Traditional vs. Scientific Eri Silkworm Rearing: A Study in Bhubaneswar Zone

ABSTRACT

Sericulture holds significant importance in the tribal economy of India, with the country being the sole producer of various natural silks including mulberry, tasar, muga, oak tasar and eri silk. Eri silkworm rearing is particularly prevalent in the Bhubaneswar zone of Odisha, encompassing districts such as Khurdha, Jagatsinghpur, Nayagarh, Cuttack and Kendrapada. This study focuses on the traditional eri culture methods in the region, highlighting indigenous rearing techniques, food plant selection, larvae management etc. Observations revealed that traditional practices were consistent across the Bhubaneswar region, emphasizing the need for adopting scientific methods. Implementing tray/platform rearing, precise feeding techniques, strategic food plant selection during different larval stages, well-designed rearing rooms and advanced spinning methods can optimize space usage, ensure disease-free larvae, promote uniform cocoon production, increase the effective rate of rearing and silk production. The disparities in shell percentage between cocoons at the farmer level and the farm level in the Bhubaneswar zone are indicative of varying practices and care in sericulture. Farmer-level cocoons exhibit a lower shell ratio ranging from 9.17% to 9.82%, implying inadequate care and nutrition provided to growing silkworms. This discrepancy suggests that these farmers might face challenges in maintaining suitable conditions such as proper temperature, humidity and nutrition, leading to inferior cocoon quality. Conversely, at the farm level, the shell ratio ranges from 10.14% to 10.71%, indicating that farmers in this category are comparatively more adept at silk rearing practices. They provide better nutrition, suitable temperature, humidity and other necessary facilities, resulting in higher-quality cocoons. The superior environment and care provided at the farm level are reflected in the Effective Rate of Rearing (ERR%) consistently above 40%, reaching a maximum of 50.85%. This signifies that farm-level cocoons have better attributes such as cocoon weight, shell thickness and filament size compared to those reared by individual farmers, where ERR% ranged from 31% to 42%. The integration of modern techniques not only enhances production potential but also creates employment opportunities for rural youth. This approach fosters better income generation, surpassing the limitations of traditional methods and paving the way for a thriving sericulture industry.

KEY WORDS: Traditional vs. Scientific; Eri; Farming; Bhubaneswar

INTRODUCTION

The primary goal of sericulture is the production of silk fiber. As a vital agro-based industry, it generates employment opportunities and significantly contributes to the enhancement of rural economy. Sericulture is broadly categorized into two distinct sectors: Mulberry and Non-mulberry (vanya). The vanya encompasses tasar, eri and muga silks. India holds a unique distinction in producing all these three types of vanya silks by *Antheraea mylitta* (Drury), S*amia ricini* (Donovan) and *Antheraea assamensis* (Helfer), respectively. Out of these, the eri silkworm stands out as the sole species that has been successfully domesticated for year-round indoor rearing (Reddy, 2000; Debaraj*et al*., 2002). The Eri silkworm feeds on more than 30 host plant species, primarily consuming the foliage of castor (*Ricinus communis* L.), known as “Eranda”. Hence, the silkworm is named ‘Eri,’ also referred to as ‘Eranda’ or ‘Endi’ (Deuri*et al*., 2016). Eri silkworm food plants are abundant in natural forests in plains and hilly areas. Leaves of these plants are available for Eri silk production in various seasons. Host plants can be interchanged during scarcity, ensuring continuous rearing. These plant species are distributed all over India, both naturally and in cultivation and are usually perennial. In the fiscal year 2022-23, India demonstrated remarkable progress in the production of various types of raw silk. Eri spun silk, a significant component of this progress, saw a substantial increase. Specifically, the country's production of eri spun silk reached 7349 metric tons (MT). This accomplishment constituted more than 82% of the total vanya raw silk production, which stood at 8928MT. Moreover, eri silk accounted for approximately 20% of the overall raw silk production in the country, which totaled 36582 MT during the same period (CSB Annual report 2022-23). Eri silk stands as India's most prominent vanya silk, with the Brahmaputra valley of Assam and its adjoining foothills regarded as its original habitat. Eri silk possesses exceptional textile properties and is unique in various aspects, including its insulation properties, intake temperature, fineness, density, cross-sectional shape and surface properties.

Sericulture has deep historical roots in Odisha, existing since ancient times and continuing into the present day. Silk fabrics and attire are prevalent in Odisha, being extensively utilized in various social, spiritual and festive events. In Odisha, mulberry, tasar and eri silklworms are cultivated. Tasar and eri have deep historical roots and are predominantly undertaken by women and disadvantaged sections of the society within the state. The practice of Eri silk moth rearing was introduced by the former Bihar-Odisha Government in the 1940s, marked by the establishment of an institute in Bhagalpur (Sahu 2015). Since then, it has been a vital part of the tribal communities in Odisha, serving as a means of supplementary income to support their economic well-being. During the fiscal year 2022-23, the state of Odisha produced a total of over 130 MT of raw silk, as reported in the CSB Annual Report 2022-23. This production comprised contributions from mulberry (0.5 MT), tasar (129 MT) and eri (1 MT).

Although eri culture has traditional significance in Odisha, it did not receive significant attention in terms of growth until recent times. However, due to the favorable climate and the potential for commercial adoption, ericulture is now practiced in fourteen districts of Odisha, including Cuttack, Kendrapara, Jagatsinghpur, Nayagarh, Khurda, Dhenkanal, Angul, Sambalpur, Keonjhar, Kalahandi, Koraput, Rayagada, Gajapati, Phulbani and Sundargarh. The sericulture sector in the Bhubaneswar zone encompasses five districts: Khurda, Jagatsinghpur, Nayagarh, Cuttack and

Kendrapada. Since 2005, these regions have been renowned for rearing two varieties of silk: eri and mulberry. The area's climate is conducive to both eri and mulberry food plantation and rearing. Eri silkworm rearing has become a regular practice in the rural areas of the Bhubaneswar zone, providing an additional source of income for people during their leisure time, apart from their primary livelihoods. In some parts of Cuttack district, members of the weaver community are attempting to preserve their ancestral work by embracing Eri culture. However, it has been observed that the charm of traditional Eri rearing diminishes due to the risk of unexpected losses caused by pests, predators, diseases, unfavorable weather conditions and the lack of knowledge about new techniques and practices. Many individuals are unaware of scientific rearing methods, different varieties and the availability of secondary and tertiary food plants. Additionally, there is a lack of knowledge about intercropping, which could enhance earnings in this sector. Poor management of infected larvae and the high mortality and morbidity rates of eri pupae under different temperature, relative humidity and environmental conditions are also significant challenges.

Sericulture is broadly done at two levels *i.e*. farm level and farmers's level. In the farms the rearing of silkworm is done in a scientific way with good infrastructure providing adequate temperature and humidity with good nutritional value by the support of govt. The food plants that are being grown are provided with sufficient micro and macro nutrients making the leaves of plants as a perfect source of nutrition for the silkworms which yields maximum amount of silk. But in case of farmer's level sericulture, they are unable to produce the same quantity of silk as farms although they are also provided with the same breed Disease Free Layings (DFLs).

Therefore, this study aims at analyzing the difference in total silk production and Effective Rate of Rearing (ERR) between farmers using traditional methods and those in sericulture farms employing scientific techniques.

REVIEW OF LITERATURE

The literature pertaining to present studies are listed hereunder:

ERI SERICULTURE IN ODISHA

The Eri silkworm holds significant importance as a source of non-mulberry silk. Its production is primarily centered in northeastern India and Assam, but it can also be found in states such as Bihar, Tamil Nadu, Andhra Pradesh, Arunachal Pradesh, West Bengal, Sikkim, Uttar Pradesh and Odisha, as documented by Harishkumar and Thirupathaiah (2023).

According to Chhatria*et al*.2017, ericulture is practiced year-round in the traditional regions of eastern India due to the plentiful presence of castor plants.

As per the findings of Das and Dwibedi (2012), eri culture in Odisha is actively practiced in twelve districts: Angul, Cuttack, Dhenkanal, Deogarh, Jagatsinghpur, Kendrapara, Kalahandi, Keonjhar, Koraput, Nayagarh, Phulbani and Sundargarh. This practice is particularly prevalent among tribals and economically disadvantaged communities in rural areas, serving as a supplementary source of income. The favorable conditions for eri culture in these regions include the availability of suitable land, favorable climatic parameters and the presence of various food plant species adapted to different agro-climatic conditions.

According to Dash *et al*., 2018,eri culture in Odisha is practiced in fourteen districts based on the suitability of the climate and the potential for commercial adoption. These districts include Cuttack, Kendrapara, Jagatsinghpur, Nayagarh, Khurda, Dhenkanal, Angul, Sambalpur, Keonjhar, Kalahandi, Koraput, Rayagada, Gajapati, Phulbani and Sundargarh. In the year 2015-16, castor plantations were established in 1405 acres, benefiting 2810 individuals.

In Odisha, non-mulberry silkworms, specifically *Antheraea mylitta* and *A. paphia*, are commonly cultured in regions such as Mayurbhanj and Keonjhar, among other places (Nayak and Dash, 1991; Mohanty and Mitra, 1991; Nayak and Dash, 1999).

Eri cultivation in Odisha is conducted under the guidance and support of the Government of Odisha, aiming to ensure a sustainable source of income for the practitioners (Ray *et al*., 2010).

According to Swain and Nayak (2019), eri culture is a traditional practice carried out during villagers' leisure hours in castor plantations, occasionally supplemented by other secondary host plants if leaves are scarce. Villagers engage in eri spinning and weaving during their spare time, creating fabrics for family consumption. Unlike mulberry silkworm cultivation, eri culture is not organized as a commercial activity. Among tribals, eri pupa is considered a delicacy and the cocoon is a by-product. Due to the inability to reel eri cocoons, the yarn derived from them does not command a high price. Consequently, eri culture remains a subsidiary household practice for tribes in the hills and plains of northeastern India. In Odisha, eri silk moth rearing was introduced by the former Bihar-Odisha Government in the 1940s, with the establishment of an institute in Bhagalpur, Bihar. The market demand for eri silk in the textile industry is increasing. The enhanced silk production has the potential to generate foreign exchange and significantly contribute to the country's economy. Eri silkworms, being multivoltine, can be reared indoors throughout the year. However, the winter season appears to be the most favorable for producing both qualitative and quantitative eri silk in Odisha. Although eri culture is currently practiced on a smaller scale in the state, the sericulture department is actively promoting its expansion. Consequently, eri silk production in Odisha has been gradually increasing over the years.

ERI SILKWORM HOST PLANTS

Lefroy and Ghosh, (1912), identified castor (*Ricinus communis* L.) as the primary host plant for eri silkworms.

Kapil (1967) stated that when *Philosamia ricini* Hutt. larvae were provided with castor and tapioca leaves to facilitate their growth, no significant difference between the two food sources was observed. However, it was noted that the larvae fed with tapioca leaves exhibited a significant reduction in the weight of the cocoon they produced.

Sengupta and Singh (1974) determined that castor as the most suitable primary food plant, with a 100% rating, followed by kesseru and tapioca, which scored 65%. Other options were categorized as secondary food plants in their study.

The eri silkwormis polyphagous and has been documented to consume a wide range of food plants, as reported by Kapil (1967) and Sengupta and Singh (1974).

Anonymous (1977) noted that *Evodia melioefolia* Benth, commonly known as payam, was identified as a viable alternative host for *Philosamia Cynthia ricini* Dovnovon. The cocoon yield from payam was nearly equivalent to that obtained from castor, which is traditionally the primary host plant

Govindan *et al*., 1978 assessed various factors, including the percentage of larval survival, larval weight, cocoon weight, pupal weight and shell weight, to determine the suitability of different host plants for rearing the Eri silkworm. Their findings led them to conclude that castor stood out as the best host plant compared to tapioca, papaya and their combinations. Tapioca was identified as the next best alternative. However, it was noted that papaya could not be employed as a sole host plant for successful rearing.

Scriber and Feeny (1979) noted that larvae of the Saturnidae family exhibited faster and more efficient growth when reared on herbaceous plants, as opposed to those reared on the foliage of shrubs and trees.

In their research conducted in 2003, Hazarika and colleagues explored the impact of diverse food plants and seasonal variations on the larval development and characteristics of eri silkworms. Their findings revealed that the duration of the larval stage was notably shorter when the silkworms were fed on castor leaves, as compared to kesseru and tapioca leaves. Additionally, they determined that the autumn season, specifically during October to November, was deemed the most favorable period for rearing eri silkworms.

Patil (2004) reported *Michelia champaka* as a promising new host plant for the eri silkworm.

ERI SILKWORM REARING PARAMETERS

Raja Ram and Saratchandra (1998) conducted a comprehensive evaluation of the rearing performance of three different host plants: castor, kesseru and phutkoul. Their study, conducted under identical conditions at Titabar during January-February, revealed significant differences in the performance of eri silkworms reared on these plants. The findings indicated that phutkoul was the least preferred host plant, showing the lowest larval weight of 4.90 g and the longest larval duration of 29 days. In contrast, castor exhibited the highest larval weight of 5.80 g and a comparatively shorter larval duration of 20 days. Kesseru fell in between, with a larval weight of 5.30 g and a larval duration of 24 days. These observations underscore the distinct preferences and developmental outcomes associated with each host plant during the rearing process.

Rajaram and Samson (1991) conducted a detailed study on the rearing performance of Erisilkworm on different host plants, including castor, kesseru and gansarai. Their research provided valuable insights into the varied outcomes associated with these host plants. The study revealed that on castor, eri silkworms achieved the highest single larval weight, measuring 5.97 g. Gansarai showed the next highest larval weight at 5.87 g, while kesseru exhibited the lowest weight of 5.527 g. Furthermore, the study indicated differences in larval duration among the host plants, with castor having a duration of 516 hours, kesseru lasting 579 hours and gansarai lasting 708 hours. Additionally, castor displayed the highest ERR at 84.87%, followed by kesseru at 77.25% and gansarai at 32.82%.

Reddy *et al*., 1989 examined the impact of different host plants on the development, survival, larval yield and reproduction of *Samia Cynthia ricini*Boisduval. Their experiments were conducted under controlled conditions, with temperatures ranging from 25 to 29°C and relative humidity fluctuating between 51% and 84%. The research revealed significant variations in larval performance across different host plants. When reared on castor leaves, the eri silkworms displayed the highest larval weight, measuring 6.40 grams. Tapioca leaves supported a slightly lower larval weight of 4.90 grams, while Ailanthus (*Ailanthus excelsa*) and Plumeria (*Plumeria rubra*) leaves resulted in larval weights of 4.39 grams and 3.63 grams, respectively. Furthermore, the study investigated the duration of the larval stage, a critical aspect of the silkworm life cycle. On castor leaves, the larval duration was the shortest at 22.63 days. In contrast, larvae reared on Ailanthus leaves exhibited the longest duration, extending to 37.33 days. Tapioca and Plumeria leaves led to intermediate larval durations of 31.58 days and 31.27 days, respectively. Additionally, the survivability of the larvae varied significantly based on the host plants. Eri silkworms reared on castor leaves demonstrated an impressive survivability rate of 96%. In comparison, survivability rates were slightly lower on tapioca (84%), further reduced on Plumeria (72%) and the lowest on Ailanthus (56%).

Eid *et al*., 1980 expressed the view that the quality and quantity of silk generated by *S. Cynthia ricini* seemed to be unaffected by the quantity of amino acid and nitrogen present in the castor leaves upon which the larvae were reared. However, they noted that the silk production could be influenced by the specific balance of amino acids within the leaf.

Dayashankar (1982) studied that the Effective Rate of Rearing (ERR) of silkworms is heavily reliant on the specific host plants provided to them. Additionally, they noted a significant impact of the rearing season on ERR. During summer months, the ERR was notably higher at 65.49% for silkworms reared on castor, compared to 55.95% on tapioca.

Devaiah *et al*., 1985 assessed the variations in larval weight, silk production and silk gland weight concerning four distinct host plants: castor, tapioca, white plumeria and red plumeria leaves, all provided to the eri silkworm. Their findings led them to the conclusion that castor emerged as the most optimal choice among the tested host plants.

Kumar *et al*., 1993 assessed various host plants including castor, kesseru, tapioca and barkesseru. Their observations revealed that the mature larval weight was highest at 6.39 g when reared on castor, followed by 5.33 g on kesseru, 4.11 g on tapioca and it was lowest at 3.10 g on barkesseru.

NeeluNangia*et al.,* 2000 explored the volumetric attributes of eri silkworms (*Samia Cynthia ricini* Boisduval) reared under controlled conditions on various host plants, including castor, tapioca, papaya, barkesseru and gulanch. Their research revealed significant differences among these host plants. The findings indicated that the ERR was highest on castor (94.65), followed by tapioca (77.25), barkesseru (77.2) and gulanch (64.8). The lowest ERR was recorded when the silkworms were fed on papaya (61.49). Regarding larval weight, the maximum weight (52.60g/10 larvae) was observed on castor, followed by 50.05g/10 larvae on barkesseru, 49.80g/10 larvae on gulancha and 48.50g/10 larvae on tapioca. The minimum weight (45.20g/10 larvae) was noted when fed on papaya. In terms of larval duration, it was shortest (26.0 days) on castor, followed by 27.0 days on barkesseru, 29.0 days on gulancha and 29.05 days on tapioca. The longest duration (30.50 days) was observed when fed on papaya leaves. The host sequence for volumetric assessment was determined in the merit order as castor >barkesseru>gulanch> tapioca > papaya under controlled conditions.

According to Patil's findings in 2004, the larvae displayed the highest weight (2.36g) when fed on champaca leaves and the lowest weight (1.98g) on local castor leaves.

Debaraj*et al*., 2003 conducted a study where erisilkworms were fed with four different host plants: castor, kesseru, tapioca and payam leaves. Their observations revealed that the larvae exhibited the highest weight (5.91g) when fed on castor leaves, followed by payam (4.98g) and kesseru (4.73g). In contrast, the larvae reared on tapioca leaves exhibited the lowest weight (4.46g) during the month of November.

Birari and Siddhapara (2022) found that when eri silkworms were reared on various hosts, castor demonstrated the highest fifth instar larval weight, silk gland weight and silk gland somatic index. Tapioca and Arduso followed, showing relatively lower values in these parameters.

MATERIAL AND METHODS

The research mentioned here was conducted under office of Assistant Director of Sericulture in Bhubaneswar, which serves as a zonal office dedicated to the development of sericulture. This zone encompasses six districts in Odisha: Khurdha, Cuttack, Jagatsinghpur, Kendrapada, Nayagarh and the recently added Puri. Sericulture activities are practiced in 72 villages across 16 blocks within these districts. Eri culture is practiced in 63 villages (87%) within five districts: Khordha, Nayagarh, Cuttack, Kendrapara and Jagatsinghpur. Among these, Cuttack district stands out for its significant involvement in eri silkworm rearing compared to other districts in the Bhubaneswar zone. Mainly Castor based eri culture is extended and monitored by this zonal office.

Additionally, the zonal office took part in the "Tasar Beyond Forest" initiative launched by the Government of Odisha in the 2021-22 fiscal year. Under this initiative, 100 hectares of Asan and Arjun plantation was undertaken in the Begunia Block of Khordha district, facilitated by the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) for the year 2022-23. Currently, these plantations are in the maintenance stage.

This zonal office operates under the Handloom, Textiles & Handicrafts Department of the Government of Odisha and is directly supervised by the Directorate of Textiles & Handloom, Odisha, Bhubaneswar. To support and enhance sericulture activities at the grassroots level, the zone has established various field units.

The Castor-based eri culture initiative involves approximately 1500 farmers across all six districts. Each year, these farmers are provided with free of cost castor seeds, with a distribution of 1.5 kg of seeds per farmer for sowing in 0.5-acre units. The sowing primarily takes place during pre-monsoon season. The castor plants reach a suitable stage for leaf harvest around September. Consequently, the first commercial eri silkworm rearing at the farmers' level is initiated in September every year. Subsequently, three more commercial crops, namely the second crop (October-November), third crop (November-December) and fourth crop (December-January) are undertaken.

Each farmer, with their 0.5acre castor plantation, is capable of rearing 200 layings in a year. This effort results in an average yield of 60 kg of green eri cocoons. In terms of earnings, each farmer makes about Rs. 9,000 to 10,000 per annum through this eri silkworm rearing activity. In addition to this income, each farmer also earns an additional Rs. 20,000/- by selling castor seeds, further contributing to their overall income and livelihood.

Table 1: OFFICE/FIELD UNITS UNDER ASSISTANT DIRECTOR SERICULTURE, BHUBANESWAR

Sl. No.	Name	Location
1.	The Zonal Office i.e. o/o The Assistant Director Sericulture, Bhubaneswar	Patia, near Silkharchandi temple, District Khordha
2.	The Mulberry Silkworm Seed Station (MSWSS) Chandaka (New Eri Seed Station)	Patia, District Khordha
3.	The Eri Seed Station	Palla, District Khordha
4.	The MulberryDemonstrationFarmDaspalla (New Eri Seed Station)	Chakradharpur, PO Daspalla, District Nayagarh
5.	The ChampeswarEriRearers' Cooperative Society	Champeswar, Narsinghpur, District Cuttack
6.	The Seiko EriRearers'-cum-Reelers' Cooperative Society Ltd	Seiko, PO Rajkanika, District Kendrapara
7.	The Raghunath Mulberry Rearers' Cooperative Society Ltd	Odagaon, District Nayagarh
8.	The Ranpur Mulberry Rearers' Cooperative Society Ltd	Ranapur, District Nayagarh
9.	The Daspalla Mulberry Rearers' Cooperative Society Ltd.	Daspalla, District Nayagarh
10.	The Government Eri Centre	Champeswar for coordination of Ericulture activities going on Narsinghpur, Baramba, Tigiria, Athagarh&Banki, District Cuttack
11.	The Government Eri Centre	Seiko, for coordination of Ericulture

		activities going on in Rajkanika, District Kendrapada
12.	The Government Eri Centre	Pattamundai for coordination of Ericulture activities going on in Pattamundai, District Kendrapada
13.	The Government Eri Centre	Jagatsinghpur for coordination of Ericulture activities going on in Jagatsinghpur district
14.	The MGNREGS Coordination Cell	Palla, District Khurdha for Asan/ Arjun plantation, maintenance & subsequent Tasr culture
15.	Odisha State Sericulture Research &Training Institute	Mancheswar, Bhubaneswar, a new organization for Sericulture Research & Training

The Government Eri Seed Stations located in Chandaka and Daspalla conduct basic eri rearing by obtaining disease-free layings (DFLs) from the Eri Silkworm Seed Production Centre (ESSPC), Muga Eri Silkworm Seed Organization (MESSO), Central Silk Board, Hosur, Tamil Nadu. These stations utilize the P1 seed cocoons to produce commercial layings for farmers. The commercial layings generated at these government eri seed stations are distributed to farmers free of cost through various channels such as Government Eri Centres, Eri Rearers Cooperative Societies and Mulberry Rearers Co-operative Society (MRCS) (which is currently functioning to facilitate eri culture).

Farmers produce green eri cocoons, which are then procured by ERCS and MRCS at a rate of Rs. 150/- per kilogram. The Champeswar Eri Rearers Co-operative Society (ERCS) in Cuttack collects eri cocoons from various ERCS and MRCS to convert them into eri spun silk. All these activities are coordinated and implemented under the Public-Private Partnership (PPP) mode, involving Non-Government Organizations (NGOs), Self-Help Groups (SHGs) and Farmer Producer Organizations (FPOs).

Presently, this zone plays a crucial role in supplying sacred eri spun silk yarn. This yarn is used for the creation of silk fabrics required for the daily attire of all the deities at the Lord Sri Jagannath Temple in Puri.

In this connection, in the present studies methodologies followed were as follows:

To analyse the difference between the total silk production & ERR (Effective Rate of Rearing) between the farmers following years of traditional method and sericulture farms following scientific methods in rearing, different samples of farmer's level through different units of ADS Bhubaneswar zone of Odisha were analyzed. The farms of eri seed station and seed farmers of government eri center under study were as follows:

Table 2: Farms of eri seed station and seed farmers of eri center under study

Sericulture farms (Scientific method of rearing)	Seed farmers of center (Traditional method of rearing)

Name	Basic Dfls reared (No.)	Name	Basic Dfls reared (No.)
Eri Seed Station Khordha	300	Government Eri Centre Champeswar (Nuapatna)	200
MDF DaspalaNayagarh	200	Government Eri Centre Champeswar	350
MSWSS Chandaka	250	Bhumi sathi NGO Ranpur	200

Basic seed were supplied by ESSPC Hosur through Directorate of Textiles, Odisha on 26.07.2023 with expected date of hatching on 01.08.2023. The data related to fecundity (No.), Hatchability (%), Number of larvae/dfls, matured larval weight (g), Cocoon weight (g), Shell weight (g), Silk ratio (%), ERR (%), Dfls to be reared per year (No.) in 1.0 Acre castor plantation, Cocoon yield (kg) and No. of green cocoon per kg were worked out using the following formulas and results were tabulated.

Table 3: Formulas employed in the study	
Hatching (%) =	(Number of worms hatched/Total number of eggs) X 100
Single Larval weight (g)=	Ten matured larvae before ripening (4th day of 5th stage)/10
Single cocoon weight (g)=	Ten live cocoons with pupae/10
Shell weight (g)=	Ten cocoon shell/10
Shell Ratio (%) =	(Weight of cocoon shell/Weight of cocoon with live pupae)X100
ERR (%) =	(Number of cocoon harvested/Numbers of worms brushed)X100
Pupation (%) =	(Number of cocoon with live pupae/ Total Larvae)X100
Cocoon Yield (g)=	Cocoon harvested/Dfl

RESULT AND DISCUSSION

The rearing practices at farmer (traditional) and farm (Scientific) levels noticed during the study are compared and listed in the following table.

Table 4: Rearing practices at farmer (traditional) and farm (Scientific) levels

Particular	Traditional Practice	Scientific Practice
Selection of Eggs & Rearing Seasons	No mother moth test, June-October season best but overlapping crops	Selection by mother moth testing, Maintaining 45 days gap for new crop
Handling of Eggs	Plastic based transportation, no hygiene and micro-environment maintenance	Dry sponge and ventilated container, controlled environment during transportation
Environmental Conditions	Varanda rearing, challenging temperature, light and humidity control	Temperature & humidity documentation, ideal conditions for larval growth
Brushing	Bird feathers used	Soft brush usage
Disinfection	Limited disinfection awareness	Proper use of lime mixture, bleaching

		powder, flaming, fumes etc
Rearing Management	Leaves collected from various sources	Dedicated farm with castor fields, trained labor, systematic rearing management @ 50 dfl/acre
Bed Cleaning	Bunch rearing with unhygienic cloth reuse to collect fecal matter	Platform and Tray rearing methods with gunny cloth fitted below shelves to collect excreta
Rearing Method	Bunch rearing without structured maintenance	Platform and Tray rearing with 3-4 bamboo shelves and wooden racks like structure
Frequency of Feeding	Irregular feeding due to lack of knowledge	4-5 feedings/day, hired trained labor for timely feeding including care during night
Spacing of Larvae	Overcrowding in minimum space leading to undernourishment and unhealthiness	Proper spacing @100 dfl/1000-1200 sqft bed for healthier larvae and quality silk
Selection of Matured Larvae	Lack of knowledge leads to immature/unripe larvae selection at 5th stage	Trained workers for identifying matured larvae, skilled selection practices
Mounting of Cocoon	Rough leaves (dry banana/mango) lead to silk filament loss	Circular bamboo tray (Chandrika) or perforated plastic net or mesh for uniform size cocoon and minimum filament loss
Eri Silkworm Egg Production	Cloth used during mating processsoiled with male secretions increase fungal infection risk	Kharika method with tied 4-5 dry sticks and wrapped cotton thread for disease-free layings by females
Disease & Pest Management	Unawareness about disease types and management	Continuous disease and pest management efforts
Cocoon Production	Survival-oriented, minimal returns	Additional income via inter-cropping and diversified farming
Rearing House & Equipment	Challenges in maintaining space and cleanliness	Proper indoor rearing house (10mx5m with tin or concrete roofand 1.5 m varanda for rearing 100 Dfls) with ventilation, net and cloth covered windows
Grainage& Egg Preparation	Selected cocoons kept in bamboo tray & hung a towel near the tray,the mother moth emerges by piercing the cocoon &male,female moth start mating in the towel & lay eggs.	Selected cocoons are stitch with a string & kept hanging in the bamboo pole or Kharika.The adult moth start mating on the kharika after the emergence & female moth start laying on the kharika, the fluid secret by the male moth is unable to soil the egg & thus able to get the layings

Infrastructure	Lack of separate rearing houses and equipment	Properly equipped farms with essential tools and training provisions
Training & Capacity Building	Untrained laborers with limited Seri-knowledge	Regular training programs by Central and State Governments for skill enhancement

Further, the findings and observation of data collected from eri rearers within the zone (5 districts) are presented and discussed hereunder:

Table 5: Effect of rearing using traditional method at farmer's level Vs scientific method at farm level

Sl. No.	Center	DFLs brushed (No.)	Hatching (%)	Single larval weight (g)	Single cocoon weight (g)	Single Shell weight (g)	Shell ratio (%)	ERR (%)
Farmers level(Average temperature ranging from 28°C to 38°C and RH from 62% to 97%)								
1	Government Eri Centre Champeswar (Nuapatna)	200	75	6.1	2.75	0.27	9.82	42
2	CIT Champeswar	350	80	6.0	2.5	0.24	9.6	31
3	Bhumi Sathi NGO, Ranpur	200	75	6.0	2.4	0.22	9.17	33
Farm level (Average temperature ranging from 25°C to 34°C and RH from 65% to 93%)								
1	Eri Seed Station Khurdha	300	75	6.9	2.8	0.35	10.71	44.80
2	MDF Daspala, Nayagarh	200	75	6.2	2.8	0.35	10.71	44.09
3	MSWSS Chandaka	250	80	7.0	3.45	0.35	10.14	50.85

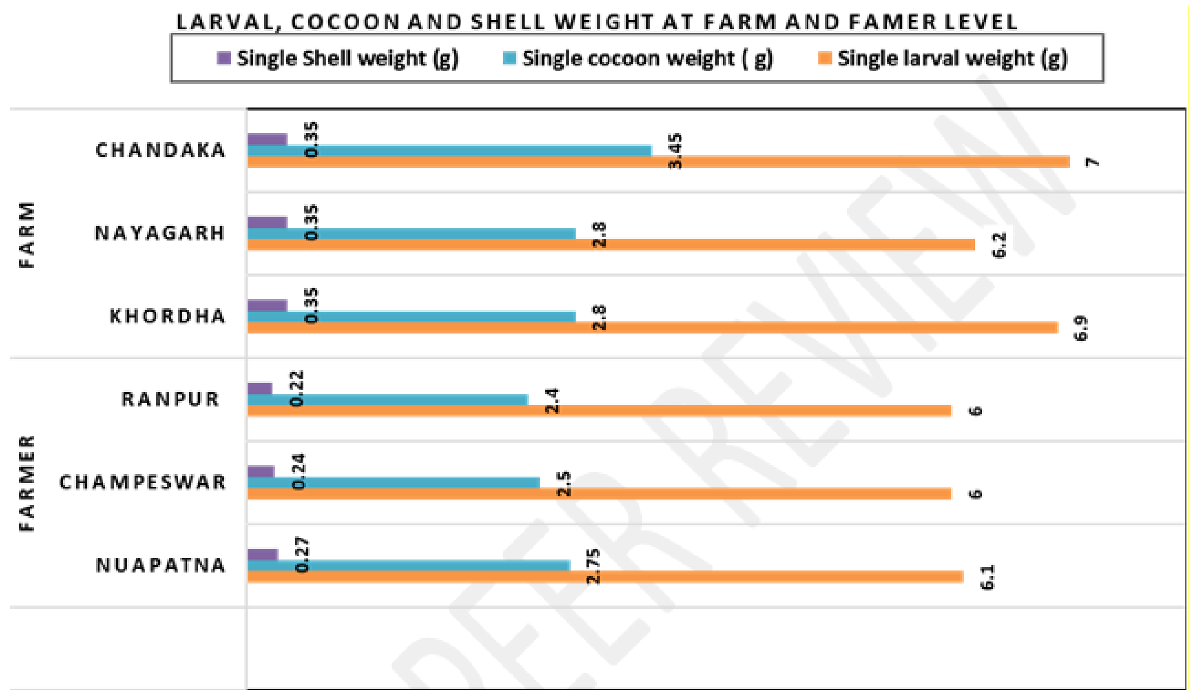

Figure 1: Larval, cocoon and shell weight at farm and famer level

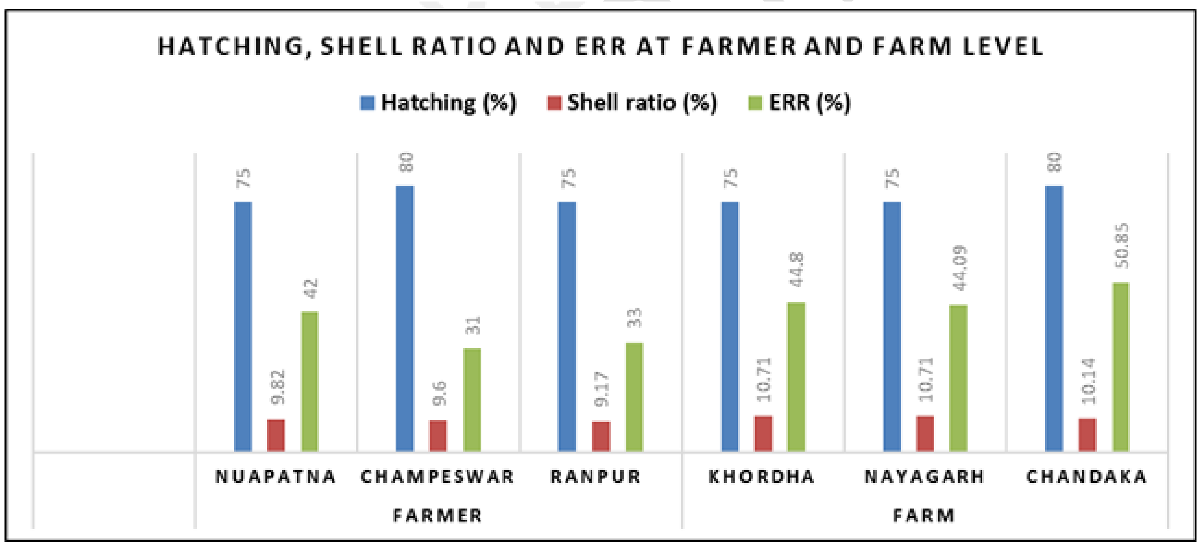

Figure 2: Hatching, Shell ratio and ERR at Farmer and Farm Level

In the regions of Nuapatna, Champeswar and Ranpur, traditional farmers reared DFLs ranging from 200 to 350, resulting in a hatching rate of 75% to 80%. The single larval weight varied from 6g to 6.1g and the single cocoon weight ranged between 2.4g and 2.75g. Correspondingly, the shell weight varied from 0.2g to 0.27g, with a shell ratio of 9.17% to 9.82%. The reported ERR fell between 31% and 42%. Comparing this with farm-level performance, it becomes evident that while hatching rates were consistently above 75% at both levels due to egg quality, significant disparities emerged in other parameters. These differences are attributed to the adoption of scientific techniques and methodologies during the rearing process. Farms implementing recommended practices achieved exceptional results, maintaining optimal temperature and humidity, providing a conducive environment for silkworm growth. This controlled setting ensured consistent and healthier larvae, resulting in significantly higher weights. Additionally, providing well-balanced and nutritious feed enhanced the larvae's growth potential, leading to heavier cocoons. Rigorous disease management protocols ensured that silkworms remained healthy throughout their lifecycle, minimizing losses and allowing them to reach their maximum growth potential. Following best practices at every stage of silkworm rearing, including careful monitoring, timely interventions and optimized feeding schedules, contributed to the overall health and weight gain of the silkworms. These factors culminated in significantly higher shell ratios ranging from 10.14% to 10.71% and an ERR of 50.85%. This underscores the importance of adopting scientific advancements in sericulture, ensuring not only higher yields but also improving the quality of silk produced.

The disparities in shell percentage between cocoons at the farmer level and the farm level in the Bhubaneswar zone are indicative of varying practices and care in sericulture. Farmer-level cocoons exhibit a lower shell ratio ranging from 9.17% to 9.82%, implying inadequate care and nutrition provided to growing silkworms. This discrepancy suggests that these farmers might face challenges in maintaining suitable conditions such as proper temperature, humidity and nutrition, leading to inferior cocoon quality. Conversely, at the farm level, the shell ratio ranges from 10.14% to 10.71%, indicating that farmers in this category are comparatively more adept at silk rearing practices. They provide better nutrition, suitable temperature, humidity and other necessary facilities, resulting in higher-quality cocoons. The superior environment and care provided at the farm level are reflected in the Effective Rate of Rearing (ERR%) consistently above 40%, reaching a maximum of 50.85%. This signifies that farm-level cocoons have better attributes such as cocoon weight, shell thickness and filament size compared to those reared by individual farmers, where ERR% ranged from 31% to 42%.

Further analysis reveals significant differences in the quality of green cocoons. In the case of farmer-level rearing, a substantial number of 435 green cocoons are needed for 1 kg, indicating poor cocoon quality compared to other regions in the Bhubaneswar zone, where only 362 cocoons are sufficient for the same weight. This emphasizes the challenges faced by farmers in maintaining high-quality cocoons under their rearing methods. However, the Eri Seed Station in Khordha stands out as a beacon of quality within this region. Here, only 357 green cocoons are required for 1 kg, indicating exceptional cocoon quality. Moreover, it achieved a remarkable 10.71% shell ratio, showcasing the superior silk rearing practices and attention to detail in this particular unit. These findings highlight the need for knowledge dissemination and support to individual farmers to enhance their sericulture practices and improve the overall quality of cocoon production in the Bhubaneswar zone.

Table 6: Effect of rearing methods in Eri Silkworm (100 Dfls)

Parameter	Unit	Scientific Method	Traditional Method	Increase (%) over traditional
Fecundity	No.	295	274	8
Hatchability	%	89.68	78.26	15
Larvae/dfls	No.	265	202	31

Matured larval weight	g	7.2	6.3	14
Cocoon weight	g	3.0	2.69	12
Shell weight	g	0.50	0.38	32
Silk ratio	%	16.66	11.63	43
ERR	%	86.56	72.02	20
Dfls reared	No./Year/Acre	400	300	33
Cocoon yield	Kg	70	32	119
Green cocoon	No./Kg	362	435	17 (-)

Above Table provides a detailed comparison between scientific and traditional eri silkworm rearing methods across several parameters. Scientific rearing demonstrates notable advantages, including an 8% increase in fecundity, indicating enhanced reproduction in controlled environments. Additionally, a 15% higher hatchability rate showcases improved egg viability and healthier larvae. The scientific method results in a 31% increase in mature larvae per dfl, signifying enhanced survival and growth. Larvae in the scientific method exhibit a 14% higher weight, reflecting superior nutrition and growth conditions. Moreover, the cocoon weight in the scientific method is 12% heavier, pointing towards increased silk yield and quality. The silk ratio is 43% higher, indicating a greater proportion of usable silk in the cocoons. The Effective Rate of Rearing is 20% higher, highlighting a more efficient rearing process.Scientific rearing leads to a 33% increase in the number of DFLs reared per acre per year, demonstrating higher overall productivity. The method yields 119% more cocoons, significantly enhancing silk production per acre. Although there are fewer cocoons per kilogram in the scientific method, the overall increase in cocoon yield compensates for this, resulting in higher silk production efficiency. Further, the test Rearing performance of five Basic Dfls with scientific method is as follows:

Table 7: Test Rearing performance of five Basic Dfls with Scientific Method

Parameter	**Detail**	**Parameter**	**Detail**
Eggs laid	21.07.2023	Cocoon harvested (No.)	1147
Dfls received	26.07.2023	Seed cocoon (No.)	1035
Blue egg stage & Black boxing	28.07.2023	Non seed cocoon (No.)	112
Expected hatching	31.07.2023	Cocoon harvested	22.08.2023
Actual hatching	30.07.2023	Cocoons/ Kg (No.)	324
Dfls hatched (No.)	05	Ten cocoons weight (g)	30
Fecundity (No.)	295	Single cocoon weight (g)	3
Hatching (%)	89.68	Single shell weight (g)	0.5
Worms brushed/laying (No.)	265	Single pupal weight (g)	2.5
Total worms brushed (No.)	1325	Shell ratio (%)	16.66

Larval color	Yellow, Blue & Green	Green cocoon weight	3.54k
Weight of ten matured larvae (g)	62.75	ERR (%)	86.56
Atmospheric temperature (°C)	28-38	Atmospheric RH (%)	65-93
Controlled temperature (°C)	25 -30	Controlled RH (%)	58-70

Details of rearing and moulting

Date	Stage	Feeding/Moulting/Spinning			Larvae (No.)
		Feeding (No.)	Moult in	Moult out	
30.07.2023 to 01.08.2023	I	10	01.08.2023-10am	02.08.2023-10am	1325
02.08.2023 to 04.08.2023	II	8	04.08.2023-10am	05.08.2023-10am	
05.08.2023 to 07.08.2023	III	7	07.08.2023-12pm	08.08.2023-12pm	1296
08.08.2023 to 10.08.2023	IV	8	10.08.2023-12pm	11.08.2023-12pm	1263
11.08.2023 to 15.08.2023	V	8	Spinning started at late night		1213
16.08.2023	-	70% spinning			1147*
17.08.2023	-	100% spinning			18 days (period)

*Spinned-86.56%; Loss-13.44%

INTERPRETATION OF POOR REARING PRACTICES OF SERICULTURE BY FARMERS

The specific interpretation of poor rearing practices of sericulture by farmers of Bhubaneswar zone was as follows:

Food plant for Eri rearing: The study revealed that rearers in the districts primarily feed castor leaves to the silkworms, with tapioca being the secondary food source. Additionally, it was noted that maintaining one's own plot is crucial for effective rearing practices. However, due to the lack of personal land, the opportunity for intercropping agricultural crops with eri culture, which could provide additional benefits to the farmers, is currently unavailable.

Rearing House & Rearing Equipment: The most effective method of rearing involves utilizing a dedicated concrete eri rearing house equipped with essential rearing appliances, significantly enhancing the success of the crop at the beneficiary level. However, it was observed that only 27% of households have access to crucial tools such as soft brushes (instead of bird feathers), rearing tray racks, feeding stands, sponge Chandrika, washbasins, black curtains, nylon nets, hygrometers, thermometers, bleaching powder, sprayers and vermicompost chambers. Access to these tools is essential for optimizing the rearing process and ensuring successful sericulture practices.

Lack of knowledge: Farmers, particularly those residing in rural areas, often lack technical knowledge about scientific sericultural practices. This limited understanding hampers their ability to recognize that these suboptimal practices significantly contribute to reduced silk production.

Disinfection of rearing house & Equipment: Few rearers properly disinfect their rearing houses and appliances following a crop loss. There is a need to raise awareness among rearers about the importance of disinfecting the rearing house, equipment and surroundings before initiating eri rearing. Proper disinfection is crucial to reduce larval mortality and morbidity, ensuring the production of high-quality cocoons.

Handling of egg during transportation & hatching of egg: Eggs are delicate and sensitive to high temperatures, humidity, chemicals and light. Therefore, it is essential to handle good quality eggs with care by placing them between dry sponges and storing them in appropriate plastic containers or trays. Additionally, careful selection of disease-free layings must be ensured before hatching and rearing to maintain a healthy silkworm population.

Rearing method/platform: Generally there are 3 types of rearing methods are followed, 1. Bunch raring method 2. Tray rearing method & 3. Platform rearing method. Bunch rearing is easy way to carry out the rearing of eri silk worm by keeping a fresh bunch near the exhausted one & the larvae crawl to a fresh bunch automatically in search of feed. This method is followed where plenty of food plants available for rearing. Tray method is traditional method of rearing with the help of bamboo tray where as platform rearing is an innovative method of rearing which consists 3-4 bamboo shelves & a wooden rack structure, it is a best way of rearing which is not popular among the rearers.

Late age silkworm rearing management: The growth rate and proper development of silk glands in the late stages (IV and V stage) of silkworms depend significantly on the supply of high-quality matured leaves. However, during the study, it was observed that rearers often face a shortage of leaves for their crops, forcing them to collect leaves from roadside or jungle areas. Unfortunately, these collected leaves are often contaminated with hazardous pollutants and dust, contributing to the mortality of late-age silkworms. To encourage healthy rearing, it is crucial to properly wash and dry the leaves before feeding them to the silkworms. Additionally, excess leaves should be stored in a leaf chamber covered with gunny cloth to maintain their quality. Addressing the issue of late-age mortality in eri culture is vital to prevent discouragement among farmers engaged in rearing practices.

Space management during late age silkworm rearing: Ensuring proper aeration and adequate spacing is crucial to maintain healthier larvae in the late stages. However, the study revealed that due to a shortage of working space or the absence of a dedicated rearing house at the farmers' level, overcrowding of worms in the tray occurs. This overcrowding leads to undernourished larvae, ultimately resulting in low-weight cocoon production.

Financial issue: Many farmers engaged in sericulture come from impoverished backgrounds, making it challenging for them to invest significantly in silk farming. Moreover, the quality of cocoons produced by these farmers is often lower than those from farms. Consequently, despite growing an equivalent number of dfls as farms, farmers receive less value for their silk. For instance, while farms require 5000 silkworms to produce 1 kg of silk, farmers need to rear 6000 silkworms to achieve the same silk yield. This disparity directly impacts the income of farmers involved in sericulture, exacerbating their financial struggles in the sector.

Figure 3: Some of the rearing practices at farmer level

CONCLUSION

Based on the above study it can be concluded that there are various underlying causes for low silk production by farmers.

- In Eri culture, skill demand is low; instead, success pivots on local climate, food plant quality, technical gaps, infrastructure absence and rearing mismanagement. Addressing these aspects is pivotal for sustainable and productive eri silk farming.
- The survival rate, quality & quantity silk production and fecundity are dependent on the

selection of nutritive superior food plants. The size of the rearing depends upon an estimation of the availability of food plants. So, a farmer must maintain food plant area (minimum 1 acre for 50 dfls) for a successful crop.

- Due to inadequate funds and a lack of proper investment, a poor farmer is hesitant to adhere to the appropriate methods of rearing. Without advanced infrastructure to optimize space utilization within the rearing room and maintain adequate temperature and humidity levels, achieving the best possible yield of silk becomes challenging. Second main underlying cause of low silk yield is providing poor nutrition to the growing silkworm larvae. They are also lacking scientific knowledge and skills which is leading to poor management in sericulture.

Addressing the challenges faced by the Eri culture industry requires strategic initiatives and focused efforts. Here are some key strategies to overcome these issues and foster the growth of Eri culture:

- Initiatives from Government for the promotion of eri silk production
- Awareness about sericulture among population that sericulture can also be a good field of income
- Providing more training about sericultural practices in mass in village areas, providing time to time updated scientific knowledge and skills to sericulture farmers so that they can apply those techniques for a better yield of silk
- Skill training to the weaver & women reelers& little orientation of the sector can contribute more to produce end product
- The farm & non-farm activities of the sector create sixty lakhs mandays of employment every year mostly in the rural sector (Dewangan 2018) because this silkworm rearing is a labor intensive agro-based industry that provides attractive income to the farming community. Hence, it will open up guaranteed employment opportunities to the unemployed rural youth.

PHOTOGRAPHS OF REARING AT FARM Vs FARMER LEVEL

Castor plant cultivation in sericultural farms

Castor plant cultivation by farmers

Advanced silk rearing practices in farms

Poor way of rearing practices by farmers

Good infrastructures available in farms to provide adequate facilities

No availability of infrastructure and care for rearing of silk by farmers

PHOTOS OF FIVE DFLS TEST REARING AT ERI FARM, CHANDAKA

After Black Boxing of Eri layings

First instar

Application of lime for uniform moulting

After First moult

Second stage

Third stage

PHOTOS OF FIVE DFLS TEST REARING AT ERI FARM, CHANDAKA (Cont.)

Fourth stage

Fifth stage

PHOTOS OF FIVE DFLS TEST REARING AT ERI FARM, CHANDAKA (Cont.)

Ripe silkworms ready to spinning

Matured worms collection & mounting

Cocoon yield traditional vs. scientific rearing method at Farmer & Farm level respectively

Cocoon production from 5 Dfls is 3.54 kg. (1147 nos.)

PHOTOS OF FIVE DFLS TEST REARING AT ERI FARM, CHANDAKA (Cont.)

Grainage work

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