

Impact of sequential plant-based diets on the growth and development of Eri Silkworm *Samia ricini* (Donovan)

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Abstract

India is a significant producer of silk, with Eri silk (*Samia ricini*) being one of the most important non-mulberry varieties. This study evaluates the growth and rearing performance of Eri silkworms when fed with different host plants to identify optimal combinations for enhancing silk production. Eri silkworms were initially fed *Ricinus communis* leaves during the 1st to 2nd instar stages and subsequently transitioned to alternate host plants, including *Manihot esculenta*, *Ailanthus excelsa*, *Jatropha curcas*, *Plumeria alba*, and *Carica papaya* for the 3rd to 5th instar stages. A control group (*R. communis* only) was maintained for comparison. Parameters such as larval duration, matured larval weight, larval survival, cocoon and shell weight, shell ratio, effective rate of rearing (ERR), pupation rate, moth emergence, fecundity, and hatchability were assessed. The results revealed that *R. communis* (T6), used exclusively throughout all stages, outperformed all other treatments. It exhibited the shortest larval duration (20.93 days), the highest matured larval weight (8.60 grams), larval survival rate (88.23%), cocoon weight (3.82 grams), shell weight (0.58 grams), and shell ratio (12.11%). It also recorded highest ERR (81.93%), pupation rate (92.52%), moth emergence rate (95.24%), fecundity (322.36 eggs), and hatchability (94.87%). Additionally, during the unavailability of *R. communis*, *M. esculenta* (T1), where their sequential treatment recorded a larval survival rate of 85.63%, matured larval weight of 6.80 grams, cocoon weight of 3.50 grams, and shell ratio of 10.85%, can serve as a viable alternative.

Keywords: Eri silkworm, *Samia ricini*, host plants, *Ricinus communis*, silk production and sustainable sericulture

Introduction

India's diverse climatic conditions enable the rearing of four primary types of silkworms: the mulberry silkworm (*Bombyx mori*) and three non-mulberry silkworms—Eri (*Samia ricini*), Muga (*Antheraea assamensis*), and Tasar (*Antheraea mylitta*). Together, these silkworms contributed to the production of 38,913 metric tons (MT) of silk during 2023–24, with mulberry silk accounting for 74% of the total output. Among the non-mulberry silks, Eri silk is the most significant, with a production of 1,586 MT (CSB, 2024) [1].

Eri silk is known for its distinctive soft, cotton-like texture and is often referred to as “Ahimsa silk” due to its ethical production process, allowing the silkworm to emerge naturally from its cocoon. This eco-friendly and sustainable textile is predominantly produced in northeastern states such as Assam, Meghalaya, Nagaland, and Manipur. However, its cultivation is gradually expanding to non-traditional states, including Tamil Nadu, Karnataka, and Gujarat, owing to its ability to thrive under varied climatic conditions. Eri silkworms can be reared throughout the year in temperatures ranging from 25°C to 30°C and relative humidity levels between 75% and 80%.

Eri silkworms are polyphagous and can feed on over 30 host plant species. Among these, castor (*Ricinus communis* Linn.) is considered the primary host, while secondary hosts include tapioca (*Manihot esculenta* Crantz), ailanthus (*Ailanthus excelsa* Roxb.), jatropha (*Jatropha curcas* Linn.), and plumeria (*Plumeria rubra* Linn.) (Directorate of Sericulture, 2024). Studies on the effects of different host plants on Eri silkworm performance have reported varied outcomes, such as extended larval duration, reduced larval weight, lower cocoon weight, and diminished shell ratios. Although Eri silkworms can adapt to alternate host plants during the third to fifth instar stages, especially in periods of

castor scarcity, the potential of sequentially using multiple host plants for rearing has not been extensively explored.

This study aims to evaluate the growth and rearing performance of Eri silkworms fed with castor, tapioca, *Ailanthus*, *Jatropha*, and *Plumeria* leaves, in sequential combinations. The findings will contribute to optimizing feeding strategies for improved silk production.

Materials and Method

The present study was conducted at the Ericulture Unit, Department of Entomology, Faculty of Agriculture, Annamalai University. Disease-free layings (DFLs) of Eri silkworms were obtained from the Eri Silkworm Seed Production Centre (ESSPC) in Hosur. The eggs were disinfected with 2% formalin solution for 15 minutes, washed in tap water, and kept for incubation for hatching (Chowdhury, 1982) [2]. Leaves of *M. esculenta*, *A. excelsa*, *J. curcas* Linn., *P. alba* Linn., *C. papaya* Linn. and *R. communis* Linn. were collected from the experimental garden attached to the Department of Entomology and used for rearing. Rearing followed standard techniques (Krishnaswamy *et al.*, 1972 [6]; Sarkar, 1980) [9]. The rearing room and appliances were thoroughly disinfected with 2% formalin solution. The temperature and humidity of the room were maintained at 25°C – 28°C and 70% – 80%, respectively. Newly hatched larvae were transferred to rearing trays with the help of a feather. First and second instar larvae were fed four times a day with tender leaves. Third instar larvae were given medium-aged leaves, and fourth and fifth instar larvae were fed five times a day with mature leaves. Bed cleaning was done regularly, and mature larvae were transferred to Plastic Montages for spinning cocoons. Cocoon harvesting was done on the sixth day of spinning. The experiment involved six treatments.

- T1 = *R. communis* (1st to 2nd instar) + *M. esculenta* (3rd to 5th instar)
- T2 = *R. communis* (1st to 2nd instar) + *A. excelsa* (3rd to 5th instar)
- T3 = *R. communis* (1st to 2nd instar) + *J. curcas* (3rd to 5th instar)
- T4 = *R. communis* (1st to 2nd instar) + *P. alba* (3rd to 5th instar)
- T5 = *R. communis* (1st to 2nd instar) + *C. papaya* (3rd to 5th instar)
- T6 = *R. communis* (1st to 5th instar)

Each treatment included four replications. Observations during rearing were made on larval duration, matured larval weight, larval survival, cocoon weight, shell weight, shell ratio, effective rate of rearing (ERR), pupation rate, moth emergence, fecundity, and hatchability.

The collected data were analyzed using analysis of variance (ANOVA), and the critical difference (CD) was calculated at the 5% level for interpretation.

Results and discussion

In this study, we explored the impact of various plant-based interventions on the productivity and quality of Eri silkworms. Each treatment (T1 to T6) involved feeding silkworms with castor up to the 2nd instar, followed by different host plants. The objective was to identify the most beneficial treatment by analyzing parameters such as larval duration, matured larval weight, larval survival, cocoon weight, shell weight, shell ratio, effective rate of rearing (ERR), rate of pupation, rate of moth emergence, fecundity, and hatchability (Table 1) (Fig 1).

Table 1: Effect of Sequential Plant Treatments on Growth and Development of Eri silkworm, *Samia ricini* (Donovan)

| Treatments | Larval Duration (days) | Matured larval weight(g) | Larval Survival (%) | Cocoon weight (g) | Shell weight (g) | Shell ratio (%) | ERR (%) | Rate of Pupation (%) | Rate of Moth Emergence (%) | Fecundity (no.of eggs) | Hatchability (%) |
|------------|-------------------------|--------------------------|-------------------------|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------|--------------------------|-------------------------|
| T1 | 22.52±0.29 ^b | 7.45±0.17 ^b | 85.63±0.29 ^b | 3.25±0.17 ^b | 0.490±0.03 ^b | 11.63±0.14 ^b | 80.75±0.29 ^b | 88.54±0.29 ^b | 92.10±0.29 ^b | 310.25±0.30 ^b | 90.21±0.29 ^b |
| T2 | 24.74±0.29 ^d | 5.85±0.17 ^d | 82.41±0.29 ^d | 2.13±0.17 ^d | 0.299±0.03 ^d | 10.71±0.14 ^d | 76.91±0.29 ^d | 83.54±0.29 ^d | 87.38±0.29 ^d | 268.59±0.30 ^d | 82.08±0.29 ^d |
| T3 | 23.64±0.29 ^c | 6.62±0.17 ^c | 83.95±0.29 ^c | 2.71±0.17 ^c | 0.380±0.03 ^c | 11.16±0.14 ^c | 78.58±0.29 ^c | 86.42±0.29 ^c | 90.54±0.29 ^c | 280.88±0.30 ^c | 86.94±0.29 ^c |
| T4 | 26.88±0.29 ^e | 5.07±0.17 ^e | 80.16±0.29 ^e | 1.58±0.17 ^e | 0.210±0.03 ^e | 10.22±0.14 ^e | 71.43±0.29 ^e | 80.44±0.29 ^e | 84.22±0.29 ^e | 251.74±0.30 ^e | 74.23±0.29 ^e |
| T5 | 28.02±0.29 ^f | 4.44±0.17 ^f | 78.69±0.29 ^f | 1.01±0.17 ^f | 0.125±0.03 ^f | 9.72±0.14 ^f | 68.14±0.29 ^f | 75.20±0.29 ^f | 81.30±0.29 ^f | 232.62±0.30 ^f | 78.43±0.29 ^f |
| T6 | 20.93±0.29 ^a | 8.60±0.17 ^a | 88.23±0.29 ^a | 3.82±0.17 ^a | 0.580±0.03 ^a | 12.11±0.14 ^a | 81.73±0.29 ^a | 92.52±0.29 ^a | 95.24±0.29 ^a | 322.36±0.30 ^a | 94.87±0.29 ^a |
| SE(m) | 0.289 | 0.173 | 0.289 | 0.173 | 0.144 | 0.289 | 0.289 | 0.289 | 0.289 | 0.299 | 0.289 |
| SE(d) | 0.408 | 0.245 | 0.408 | 0.245 | 0.204 | 0.406 | 0.408 | 0.408 | 0.408 | 0.423 | 0.408 |
| CD (0.05%) | 0.905 | 0.596 | 0.890 | 0.529 | 0.080 | 0.445 | 0.890 | 0.887 | 0.832 | 0.926 | 0.890 |

Means followed by similar alphabets are not significantly different at 0.05% by DMRT

All the treatments are fed with castor up to 2nd instar then with *Manihot esculenta* Crantz (T1), *Alianthus excelsa* Linn. (T2), *Jatropha curcas* (T3), *Plumeria alba* Roxb. (T4), *Carica papaya* Linn. (T5) and *Ricinus communis* Linn. (T6)



12a. T1- *Manihot esculenta* Crantz



12b. T2- *Jatropha curcas* Linn.



12c. T3- *Plumeria rubra* Linn.



12d. T4- *Alianthus excelsa* Roxb



T5- *Carica papaya* Linn.



12f. T6- *Ricinus communis* Linn.

Fig 1: Host Plants of Eri silkworm, *Samia ricini* (Donovan) used in the experiment

Larval Duration

The data revealed significant variations in larval duration across treatments. Treatment T6 (*R. communis*) exhibited

the shortest larval duration of 20.93 days, indicating a more efficient developmental period. On the contrary, Treatment T5 (*C. papaya*) recorded the longest larval duration at 25.5

days, suggesting suboptimal conditions for the silkworms. The other treatments fell between these extremes, with T1 (*M. esculenta*) showing relatively favourable results. Venu and Munirajappa (2013) [11] reported that the Eri larvae exhibited varying larval durations based on the combinations of host plants they were fed. When fed *R. communis* leaves from the 1st to 3rd instar and then switched to *M. esculenta*, *A. excelsa*, and *J. curcas* from the 4th instar to spinning, the mean larval duration recorded was 20.67 days, 23.33 days, and 24.67 days, respectively. Additionally, Deka *et al.* (2011) [3] observed the larval duration for Eri larvae fed *R. communis*, castor leaves from the 1st to 3rd instar and *M. esculenta* leaves from the 4th instar to spinning had a larval duration ranging from 21.33 days to 27.76 days.

Matured larval weight

Host plants directly influence growth and development of larvae. The quality and quantity of silk produced by a ripe larva directly depend on the quality and quantity of the silk contents in the silk gland (Hazarika 2012) [5]. Healthy growth of the larva ensures luxuriant growth of the silk gland in turn results in the maximum production of silk.

Matured larval weight is a critical indicator of the silkworm's health and growth. Treatment T6 (*R. communis*) again proved to be the most beneficial, recording the highest matured larval weight of 8.60 grams. This indicates that *R. communis* provides optimal nutrition and growth conditions. Conversely, T5 (*C. papaya*) had the lowest matured larval weight at 4.44 grams, further emphasizing the inadequacy of this treatment for Eri silkworm rearing.

Venu and Munirajappa (2013) [11] reported that Eri larvae reared on *R. communis* leaves from the 1st to 3rd instar, and subsequently on *M. esculenta*, *A. excelsa* and *J. curcas* during the 4th and 5th instars, recorded mean larval weights of 6.48g, 6.00g, and 5.78g respectively. Larvae fed *R. communis* leaves from the 1st to 3rd instar, then *M. esculenta* leaves from the 4th instar to spinning, recorded weights between 5.20g and 7.23g. Additionally, Rajesh Kumar and Elangovan (2010) [8] found maximum larval weights in *R. communis* (7.38g), followed by *M. esculenta* (6.45g), *C. papaya* (6.18g), with the minimum observed in *J. curcas* (5.55g). However, various researchers have reported different larval weights when eri worms were fed leaves from different plant species (Table 1) (Fig.2).



19a. Larval Mortality

19b. Improper Moulting Plate

19c. Necrotic Patches

Fig 2: Larval Deformities due to change in host plant

Larval survival

Larval survival rates are crucial for maintaining sustainable silkworm populations. Treatment T6 (*R. communis*) recorded the highest survival rate at 88.23%, followed closely by T1 at 85.63%. Treatment T5 (*C. papaya*) exhibited the lowest survival rate at 78.69%, underscoring its limited effectiveness in supporting larval viability.

The study by Nurkomar *et al.* (2022) [7] demonstrated that host plants significantly affect the survival and overall performance of *Samia cynthia ricini*. Diets with higher nutritional content and digestibility supported improved survivorship and fecundity. Similarly, the data on T6 (*R. communis*) achieving the highest survival rate (88.23%) aligns with the observations in Nurkomar *et al.* (2022) [7] 's study, where castor (*R. communis*) was identified as a highly suitable host plant due to its balanced nutrient profile, palatability, and consistent availability (Fig. 2).

Cocoon weight and shell weight

Cocoon weight and shell weight are essential factors for silk production. Treatment T6 (*R. communis* L.) outperformed other treatments, achieving the highest cocoon weight (3.82

grams) and shell weight (0.580 grams). These results highlight the superior quality and productivity associated with *R. communis*. In contrast, T5 (*C. papaya*) recorded the lowest values, indicating its negative impact on silk yield and quality.

The results broadly agree with Rajesh Kumar and Elangovan (2010) [8] and Venu and Munirajappa (2013) [11], where with Rajesh Kumar and Elangovan (2010) [8] who found the highest cocoon and shell weight in Eri larvae fed *R. communis* leaves (3.59g & 0.54g), followed by *M. esculenta* Crantz (3.20g & 0.49g), *J. curcas* L. (2.70g & 0.46g), and *C. papaya* (2.65g & 0.44g). These variations may result from the nutritional impact of different host plants. When Eri silkworms were reared on *R. communis* leaves from the 1st to 3rd instar, and then on *M. esculenta*, *A. excelsa* and *J. curcas* leaves from the 4th instar to spinning, the mean cocoon weights recorded were 3.31g, 3.16g, and 2.67g, respectively Venu (2013) [11]. Deka *et al.* (2011) [3] recorded the highest cocoon weight (3.51g) in the combination of *R. communis* (1st to 3rd instar) and *M. esculenta* leaves (4th instar to spinning).

Shell ratio

The shell ratio, representing the proportion of shell weight to the total cocoon weight, is a key determinant of silk quality. Treatment T6 (*R. communis*) recorded the highest shell ratio of 12.11%, suggesting optimal conditions for high-quality silk production. Treatment T5 (*C. papaya*), with the lowest shell ratio at 9.72%, further emphasizes its unsuitability for Eri silkworm rearing.

Venu and Munirajappa (2013) [11] reported that eri worms fed on *R. communis*, *M. esculenta*, *J. curcas*, *P. rubra*, *A. excelsa*, and *C. papaya* had mean shell ratios of 14.19%, 15.69%, 15.24%, 15.15%, 14.14%, and 14.67%, respectively. Rajesh Kumar and Elangovan (2010) [8] recorded the highest shell ratio of 14.74% in *R. communis* L., followed by *M. esculenta* (14.05%), *J. curcas* (13.65%), and *C. papaya* (12.10%). The present findings are in agreement with these results. Additionally, Deka *et al.* (2011) [3] observed the highest shell ratio of 16.07% during autumn when Eri worms were fed on a combination of *R. communis* leaves (1st to 3rd instar) and kesseru leaves (4th instar to spinning), and a shell ratio of 15.88% when the combination included *M. esculenta* leaves.

ERR

The ERR is a measure of rearing success. Treatment T6 (*R. communis*) had the highest ERR at 81.93%, followed by T1 (*M. esculenta*) at 80.75%. Treatment T5 (*C. papaya*) recorded the lowest ERR at 68.14%, indicating inefficiencies in this treatment and its negative impact on rearing success.

The present findings align with those of Rajesh Kumar and Elangovan (2010) [8], and Venu and Munirajappa (2013) [11]. Venu and Munirajappa (2013) [11] reported an ERR (Effective Rate of Rearing) of 92.14% when Eri worms were reared on *R. communis* L. leaves, followed by 89.60% on *M. esculenta*. Significant differences were observed when Eri worms were reared on other host plants from brushing to spinning. The mean ERRs recorded were 85.47% for *J. curcas*, 83.70% for *P. rubra* L., 81.65% for *A. excelsa*, and 80.27% for *C. papaya*. Rajesh Kumar and Elangovan (2010) [8] recorded the highest ERR in *R. communis* (91.05%), followed by *M. esculenta* (88.00%) and *J. curcas* (86.50%), with the lowest ERR observed in *C. papaya* (85.60%).

Rate of pupation and moth emergence

Pupation and moth emergence rates are indicators of the overall success of the silkworms' life cycle. Treatment T6 (*R. communis*) recorded the highest rates for both pupation (92.52%) and moth emergence (95.24%), suggesting better adaptability and success. Treatment T5 (*C. papaya*) exhibited the lowest rates, reinforcing its unsuitability. The results were in agreement with Sarmah *et al.* (2015) [10], showing that the C2 breed had a pupation rate of 95.00% when fed with *R. communis* leaves, and 90.00% when fed with *A. excelsa* leaves.

Fecundity and hatchability

Fecundity and hatchability are vital for sustaining silkworm populations. Treatment T6 (*R. communis*) demonstrated the highest fecundity (322.36 eggs) and hatchability (94.87%), indicating its superiority in supporting reproductive success. Treatment T5 (*C. papaya*) had the lowest values, affecting the potential for future generations of silkworms. The results

aligned with Sarmah *et al.* (2015) [10], indicating that the C2 breed laid 355 eggs and had an 85% hatchability rate when fed with leaves of *R. communis* and *A. excelsa* respectively.

Conclusion

The study highlights the critical role of host plant selection in Eri silkworm rearing. Among the six treatments evaluated, *R. communis* (T6) demonstrated superior performance across all measured parameters, including larval development, cocoon quality, and reproductive success. The findings indicate that *R. communis* provides optimal nutritional and environmental conditions, resulting in shorter larval duration, higher cocoon and shell weights, and enhanced reproductive rates. Conversely, *C. papaya* (T5) proved to be the least effective host plant, yielding suboptimal results in all metrics. The study emphasizes the importance of utilizing *R. communis* as the primary host plant to maximize silk yield and ensure sustainable sericulture practices. Leaves of *M. esculenta* can be used as an alternative during unavailability of *R. communis* leaves. These insights can guide sericulture farmers and policymakers in optimizing rearing strategies to enhance productivity and sustainability in Eri silk production.

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Competing interest

The authors declare that they have no competing interests related to this research.

Authors contributions

B.A.: Conducted the research, performed Experiments, collected and analysed the data, and wrote the initial draft of the manuscript. S.A.: Provided guidance and supervision throughout the research, contributed to study design, and critically reviewed and revised the manuscript for important intellectual content. Both authors read and approved the final version of the manuscript.

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