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Precision Rearing: Optimizing Silkworm Growth through Climate Stability

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Abstract: *Sericulture mainly depends on environmental conditions, and temperature is one of the most important factors for silkworm growth. Small changes in temperature can affect feeding, growth, and cause uneven cocoon formation. It is difficult to keep the temperature stable because of changing weather in a traditional system.*

This paper examines how temperature influences the various developmental stages of silkworms. It shows that keeping the temperature stable is very important. The paper also looks at the use of technologies like sensors and IoT systems to control the temperature inside rearing houses. The study is based on previous research and practical observations in sericulture. It illustrates how silkworms respond to temperature changes and how proper control can enhance their growth. The results show that keeping the temperature steady can raise silk production, enhance cocoon quality, and reduce silkworm deaths. Still, there are challenges in implementing automated systems in rural areas, such as high initial costs and inadequate infrastructure. The paper proposes simple, low-cost solutions that farmers can easily adopt in real-world conditions.

Keywords: sericulture, temperature control, silkworm growth, IoT system, automated systems.

I. INTRODUCTION

Sericulture is an important agro-based industry that provides livelihood to rural populations and contributes significantly to textile production. The success of sericulture largely depends on environmental conditions such as temperature, humidity, and ventilation. Between these, temperature plays a main role in silkworm development. Silkworms are poikilothermic organisms, means their body temperature depends on surrounding environmental conditions. Therefore, even small variations in temperature can significantly affect their growth, metabolism, and silk production [4]. Improper environmental conditions can lead to increased susceptibility to diseases, reduced cocoon quality, and lower silk yield [1]. Farmers generally depend on manual methods to regulate these conditions, such as opening windows, using heaters, or sprinkling water, which are not only labour-intensive but also inefficient at maintaining precise environmental control. In traditional rearing systems, maintaining a stable temperature is difficult because of natural climatic variations, which leads to inconsistent productivity. Recent technological developments have increased interest in using automated environmental control systems in sericulture. Modern approaches involve the use of sensors, microcontrollers, and Internet of Things (IoT)-based systems to monitor and regulate temperature and humidity in real time [2]. These systems can help maintain optimal rearing conditions, reduce human intervention, and improve overall productivity and quality of silk. Climate change and increasing environmental variability have made it even more challenging to sustain consistent silkworm rearing conditions using conventional methods [3]. This approach involves the development of cost-effective, energy-efficient, and reliable systems that can assist farmers in maintaining ideal rearing environments throughout different seasons. Therefore, this study focuses on analyzing the impact of temperature on silkworm growth and proposes a controlled system for maintaining optimal environmental conditions. The objective is to enhance cocoon quality, increase silk yield, and provide a sustainable solution for sericulture farmers by integrating modern technological tools with traditional practices.

II. LITERATURE REVIEW AND ANALYSIS OF TEMPERATURE EFFECTS

A. LITERATURE REVIEW

Previous research consistently emphasizes the importance of temperature control in sericulture. It has been reported that each developmental stage of silkworms requires a specific thermal range to ensure proper growth and development [4]. Inadequate environmental regulation results in poor cocoon quality and decreased survival rate, ultimately reducing overall production efficiency [5].

Further studies have shown that silkworm feeding behaviour is highly affected by temperature variations, which directly impacts larval weight gain and silk yield [6]. Elevated temperatures generally speed up larval development but may produce weaker larvae, whereas lower temperatures slow down metabolic activity and prolong the rearing cycle [7].

Maintaining a stable temperature environment has been found to significantly enhance cocoon shell weight and improve silk quality [8]. In recent years, IoT-based monitoring systems have been developed for sericulture applications. These systems integrate sensors, microcontrollers, and automated control mechanisms to regulate temperature and humidity in real time [9], [13]. In summary, existing literature clearly indicates that accurate temperature regulation plays a crucial role in improving silkworm growth, cocoon quality, and silk productivity. At the same time, modern technological solutions present promising alternatives to overcome the limitations of conventional rearing practices. Traditional sericulture practices rely on manual techniques such as natural ventilation control, wet cloth-based cooling, and basic heating arrangements. Although these methods are inexpensive and easy to implement, they are unable to provide accurate regulation of environmental conditions and often result in inconsistent performance [12]. Recent developments in technology have led to the adoption of sensor-based monitoring techniques and IoT-enabled systems for regulating environmental conditions. These systems are capable of automatically controlling temperature through devices such as fans, heaters, and cooling units [13]. IoT-integrated solutions enable continuous real-time monitoring along with remote accessibility, which enhances system reliability and improves productivity. However, their practical deployment is still limited in rural regions due to challenges such as high implementation cost, lack of technical expertise, and maintenance difficulties [14].

B. Analysis of Temperature Effects

Temperature has a significant influence on silkworm physiological processes such as metabolism, digestion, and enzyme functioning. For effective sericulture, the recommended temperature range is typically maintained between **23°C and 28°C** [5].

Within this optimal range, silkworms exhibit better feeding activity, faster growth, and overall healthy development. However, when the temperature moves outside this range, the larvae experience environmental stress, which negatively affects their growth performance and reduces productivity.

i. Feeding and Growth Behaviour-

Silkworm feeding behaviour is highly dependent on surrounding environmental temperature. When maintained within the ideal range of **23°C to 28°C**, larvae consume mulberry leaves actively and show consistent growth.

In contrast, temperatures below the optimal range lead to reduced metabolic rate, weak feeding response, and delayed larval development. On the other hand, higher temperatures cause heat stress conditions, resulting in decreased appetite, reduced growth efficiency, and poor cocoon formation [6], [7].

Temperature Range	Effect on Silkworms	Result
Below 23°C	Slow metabolism, reduced feeding	Delayed growth
23°C – 28°C	Optimal growth and feeding	High yield
Above 28°C	Heat stress, reduced appetite	Poor cocoon quality
Above 32°C	Severe stress	High mortality

Table 1: Effect of Temperature on Silkworm Performance

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ii. Effect of Temperature on Silkworm Performance-

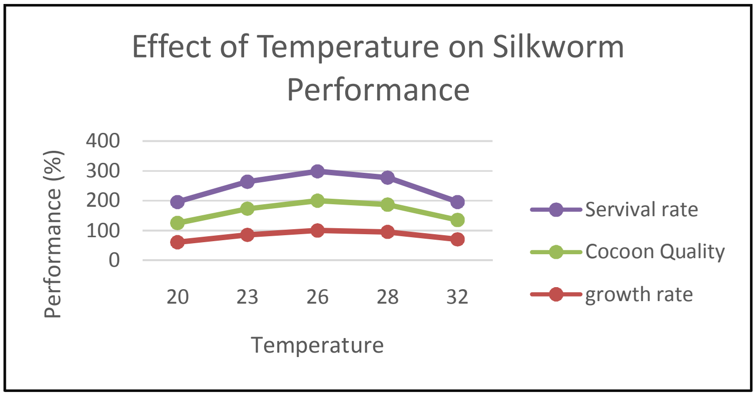

Figure 1: Effect of Temperature on Silkworm Performance

Fig. 1 indicates that silkworm performance gradually improves with increasing temperature and reaches its peak near 26°C. Within the optimal range of 23°C to 28°C, key parameters such as growth rate, cocoon quality, and survival rate remain at their highest levels. However, when the temperature deviates beyond this range, a noticeable decline in performance is observed due to thermal stress conditions. Lower temperatures slow down metabolic processes, whereas higher temperatures adversely affect larval health and reduce silk productivity.

iii. Cocoon Quality and Yield-

Maintaining a stable thermal environment contributes to better cocoon uniformity, increased shell weight, and improved silk quality. In contrast, fluctuations in temperature negatively impact cocoon structure and lead to reduced overall yield [8].

iv. Mortality and Disease-

Extreme temperature conditions significantly influence silkworm health and survival. Elevated temperatures create favourable conditions for pathogen development, increasing disease risk, while lower temperatures weaken the immune response of larvae, thereby raising mortality rates [11].

III. METHODOLOGY

The methodology followed in this work is based on a detailed examination of existing literature along with the conceptual development of a cost-effective temperature regulation system for silkworm rearing applications. In the initial phase, various research articles, technical documents, and previously developed sericulture monitoring systems were studied to gain a clear understanding of how environmental factors influence silkworm growth and productivity. From this investigation, temperature was identified as the most significant parameter affecting key biological activities such as feeding behaviour, metabolic processes, cocoon development, and overall yield. Based on reported studies, the suitable temperature range for efficient silkworm rearing is considered to be 23°C to 28°C.

Using these observations, a system-oriented approach is formulated to ensure stable environmental conditions within the rearing environment. The proposed approach is based on continuous monitoring of temperature, followed by processing of the measured data and automated control of heating and cooling mechanisms. A temperature sensor is employed to capture real-time environmental readings, which are then forwarded to a microcontroller serving as the central processing unit. The microcontroller evaluates the incoming data by comparing it with predefined threshold limits and initiates appropriate corrective actions. If the recorded temperature rises above the upper limit, cooling devices such as fans are activated, whereas heating elements are switched on when the temperature drops below the

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lower limit. When the temperature remains within the desired range, the system operates in a monitoring state without triggering any control action.

Furthermore, an optional IoT-based module is included in the design to support remote observation of environmental conditions through mobile or web platforms. This allows farmers to access real-time data without being physically present at the rearing site. The overall approach emphasizes the development of a simple, economical, and efficient solution that can be easily implemented in rural sericulture environments to enhance silk production and improve cocoon quality.

IV. PROTOTYPE DESIGN

The proposed system focuses on developing an automated temperature regulation framework for silkworm rearing environments to maintain stable climatic conditions. The primary objective of this system is to reduce dependency on manual monitoring while ensuring that silkworms are reared under optimal environmental conditions, thereby improving growth performance and productivity.

The system is organized into three fundamental units: a sensing unit, a processing unit, and an actuation unit. The sensing unit is responsible for continuously capturing ambient temperature inside the rearing chamber using sensors such as DHT11 or DHT22. The measured values are transmitted to a microcontroller, which functions as the central control unit of the system. This microcontroller processes the incoming data and evaluates it against predefined threshold limits corresponding to the optimal temperature range of 23°C to 28°C.

Based on this comparison, appropriate control actions are executed automatically. If the temperature rises above the upper threshold, a cooling system such as a fan is activated to reduce the temperature. Conversely, if the temperature falls below the lower threshold, a heating element is switched on to restore suitable conditions. When the temperature remains within the desired range, the system operates in a passive monitoring mode without activating any external devices.

In addition, the system integrates an IoT-based module to facilitate remote monitoring and data access through mobile applications or web interfaces. This feature enables farmers to observe environmental conditions in real time without requiring physical presence at the rearing site.

Overall, the proposed design emphasizes simplicity, cost-effectiveness, and ease of deployment, making it suitable for rural sericulture applications where resources and technical infrastructure are limited.

Working of the system:

The work is based on continuous monitoring and automatic control of temperature inside the silkworm rearing house. The process starts with the temperature sensor, which continuously measures the environmental temperature within the rearing house. This sensor sends data to the microcontroller. The microcontroller acts as the central unit of the system. It receives the real-time temperature from the sensor and compares it with the predefined optimal range required for silkworm growth, typically between 23°C and 28°C. If the temperature is higher than the upper limit, the microcontroller activates the cooling system, such as a fan or ventilation unit, to reduce the temperature inside the rearing environment. If the temperature drops below the lower limit, the heating system is switched on to restore suitable conditions for silkworm development. In addition to temperature control, the system also includes an IoT module. This module transmits real-time environmental data to a mobile or web-based application. It allows farmers to monitor the rearing conditions remotely. This feature improves accessibility and helps in quick decision-making without requiring physical presence at the site.

Overall, the system works in a closed-loop feedback manner where continuous sensing, processing, and actuation ensure a stable environment, which is necessary for healthy silkworm growth and improved silk production.

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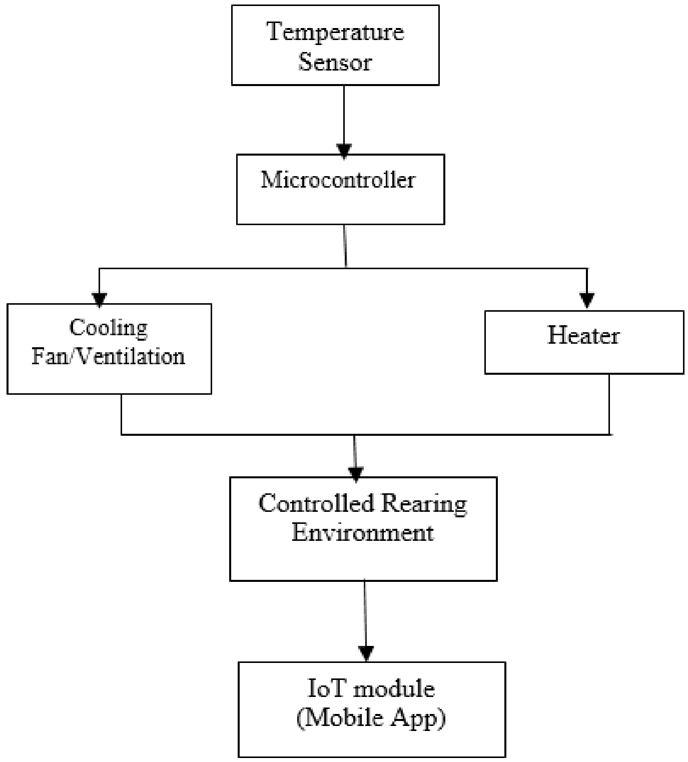

Fig. 2. Block diagram of IoT-based temperature control system for silkworm rearing

V. CHALLENGES IN IMPLEMENTATION

While automated temperature control systems provide several advantages, their practical application in sericulture is still limited due to real-world constraints. One major challenge is the relatively high initial cost of sensors, controllers, and other electronic components, which may be difficult for small-scale farmers to afford. In many rural areas, another challenge is the lack of awareness and basic technical knowledge about electronic systems. This makes installation and operation difficult without proper training or guidance. In addition, irregular electricity supply can break system functioning and stop continuous monitoring and control of environmental conditions. Maintenance is also a concern because repairing and servicing electronic devices may not be easily available in farming locations. Because of these combined factors, the implementation of automated solutions remains slower in traditional sericulture practices.

VI. FUTURE SCOPE

In future scope one can focus on designing affordable, energy-efficient, and user-friendly automation solutions suitable for farmers. Many small-scale farmers experience financial and technical boundaries, so proposed systems should be easy to operate and maintain. Solar-powered technologies can help as a sustainable option, particularly in rural regions with access to irregular electricity. In addition, hybrid control systems that connect both manual and automated operations can provide greater flexibility and help farmers accept new technologies with confidence.

VII. CONCLUSION

Temperature management plays a vital role to increase the yield of sericulture production. Maintaining stable environmental condition helps to ensure healthy silkworm growth, better cocoon quality, and higher silk yield. Although modern technologies offer efficient solutions, their high cost and complexity often make them difficult for small-scale farmers to adopt. In many rural areas, limited access to resources further adds to these challenges. Therefore, there is a strong need for affordable, simple, and easy-to-use temperature control systems. Such practical solutions can support farmers in improving productivity while promoting sustainable and inclusive growth in the sericulture sector. Further the IoT integration will help for continuous monitoring and controlling of vital parameters affecting the growth of silkworms.

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