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CREATING ENERGY-EFFICIENT DEVICES TO MAINTAIN MICROCLIMATE PARAMETERS IN SERICULTURE BUILDINGS (EXAMPLE OF SILKWORM REARING FACILITIES)

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Abstract: This study investigates the development and implementation of energy-efficient devices for maintaining optimal microclimate conditions in silkworm rearing facilities. Microclimate parameters such as temperature, relative humidity, and air circulation are critical for silkworm growth, cocoon quality, and overall productivity. The research involved the installation of automated heating, cooling, ventilation, and lighting systems equipped with real-time sensors in three sericulture buildings. Results showed that these devices stabilized temperature and humidity, improved air circulation, reduced silkworm mortality, and enhanced cocoon weight and silk thread length. Additionally, energy consumption decreased by approximately 29%, demonstrating both economic and environmental benefits. The findings highlight the importance of integrating energy-efficient technologies in sericulture to ensure sustainable production and improved biological outcomes.

Keywords: Sericulture, Microclimate control, Energy-efficient devices, Silkworm productivity, Sustainable agriculture, Automated ventilation, Temperature and humidity management

Introduction

Sericulture, the cultivation of silkworms for silk production, is a significant sector in the agricultural industry due to its contribution to textile manufacturing and rural employment. The productivity and quality of silkworm cocoons are highly dependent on the microclimate conditions within rearing facilities, including temperature, humidity, ventilation, and light (Kuznetsov et al., 2017)[1]. Maintaining optimal microclimate parameters ensures healthy larval development, reduces mortality rates, and enhances silk yield and quality.

However, conventional methods of controlling the microclimate in sericulture buildings often rely on energy-intensive systems, leading to high operational costs and environmental impacts. Energy consumption in silkworm rearing facilities accounts for a substantial portion of production expenses, particularly in regions with extreme seasonal temperatures (Rahman et al., 2020)[2]. Therefore, developing energy-efficient devices and technologies that can maintain stable microclimate parameters while minimizing energy use has become a priority for sustainable sericulture.

Recent advancements in sensor technologies, automated control systems, and energy-saving devices provide opportunities to optimize the internal environment of sericulture buildings. For instance, automated ventilation systems, humidity controllers, and LED lighting systems can adjust environmental conditions in real-time, responding to fluctuations in external weather and internal microclimate requirements (Sharma & Singh, 2019)[3]. Such innovations not only improve silkworm health and cocoon quality but also reduce energy consumption and operational costs, contributing to sustainable production practices.

The aim of this study is to investigate the design and implementation of energy-efficient devices for maintaining optimal microclimate conditions in sericulture buildings. Specifically, the study focuses on silkworm rearing facilities, examining the effectiveness of these devices in stabilizing temperature, humidity, and ventilation while minimizing energy use. By addressing these challenges, the study seeks to provide practical solutions for sustainable sericulture and enhanced silk production efficiency.

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[1] Kuznetsov, V. N., Ivanov, P. S., & Petrov, A. M. (2017). *Microclimate management in sericulture: Principles and practice*. Journal of Sericulture Science, 45(2), 112–123.
[2] Rahman, M. A., Hossain, M. K., & Islam, M. R. (2020). Energy consumption patterns in silkworm rearing facilities and sustainable solutions. *Renewable Agriculture and Food Systems*, 35(5), 421–430.
[3] Sharma, R., & Singh, K. (2019). Automation and energy efficiency in sericulture buildings. *International Journal of Agricultural Engineering*, 12(3), 215–224.

Materials and Methods

This study aimed to develop and evaluate energy-efficient devices for maintaining optimal microclimate parameters in silkworm rearing facilities. The research focused on three sericulture buildings located in regions with different climatic conditions to ensure comprehensive assessment. The main microclimate parameters monitored included temperature, relative humidity, and air circulation, as these are critical for silkworm health, larval development, and cocoon quality.

The materials used included standard silkworm rearing trays and racks, temperature and humidity sensors, air velocity sensors, programmable heating and cooling units, automated ventilation systems, energy-efficient air circulation fans, LED lighting systems optimized for silkworm activity, and data acquisition systems for continuous monitoring. Baseline measurements of microclimate parameters and energy consumption were first taken over a 30-day period during peak silkworm rearing season without the use of energy-efficient devices to identify areas requiring improvement.

Following baseline data collection, energy-efficient devices were installed and calibrated to maintain temperature between 24 and 28 degrees Celsius, relative humidity between 70 and 85 percent, and adequate air circulation throughout the facilities. The devices were programmed to respond automatically to external weather changes and internal microclimate fluctuations. Data on energy consumption, temperature, humidity, larval growth rates, and cocoon quality were recorded continuously.

The effectiveness of the devices was evaluated by comparing the microclimate stability, energy consumption, silkworm mortality rates, larval growth uniformity, and cocoon quality, including weight, silk thread length, and silk uniformity, before and after the installation. Statistical analysis was performed using descriptive statistics and paired t-tests to determine the significance of changes in environmental stability, energy savings, and silkworm productivity. Qualitative observations were also made regarding the operational efficiency, maintenance requirements, and usability of the devices.

This comprehensive methodological approach provided reliable data on the impact of energy-efficient devices on microclimate regulation and silkworm productivity, enabling practical recommendations for sustainable sericulture practices.

Results

The implementation of energy-efficient devices in silkworm rearing facilities led to significant improvements in microclimate stability, energy consumption, and silkworm productivity. Temperature and humidity were maintained within the optimal range of 24–28°C and 70–85% relative humidity, respectively, compared to fluctuating conditions prior to device installation. Air circulation throughout the facilities became more uniform, ensuring proper ventilation and preventing hotspots that could negatively affect larval development.

Energy consumption decreased substantially after the installation of energy-efficient heating, cooling, and ventilation systems. The automated devices adjusted to external weather conditions and internal fluctuations, leading to energy savings while maintaining ideal microclimate parameters. Silkworm mortality rates decreased, growth uniformity improved, and cocoon quality, including weight and silk thread length, increased.

Table 1. Comparison of Microclimate Parameters, Energy Consumption, and Silkworm Productivity Before and After Device Installation

Parameter	Before Installation	After Installation	Change (%)
Average Temperature (°C)	26.5	26.8	+1.1
Relative Humidity (%)	65–90	72–83	Improved stability
Air Circulation (m/s)	0.2–0.8	0.5–0.6	More uniform
Energy Consumption (kWh/day)	120	85	-29.2
Silkworm Mortality Rate (%)	12	5	-58.3
Average Cocoon Weight (g)	1.2	1.45	+20.8
Silk Thread Length (m)	400	480	+20

The results demonstrate that energy-efficient devices effectively stabilized temperature and humidity, improved air circulation, and reduced energy consumption by approximately 29%. Silkworm mortality was reduced by more than half, and cocoon quality metrics improved by around 20%. These findings highlight the dual benefit of maintaining optimal microclimate conditions while reducing operational costs, confirming the efficiency and practicality of the proposed devices.

Discussion

The results of this study indicate that the implementation of energy-efficient devices in sericulture buildings significantly improves microclimate stability, reduces energy consumption, and enhances silkworm productivity. Maintaining optimal temperature and humidity levels is critical for silkworm growth and cocoon quality, as fluctuations in these parameters can lead to increased mortality, slowed larval development, and lower silk yield (Kuznetsov et al., 2017)[1]. The devices used in this study maintained temperature within 24–28°C and relative humidity within 70–85%, which aligns with recommended conditions for optimal larval health (Rahman et al., 2020)[2].

Energy savings were substantial, with a reduction of approximately 29% in daily energy consumption. This demonstrates that automated heating, cooling, and ventilation systems, when combined with sensors and real-time feedback, can optimize the internal environment while minimizing energy costs. Similar findings have been reported in other studies, where smart climate control systems in agricultural and animal-rearing facilities reduced energy consumption without compromising productivity (Sharma & Singh, 2019)[3]; (Li et al., 2021)[4].

The decrease in silkworm mortality from 12% to 5% and the improvement in cocoon weight and silk thread length by about 20% highlight the direct impact of stable microclimate conditions on silkworm health and productivity. These outcomes suggest that precise environmental control not only benefits energy efficiency but also enhances the economic viability of sericulture operations. Previous research has similarly emphasized that optimal microclimate management is closely associated with improved biological performance and silk quality (Khan et al., 2018)[5].

Air circulation improvements observed in this study also contributed to better larval development by preventing localized hotspots and ensuring even distribution of temperature and humidity throughout the facility. Proper ventilation is essential for reducing the risk of fungal infections and maintaining a healthy rearing environment (Chowdhury et al., 2019)[6]. The use of automated fans and airflow management systems ensured consistent circulation, which is particularly important during periods of high larval density.

Furthermore, the integration of energy-efficient devices supports sustainable sericulture practices by reducing operational costs and environmental impact. The combination of sensor-based automation, LED lighting, and efficient heating and ventilation systems aligns with global trends in sustainable agriculture and precision farming. Such innovations not only improve productivity but also contribute to environmental conservation by reducing carbon footprint and energy demand (Rahman et al., 2020)[2].

The findings of this study also underscore the importance of combining quantitative monitoring with qualitative observations. Operational efficiency, ease of maintenance, and usability of devices were positively received by facility managers, indicating that practical implementation is feasible and scalable. Future studies could explore the integration of renewable energy sources, such as solar panels, to further enhance sustainability and cost-effectiveness in sericulture facilities.

Overall, this discussion highlights that energy-efficient devices provide a comprehensive solution for maintaining optimal microclimate conditions, enhancing silkworm productivity, and promoting sustainable practices. The combination of environmental control, energy savings, and improved biological outcomes demonstrates the multifaceted benefits of technology integration in modern sericulture.

Conclusion

The study demonstrates that the implementation of energy-efficient devices in silkworm rearing facilities significantly improves microclimate stability, reduces energy consumption, and enhances silkworm productivity. Temperature, relative humidity, and air circulation were maintained within optimal ranges, contributing to lower larval mortality, more uniform growth, and improved cocoon quality, including higher weight and longer silk threads.

Energy-efficient heating, cooling, and ventilation systems, combined with automated control and real-time monitoring, achieved approximately 29% reduction in energy consumption without compromising environmental conditions. These findings highlight the dual benefits of technology integration: sustainable resource use and enhanced biological performance.

Additionally, the practical usability of these devices and positive feedback from facility managers suggest that the approach is scalable and applicable to various sericulture operations. The integration of automated, energy-saving devices not only supports sustainable production but also promotes economic efficiency and environmental responsibility.

Overall, the study confirms that energy-efficient devices are indispensable for modern sericulture practices, offering a comprehensive solution for maintaining optimal microclimate parameters, improving silkworm productivity, and reducing operational costs. Future research could focus on incorporating renewable energy sources and further automation to maximize sustainability and cost-effectiveness.

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