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Exploring the impact of food plants on the life cycle of Samia ricini: A study on Eri silkworm rearing

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Abstract
The North-Eastern region of India boasts a rich and proud Seri cultural legacy, where a diverse ecosystem of sericigenous insects thrives and giving rise to a vibrant silk culture. Among the remarkable silk-producing species found here are the Eri (*Samia ricini* Donovan), Muga (*Antheraea assamensis* Helfer), Oak Tasar (*Antheraea proylei* Jolly), and Mulberry silk (*Bombyx mori* Linn.). At the heart of this silk-producing ecosystem are the visually captivating Eri silkworm larvae, known for their polyphagous nature as they consume a diverse range of host plants. Among them, the Castor plant (*Ricinus communis*) plays a pivotal role as the primary food source. However, in times of food scarcity, the Eri silkworms display remarkable adaptability by surviving on select non-host plant species, known as secondary and tertiary host plants. To gain deeper insights into the dynamics of Eri silkworm feeding, a comprehensive study has been undertaken to explore the acceptance of two commonly available alternative food plants, Gamari (*Gmelina arborea*) and Papaya (*Carica papaya*), during the rearing period. The study specifically investigates the impact of independent feeding of castor and sequential feeding of castor, gamari, and papaya on the life cycle duration of *Samia ricini*. Key objectives include determining the life cycle duration under different feeding scenarios and assessing the survival rate across various feeding conditions. By unraveling the intricate relationship between food plants and the life cycle of *Samia ricini*, this experimental study sheds crucial light on the potential benefits of alternative food sources for Eri silkworm rearing.

Keywords: Castor, gamari, papaya, life cycle duration, interchanged feeding, independent feeding

Introduction

The North-Eastern region of India serves as an ideal habitat for a diverse range of wild sericigenous insects, making it a prominent center for wild silk production. This includes the cultivation of Eri (*Samia ricini* Donovan), Muga (*Antheraea assamensis* Helfer), Oak Tasar (*Antheraea proylei* Jolly), and Mulberry silk (*Bombyx mori* Linn.). India proudly stands as the largest global producer of Eri silk, with a staggering 96% of Eri silk originating from the country. The North-Eastern region of India, known for its abundant sericigenous insect population and their host plants, boasts a rich heritage of sericulture that dates back to ancient times [1]. The cultural significance of Samia species silk is deeply ingrained within the local communities of North-Eastern India. Eri-culture plays a pivotal role in India's sericulture sector, and it has recently expanded to non-traditional regions across the country. The Eri silkworm genus, Samia, comprises 19 species worldwide, including the wild species Samia fulva and Samia canningi. Additionally, the domesticated species, *Samia ricini*, can be found in the North-Eastern region of India, as well as in other parts of the country [2]. The rearing of the multivoltine *Samia ricini* Donovan primarily takes place indoors, resulting in the production of white or brick-red cocoons. Although its cultivation is mainly concentrated in the North-Eastern states of India, particularly Assam, it is also practiced on a smaller scale in Orissa, West Bengal, and Bihar. The Eri silkworm larvae exhibit a variety of colors, including green, blue, yellow, white, and zebra or semi-zebra patterns. Being a polyphagous insect, Eri silkworm has a diverse diet consisting of leaves from various food plants, such as Castor (*Ricinus communis* L), Tapioca (*Manihot esculenta* Crantz), Wild Castor (*Jatropha curcas* L), Papaya (*Carica papaya* L), Barkesseru (*Ailanthus excelsa* Roxb), Kesseru (*Heteropanax fragrans* Seem), and many others.

Although the Eri silkworm is known to consume leaves from over 30 host plant species, castor is widely recognized as the primary host plant [3-7]. The quality of feed significantly influences the growth and development of the silkworms, ultimately impacting the economic traits of the cocoons [8]. Not all food plants are equally suitable for Eri silkworm rearing, and the silkworms exhibit different behaviors when reared on different food plants [9]. In situations where Eri silkworms face food scarcity and their preferred host plants are unavailable, they can survive on certain non-host plant species, which are referred to as secondary and tertiary host plants. Thus, the present study aims to explore the acceptance of commonly available Gamari (*Gmelina arborea*) and Papaya (*Carica papaya*) by Eri silkworms during their rearing period. Considering the aforementioned facts and factors, this experimental study focuses on the impact of independent feeding of Castor (*Ricinus communis*) and the alternation between feeding Castor (*Ricinus communis*) and Gamari (*Gmelina arborea*) or Papaya (*Carica papaya*) as food plants on the life cycle duration of *Samia ricini* Donovan. Additionally, the study investigates the survival rate of the Eri silkworms under these feeding conditions.

Materials and Methods

The present study aimed to investigate the effects of independent and sequential feeding of different food plants on the life cycle duration of *Samia ricini* Donovan over a period of two and a half months. Throughout the study, the temperature was maintained at 25 °C – 28 °C, while the humidity levels were kept between 75% and 80%. Disease-free Eri silkworm eggs, obtained from Bogidhola Village Grazing Reserve in Golaghat, Assam, were used for the experiments. To ensure cleanliness and prevent contamination, the eggs underwent a 15-minute disinfection process using a 2% formalin solution, followed by rinsing with tap water before being placed in an incubator for hatching [10]. Given the polyphagous nature of the larvae, three different host plants, namely Castor, Gamari, and Papaya, were utilized to assess the impact on the life cycle duration. Upon hatching, the newly emerged larvae were carefully transferred to rearing trays using a feather. First and second instar larvae were fed tender leaves four times a day, while third instar larvae received medium-aged leaves. Matured leaves were provided five times a day to the fourth and fifth instar larvae. Regular bed cleaning was conducted to maintain hygiene, and once the larvae reached maturity, they were transferred to the mount age for cocoon spinning. On the sixth day of spinning, the cocoons were harvested.

Food Plants

The food plants can be found in both their natural habitats and cultivated environments. In the context of the current experimental study, castor (*Ricinus communis* Linn.) was chosen as the primary food plant for the Eri silkworms. Additionally, Gamari and Papaya were utilized as secondary food plants in the study.

Ricinus communis **(Castor):** Castor, belonging to the family Euphorbiaceae, serves as the primary food plant for the Eri silkworm. It is a heat-loving intermediate plant that typically exhibits an annual growth cycle, although it can occasionally be perennial. Castor thrives in acidic to neutral pH conditions and prefers well-drained, sandy loam, loamy, and black soils. In India, there are several varieties of castor available, including NBR-1, local green, local pink, and 48-1, which have shown exceptional performance in terms of leaf yield and suitability for silkworm rearing in the North-Eastern region. During independent rearing, the Eri silkworm (Samia ricini Donovan) larvae were fed tender castor leaves twice a day until the third instar stage. As the larvae progressed to the fourth and fifth instar, they were provided semi-tender and mature castor leaves, respectively, five times a day. In the case of interchanging feeding, tender castor leaves were offered twice a day until the third instar larvae stage.

Gmelina arborea **(Gamari):** Gamari is a timber plant that can be found across the North-Eastern and Eastern regions of India. While it is not commonly used as a primary host plant for the Eri silkworm (*Samia ricini* Donovan), it serves as an alternative option during periods of acute leaf shortage. Gamari is an unarmed, moderate to large deciduous tree characterized by a straight trunk. With its wide-spreading growth pattern and numerous branches, it forms a large shady crown. The leaves of gamari are opposite, decussate (arranged in a cross pattern), and possess a soft and limp texture. During the fourth and fifth instar stages of the Eri silkworm larvae, gamari leaves are interchanged with castor leaves. The larvae are fed gamari leaves thrice a day, alongside the regular feeding schedule.

Carica papaya **(Papaya):** Papaya, scientifically known as *Carica papaya* and locally referred to as "Omita" in Assam, is a remarkable herbaceous succulent plant that belongs to the Caricaceae family. While not commonly utilized as a primary host plant, it serves as a tertiary food option for the Eri silkworm. The distinctive papaya leaves are palmately-lobed. They are attached to long, hollow petioles. The leaf blades are intricately divided into five to nine main segments, exhibiting prominent ribs and veins. During the crucial fourth and fifth instar stages, papaya leaves are introduced as an alternative to castor leaves. The Eri silkworm (*Samia ricini* Donovan) larvae are provided with papaya leaves thrice a day, alongside their regular feeding schedule. This interchange of food sources aims to ensure the nutritional needs of the larvae are met effectively.

Experimental Sets

The Eri silkworm (Samia ricini Donovan) larvae were divided into one control batch (C) and two treatment batches (T_1 & T_2) depicted in table 1. Each batch was then replicated into three sets, denoted as C_1, C_2, and C_3 for the control batch, and T_{1A}, T_{1B}, T_{1C}, T_{2A}, T_{2B}, and T_{2C} for the treatment batches. Each set consisted of 100 larvae. The objective of the experiment was to assess the impact on rearing by conducting independent and interchanging feeding of food plants. The experimental setup and feeding protocols for each batch are described below:

- **Control Batch (C_1, C_2, and C_3):** The larvae in this batch were independently fed using Castor (*Ricinus communis*) leaves as the primary food plant from the 1st to 5th instar.
- **Treatment Batch 1 (T_{1A}, T_{1B}, and T_{1C}):** The larvae in this batch were provided with Castor leaves as the primary food plant for the 1st to 3rd instar, followed by a transition to Gamari (*Gmelina arborea*) leaves for the 4th to 5th instar.
- **Treatment Batch 2 (T_{2A}, T_{2B}, and T_{2C}):** The larvae in this batch were initially fed Castor leaves for the 1st to 3rd instar, after which they were switched to Papaya (*Carica*

papaya) leaves for the 4th to 5th instar.

Table 1: Experimental Design

Batches	Replications		
Control	C_1	C_2	C_3
$Treatment_1$	T_{1A}	T_{1B}	T_{1C}
$Treatment_2$	T_{2A}	T_{2B}	T_{2C}

Survival Rate

The survival rate was calculated using the following equation. Survival Rate = Total number of cocoon harvested in a defined replication ÷ Total number of larvae in a defined replication × 100%.

Results

The present experimental study designed to investigate the effects of different feeding regimes on the life-cycle duration and survival rate of the Eri silkworm (*Samia ricini* Donovan). Specifically, the study focused on the independent feeding of castor leaves and the interchanging feeding of castor leaves with gamari and papaya leaves. The study findings revealed intriguing insights into the impact of varied feeding conditions on the Eri silkworm's (*Samia ricini* Donovan) life-cycle. Through interchanging feeding of castor leaves with gamari and papaya leaves, it was observed that the duration of the life-cycle was influenced, suggesting the potential role of specific food sources in accelerating or prolonging the developmental stages of the silkworms. Additionally, the survival rate of the silkworms was examined for both control and treatment condition. This aspect proved to be crucial in understanding how the silkworms adapt and respond when their primary food source becomes scarce or unavailable.

Table 2: Independent feeding of Castor leaves

Control Batch (C)				
Replication	Larval Period (Days)	Pupal Period (Days)	Incubation Period (Days)	Total Life Cycle Duration
C_1	22.8	18.8	7.8	49.4
C_2	21.1	18.2	7.2	46.5
C_3	21.2	18.3	7.6	47.1
Average (Mean± SD)	21.7±0.95	18.4±0.32	7.5±0.31	47.6±1.53

After completing the rearing process with independent feeding of castor leaves as the primary food source from the 1st to 5th instar, the larval period was observed to be 22.8, 21.1, and 21.2 days for C_1, C_2, and C_3 replications, respectively. The average larval period for the control batch was recorded as 21.7 days. Likewise, the pupal period was observed to be 7.8, 7.2, and 7.6 days for C_1, C_2, and C_3 replications, respectively. The average pupal period for the control batch was recorded as 7.5 days. Similarly, C_1, C_2, and C_3 replications exhibited incubation periods of 7.8, 7.2, and 7.6 days, respectively, for the eggs to hatch out. So, table 2 concluded that the total life cycle duration for independent feeding of castor leaves was 47.6 days.

Table 3: Interchanged feeding of Castor leaves with Gamari leaves

Treatment Batch (T_1)				
Replication	Larval Period (Days)	Pupal Period (Days)	Incubation Period (Days)	Total Life Cycle Duration
T_{1A}	26.6	22.8	9.8	59.2
T_{1B}	26.3	21.2	9.2	56.7
T_{1C}	26.6	22.7	9.4	58.2
Average (Mean ±SD)	26.5±0.17	26.5±0.32	9.4±0.30	58.2±1.32

In treatment batch (T_1), the larvae were provided with castor leaves as the primary food plant during the 1st to 3rd instar stages. Subsequently, a transition was made to gamari leaves to serve as the primary food source for the 4th to 5th instar stages. Upon completion of the rearing process, the T_1 batch exhibited larval periods of 26.6, 26.3, and 26.6 days for the T_{1A}, T_{1B}, and T_{1C} replications, respectively. The average larval period for the treatment batch (T_1) was recorded as 26.5 days. Following the larval stage, the pupal period was observed to be 18.8, 18.2, and 18.3 days for the T_{1A}, T_{1B}, and T_{1C} replications, respectively. The overall average larval period for the treatment batch (T_1) was recorded as 26.5 days. Eventually, T_{1A}, T_{1B}, and T_{1C} replications show incubation periods of 9.8, 9.2 and 9.4 days respectively for the eggs to hatch out So, table 3 concluded that the total life cycle duration for interchange feeding of castor leaves with gamari leaves was 58.2 days.

Table 4: Interchanged feeding of Castor leaves with Papaya leaves

Treatment Batch (T_2)				
Replication	Larval Period (Days)	Pupal Period (Days)	Incubation Period (Days)	Total Life Cycle Duration
T_{2A}	23.3	21.2	9.1	53.6
T_{2B}	22.9	20.9	8.8	52.6
T_{2C}	23.8	21.4	9.3	54.5
Average (Mean ±SD)	23.3±0.45	21.1±0.32	9.07±0.25	53.5±0.95

In treatment batch (T_2), the larvae were provided with castor leaves as the primary food plant during the 1st to 3rd instar stages, followed by a transition to papaya leaves to serve as the primary food source for the 4th to 5th instar stages. Upon completion of the rearing process, the T_2 batch exhibited larval periods of 23.3, 22.9, and 23.8 days for T_{2A}, T_{2B}, and T_{2C} replications, respectively. The average larval period for the treatment batch (T_2) was recorded as 23.3 days. Following the larval stage, the pupal period was observed to be 21.2, 20.9, and 21.4 days for T_{2A}, T_{2B}, and T_{2C} replications, respectively. The overall average pupal period for the treatment batch (T_2) was recorded as 21.1 days. Eventually, T_{2A}, T_{2B}, and T_{2C} replications showed incubation periods of 9.1, 8.8, and 9.3 days, respectively, for the eggs to hatch out. Table 4 concluded that the total life cycle duration for interchange feeding of castor leaves with papaya leaves was 53.5 days.

The rearing data of the control group (C) and treatment batches (T_1 and T_2) of Eri silkworms provides compelling evidence for the superiority of castor leaves as the primary food source, both in terms of feeding habit and life cycle duration. Castor leaves clearly play a dominant role in promoting better growth and development of the silkworm larvae. However, the study also reveals intriguing outcomes regarding the adaptability of Eri silkworms (*Samia ricini* Donovan) to alternative food sources. In situations where there is a scarcity of castor leaves, farmers may resort to feeding gamari and papaya leaves to the larvae. While this substitution helps sustain the larvae, it does come at a cost of prolonging the life cycle duration. The Eri silkworms (*Samia ricini* Donovan) fed with gamari leaves showed life cycle duration of 58.2 days, and those fed with papaya leaves had life cycle duration of 53.5 days, both of which are longer compared to the standard when castor leaves are available.

These findings underscore the importance of castor leaves as the preferred food choice for Eri silkworms (*Samia ricini* Donovan), but they also highlight the insects' adaptability to survive on alternative food sources when necessary. Farmers can consider this flexibility as an option during periods of castor leaf scarcity, although they should be prepared for the extended time required for the silkworms to complete their life cycle. Ultimately, a balanced approach in food availability can aid in successful Eri silkworm (*Samia ricini* Donovan) rearing while maintaining optimal life cycle durations.

Table 5: Interchanged feeding of Castor leaves with Papaya leaves

Food Plants	**Castor**			**Castor +Gamari**			**Castor +Papaya**		
Replications	C_1	C_2	C_3	T_{1A}	T_{1B}	T_{1C}	T_{2A}	T_{2B}	T_{2C}
No. of Larvae	100	100	100	100	100	100	100	100	100
No. of harvested Cocoon	97	92	93	82	74	79	82	81	86
Survival Rate (%)	97	92	93	82	74	79	82	81	86
Average (%)	94			78.33			83		

In Table 5, it is evident that the feeding habit of Eri silkworm (*Samia ricini* Donovan) larvae significantly influences their survivability. Notably, when the larvae were exclusively fed with castor leaves, an impressive survival rate of 94% was observed. However, this rate decreased to 78.33% and 83% when the independent feeding of castor leaves was substituted with a rotation of gamari and papaya leaves during the 3rd to 5th in star of the larval period which is clearly showed in fig.1. These findings highlight the importance of the larvae's diet in determining their survival rates.

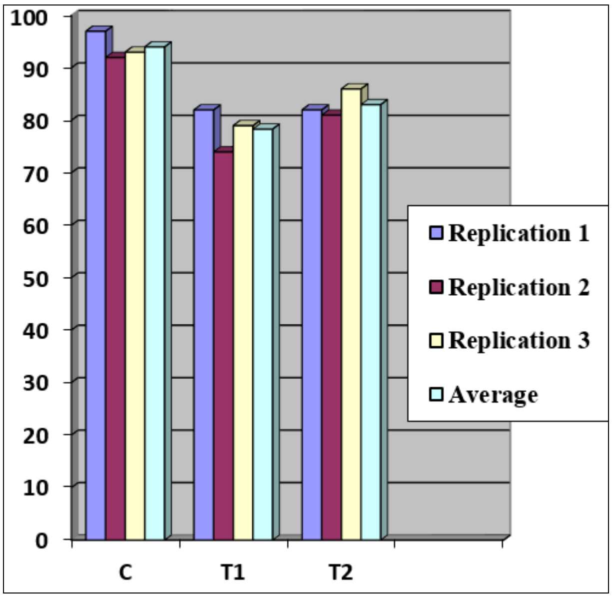

Fig 1: Survivability Graph

Discussion

Life cycle duration, from the incubation of eggs to the emergence of moths, holds significant importance for farmers in terms of profitability. Any delays in this process can lead to additional costs that might be challenging for farmers to recover. However, even though crop failure is undesirable, it is wiser to prioritize the preservation of food plants during times of scarcity rather than pushing for productivity at any cost. In the context of farming, the temporal span encompassing the development of eggs into mature moths plays a crucial role. This period profoundly impacts a farmer's bottom line, and any prolongation can result in increased expenses that may be hard to offset. Nonetheless, it is vital to recognize that ensuring the survival and abundance of food plants should take precedence over a farmer's desire to achieve maximum profitability. In this fascinating study on the feeding behavior of Eri silkworm (Samia ricini Donovan) larvae on castor plant, it was observed that the total life cycle duration is significantly shorter when the larvae were independently fed on castor plants. This duration of 47.6 days was found to be comparable to the findings of previous researchers, including P.L. Kamble and A.D. Jadhav [11], D. Bhuyan [12], N. Venu and Munirajappa [13], and Rajesh Kumar and V. Elangovan [14]. Interestingly, when castor leaves was interchanged with other plants like gamari and papaya, the total life cycle increased. The larvae took 58.2 days to complete their development with gamari and 53.4 days with papaya. P.L. Kamble and A.D. Jadhav [11] also noted a similar increase in larval duration to 23.34 days when castor leaves was mixed with papaya leaves. Furthermore, the pupation and incubation periods were found to be shorter when the larvae were exclusively fed on castor plants. However, when castor leaves was interchanged with gamari or papaya leaves, these periods increased. The pupation period was 26.5 days with gamari leaves and 21.1 days with papaya leaves, while the incubation period was 9.4 days with gamari leaves and 9.07 days with papaya leaves. The results suggest that independent feeding on castor plants is more conducive to shorter larval development and faster pupation and incubation periods compared to interchanging with other plants. This information can be valuable in understanding the impact of plant diversity on the development of Eri silkworm (Samia ricini Donovan) larvae and may have implications for their pest management and agricultural practices. As researchers continue to explore the intricacies of this intriguing interaction between castor plants and Eri silkworm (*Samia ricini* Donovan) larvae, there is potential for discovering unique ways to optimize agricultural practices and enhance the overall ecosystem. By further understanding the factors influencing larval development and growth, we can aim to strike a balance that benefits both the castor plants and the surrounding environment.

Conclusion

Here we found that independent feeding on castor plants resulted a shorter life-cycle duration in Eri silkworm (*Samia ricini* Donovan) compared to interchanging feeding with gamari and papaya plants. Additionally, the life-cycle duration was somewhat shorter when castor was interchanged with papaya compared to gamari. The findings also demonstrated that the survival rate of the Eri silkworm (*Samia ricini* Donovan) was highest when independently fed on castor plants, indicating that this is the most favorable feeding method for their development. However, in situations where there is a shortage of the primary food plant (castor), rearing the Eri silkworm (*Samia ricini* Donovan) with the help of gamari and papaya plants can be a viable alternative, as the survival rate was found to be higher when castor was interchanged with papaya compared to interchanging with gamari.

These results offer valuable insights for Seri culturists and farmers, providing them with options for efficient Eri silkworm rearing practices. By understanding the impact of different feeding methods and plant interchanges, it becomes possible to optimize the production of Eri silk and adapt to varying agricultural conditions. Ultimately, this knowledge can contribute to sustainable sericulture practices and ensure the continued success of the Eri silkworm industry.

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