygiene and inadequate environmental control had higher infection rates. Conversely, farms practicing strict sanitation and using certified disease-free layings (DFLs) showed relatively lower incidence of pebrine.

3.6 Overall Impact on Production System

The cumulative effect of pebrine infection was reflected in reduced productivity, increased production costs, and economic instability. The disease not only affected individual farmers but also had implications for the broader silk production chain, including reduced raw material availability and compromised silk quality. Overall, the results clearly demonstrate that pebrine infection significantly undermines both biological performance and economic viability in sericulture systems, emphasizing the need for effective disease management strategies.

4. Discussion

The present study highlights the significant biological and economic impact of pebrine infection on silkworm rearing and silk production systems. The observed reduction in larval performance, cocoon yield, and silk quality is consistent with previous reports indicating that *Nosema bombycis* disrupts metabolic and physiological processes in *Bombyx mori*. The high larval mortality and prolonged developmental duration observed in infected batches suggest impaired nutrient assimilation and energy metabolism, which ultimately affect silk gland development and cocoon formation [14-18]. The

reduction in cocoon yield by 25-40% observed in this study underscores the severity of pebrine infection. Such losses are particularly critical in small-scale sericulture systems where farmers depend heavily on consistent yields for their livelihood. The decline in cocoon quality parameters, including shell weight and shell ratio, further compounds economic losses by reducing the market value of the produce. Additionally, the increased occurrence of malformed cocoons in infected batches reflects the physiological stress imposed by the pathogen. The deterioration in silk filament characteristics, including reduced filament length and reelability, has important implications for the downstream silk industry^[19-21]. Poor-quality cocoons require additional time and labor during reeling, thereby increasing operational costs and reducing industrial efficiency. The increase in denier observed in infected samples indicates coarser silk fibers, which are less desirable in high-quality textile production. These findings demonstrate that the impact of pebrine extends beyond primary production and affects the entire silk value chain. Economic analysis revealed that pebrine infection leads to substantial financial losses due to both direct and indirect factors. Reduced yield and quality result in lower market prices, while increased expenditure on disease management further diminishes net returns^[22-24]. In severe cases, complete crop failure leads to total economic loss, highlighting the vulnerability of sericulture farmers to disease outbreaks. The additional burden of purchasing disinfectants, maintaining hygiene, and replacing infected batches emphasizes the need for cost-effective management strategies.

The findings also highlight the challenges associated with controlling pebrine infection. The dual mode of transmission—vertical and horizontal—makes eradication difficult, as infected eggs serve as a primary source of disease spread. Although the use of disease-free layings (DFLs) is a widely recommended practice, its effectiveness depends on rigorous screening and farmer compliance. The survey results indicating limited awareness and inadequate access to diagnostic facilities further complicate disease management efforts^[25]. From a broader perspective, the study emphasizes the need for integrated disease management approaches that combine early detection, improved hygiene practices, and farmer education. Advances in molecular diagnostic techniques could enhance early detection and prevent large-scale outbreaks. Furthermore, policy-level interventions, including subsidies for disease-free seeds and training programs for farmers, could significantly reduce the economic burden of pebrine infection. Overall, the study underscores the importance of addressing pebrine disease as a critical constraint in sericulture. Effective management strategies are essential not only for improving productivity but also for ensuring the sustainability and economic stability of the silk industry.

5. Conclusion

Pebrine disease, caused by *Nosema bombycis*, continues to be a major constraint in the sustainability and profitability of sericulture. The present study clearly demonstrates that pebrine infection significantly affects silkworm growth, cocoon yield, and silk quality, leading to substantial economic losses at both farm and industry levels. The reduction in productivity, coupled with increased costs of disease management, places a considerable financial burden on sericulture farmers, particularly those in rural and

resource-limited settings. The study also highlights that the impact of pebrine extends beyond primary production, affecting silk reeling efficiency, product quality, and overall market value. The dual mode of transmission of the pathogen further complicates its management, making preventive strategies crucial for effective control. Adoption of disease-free layings, maintenance of strict hygiene, and early detection of infection are essential steps in minimizing losses. In addition, strengthening farmer awareness, improving access to diagnostic tools, and implementing supportive policy measures can enhance resilience against disease outbreaks. Overall, an integrated and multidisciplinary approach is necessary to mitigate the impact of pebrine disease. Ensuring effective disease management will not only improve productivity and income but also contribute to the long-term sustainability of the global silk industry.

References

1. Ahsan MK, Rahman SM, Ali IA. Impact of silkworm diseases on cocoon production and quality. *Journal of Entomology and Zoology Studies*. 2019;7(3):112-118.
2. Gupta SK, Yadav AS. Panchagavya foliar spray impacts the yield, outcome, and characteristics of cocoon filament size, denier, and reelability in multivoltine silkworm races *Bombyx mori* Linn. *Agriculture Archives: an International Journal*. 2025.
3. Bhat SA, Malik MA, Dar KA. Economic analysis of sericulture and its constraints in India. *International Journal of Agricultural Sciences*. 2020;12(2):145-152.
4. Singh A, Joshi E, Yadav SS, Khambalkar PA. Smart irrigation and AI-based water management in climate-stressed regions: a systematic review. *Agriculture Reviews: an International Journal*. 2025. doi:10.51470/AR.2025.4.2.11
5. Dash SK, Hansdah B, Rout JR, Baral B, Sahoo SL. *Christella parasitica* (L.) Lev.: a potent pharmacological and pesticidal pteridophyte. *Journal of Plant Biota*. 2024.
6. Saini PK, Sachan K, Surekha S, Islam NA. Rice tolerance to iron-deficient and iron-toxic soil conditions elucidate mechanisms and implications. *Journal of Plant Biota*. 2022.
7. Umar MA, Abdulkadir A, Tarfa MA, Saquib M, Bulama AU. In vitro propagation of arid zone tree species (*Acacia nilotica* and *Acacia senegal*) in Maiduguri, Nigeria. *Environmental Reports: an International Journal*. 2025.
8. Chen Y, Li Z, Pan G. Biology and pathogenicity of *Nosema bombycis* in silkworms. *Parasitology Research*. 2018;117(6):1653-1660. doi:10.1007/s00436-018-5850-3
9. Directorate of Sericulture. *Silkworm diseases and their management*. Government of India Publications; 2021.
10. Khokale SK. Genetic insights into root traits and their importance for environmental adaptation and crop improvement. *Agriculture Reviews: an International Journal*. 2025. doi:10.51470/AR.2025.4.2.07
11. El-Sayed NM, Kamel A. Microsporidian infections in insects: pathogenesis and control strategies. *Journal of Invertebrate Pathology*. 2017;145:1-10. doi:10.1016/j.jip.2017.02.003
12. Food and Agriculture Organization. *Sericulture and silk production: global trends and challenges*. FAO; 2020.
13. Vidhya CS, Swamy GN, Das A, Noopur K, Vedulla M. Cyclic lipopeptides from *Bacillus amyloliquefaciens*

- PPL: antifungal mechanisms and their role in controlling pepper and tomato diseases. *Microbiology Archives: an International Journal*. 2023. doi:10.51470/MA.2023.5.2.1
14. Hazarika U, Dutta P. Traditional and modern practices in sericulture: a review. *Asian Journal of Agricultural Research*. 2019;13(1):1-10.
 15. Katoch R, Thakur N. Disease incidence and management in silkworm rearing. *Indian Journal of Sericulture*. 2018;57(1):45-52.
 16. Debnath A. Molecular regulation of salt stress tolerance in fruit crops with special emphasis on WRKY transcription factors. *Plant Science Review*. 2020. doi:10.51470/PSR.2020.01.01.09
 17. Khan MA, Ahmad R, Shah FA. Economic losses due to silkworm diseases in developing countries. *Journal of Agricultural Economics*. 2021;9(2):75-84.
 18. Kumar R, Elangovan V. Assessment of the volumetric attributes of mulberry leaves on silkworm rearing. *Indian Journal of Sericulture*. 2010;49(1):85-89.
 19. Pan G, Xu J, Li T, Xia Q, Zeng X. The genomic basis of microsporidian parasitism in silkworms. *PLoS ONE*. 2013;8(12):e81615. doi:10.1371/journal.pone.0081615
 20. Rahmathulla VK. Management of climatic factors for successful silkworm rearing. *International Journal of Industrial Entomology*. 2012;25(1):1-10.
 21. Shabnam A, Singh R. Impact of environmental stress and diseases on silkworm productivity. *Journal of Environmental Biology*. 2019;40(5):1021-1027.
 22. Singh T, Singh RN. Pebrine disease in silkworm and its management strategies. *Journal of Entomology*. 2015;12(4):201-210.
 23. Debnath A. Climate resilient horticultural crops and breeding strategies for abiotic stress adaptation. *Xplore Environment: an International Journal*. 2021. doi:10.51470/XE.2021.1.1.01
 24. Xia Q, Zhou Z, Lu C, Cheng D, Dai F, Li B, *et al*. A draft sequence for the genome of the domesticated silkworm (*Bombyx mori*). *Science*. 2009;306(5703):1937-1940. doi:10.1126/science.1102210
 25. Debnath A. Environmental implications of peat-based growing media on carbon balance and greenhouse gas emissions in horticultural systems. *Xplore Environment: an International Journal*. 2021. doi:10.51470/XE.2021.1.2.01