Probing the potentiality of the defoliator *Cricula trifenestrata* Helfer silk: a revisit

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**Abstract**

**Background:** Transformation of pest to valuable product is considered to be a noteworthy innovation. This article explores the potentiality of wild silkworm *Cricula trifenestrata* Helfer for sustainable development towards human livelihoods.

**Results:** The innate characteristics of this silkworm with robust rearing capacity have bestowed various aspects of biomaterials with special context to diversification of wild silk products. Views on challenges, prospects and the enigma of converting a pest to beneficial product are also unraveled. Exploration on utmost utilization of raw silk, scope for varied byproduct from silk waste may contribute a ray of hope for income generation to the rural population.

**Conclusion:** With suitable plantation and congenial climatic conditions for rearing *Cricula trifenestrata* may serve as an alternative wild silk in contributing to the country’s wild raw silk production.

**Keywords:** Wild, Silkworm, Cocoon, *Cricula*, Pest, Product, Silk

**Background**

Wild/Vanya silkworm confers to non-mulberry silkworm which comprises *Antheraea mylitta*, *Antheraea proylei*, *Antheraea assamensis* and *Samia ricini* which are commercially exploited in India. In other countries wild silkworms which are commercially exploited includes *Gonometra*, *Hyphaphora*, *Antheraea yamamai*, *Antheraea pernyi* etc. In the present scenario, India’s vanya raw silk production is around 10,581 MT (29.5%) against the country’s total production of 35,820 MT for the year 2019–20. In 2020–21, despite of covid-19 pandemic 33,739 MT of Raw silk was produced in which 9879 MT (29.2%) is contributed by vanya silk (Source Central Silk Board, Bangalore, India). There are numerous wild silkworm in India, which are least concerned for its probable productivity. An attempt is made to discuss about a common pest which can be transformed into a commercial product with scientific and technological intervention.

*Cricula trifenestrata* Helfer is a wild Lepidopteran sericigenous moth known for its lustrous golden cocoon. The Genus *Cricula* was proposed by Walker in 1855. Capt. Jenkins and Helfer coined the species trifenestrata due to the presence of 3 windows like structure in the forewing as represented in Fig. 1 (Tikader et al. 2014; Kaleka et al. 2018). It is invariably considered as a pest for *Antherea assamensis* i.e., muga silkworm as it depletes the foliage by feeding thereby affecting the Effective Rearing Rate (ERR) of Muga silkworm. They infect a wide range of host plants namely *Mangifera indica*, *Persea bomycina*, *Anacardium occidentale*, *Arachis hypogaeal Cinnamomum cassia*, *litchi cheinensis*, *Machilus odoratissima* and *Camellia sinensis* (Ahmed et al 2012; Gharde and Chaudhuri 2018; Narang and Gupta 1979; Tikader et al. 2014). Host diversity of *Cricula trifenestrata* is detailed in (Table 1). *Cricula trifenestarata* is widely distributed in South Asian countries (Fig. 2). *Cricula trifenestrata* is...
reported to be predominant in India, Andaman, Myanmar, Vietnam, Cambodia, Malaysia, Singapore, Thailand, Bangladesh, Java, Philippines countries (Tikader et al. 2014; UK 2014).

*Cricula trifenestrata* takes up to 61–125 days to complete the life cycle. Complete defoliation occurs in 4th and 5th instar. The larvae have 5 instars and passes 4 generation in a year (Tikader 2012; Huq et al. 1991). The average fecundity was reported to be 141.7 ± 11.79, and observed hatching rate was 88.81 ± 1.37% when reared in *Mangifera indica*. The average *Mangifera* leaf consumption was about 29.4 g (Amin et al. 2008) *Persea bombycina* fed larvae (Figs. 3, 4) exhibited higher content of protein and lipid in the haemolymph suggesting *Persea bombycina* as the superior host in respect to silk deposition (Ghosh et al. 2015). High Infestation in *Persea bombycina* was observed during September to January (Ahmed et al. 2012). The efficiency of conversion of digested food in first instar when fed with *Persea bombycina* was observed during September to January (Ahmed et al. 2012). The efficiency of conversion of digested food in first instar when fed with *Persea bombycina* was 36.54% and the digestability was 67.74% indicating *Persea bombycina* as the preferred host plant by *Cricula* on the basis of nutritional indices. (Biswas et al. 2013). *Cricula trifenestrata* were even recorded, at an altitude of 1097 m in some parts of Tamilnadu (Singh 1992). In cashew, *Cricula trifenestrata* larval infestation had a positive correlation with number of flower and seeds (Siswanti et al. 2017).

In Sikkim, *Cricula* was reported infesting Cardamom i.e., *Amomum subulatum* causing huge devastation of the crop. The average fecundity was observed to be 157–252 eggs per month. The mature larvae is black-brown with red sublateral stripes, 2–11 somites with six setiferous tubercles. Larval period ranges to 87.16 ± 2.65 days and larval mortality 23.23%. Life cycle takes around 168.92 days (Yadav and Kumar 2004). The chromosome number (*n*) of *C. trifenestrata* was found to be 31 (Narang and Gupta 1979). The cytochrome C oxidase subunit gene of *Cricula trifenestrata* was studied to identify specific unique sites for species identification to develop species marker. It was noted that 595 nucleotides are conserved in the species of cytochrome C oxidase gene. The 107th amino acid (valine) and 138th (threonine) were diagnostics amino acid for *C. trifenestrata*. The phylogenetic study revealed that *Cricula* and *Antherea* share the same node of the saturnidae family suggesting monophyletic (Solihin et al. 2012).

**Control measures**

The *Cricula* infestation causes havoc destruction to the foliage hence researchers have studied various physical,
chemical and biological control methods to prevent infestation in field crops. Proper weeding of the tree cover in summer is seen effective to prevent to Cricula larval infestation in Cinchona plantations. This cultural operation serves as a first line of physical defence in preventing infestation (Van Zwet 1950). Biological control by utilizing parasitoid serves as an effective control measure in controlling the Cricula (Table 2). Parasitization of Cricula trifenestrata eggs with Telenomus sp has complete efficacy up to pupal stages of Cricula trifenestrata, when parasitized with Brachymeria tibialis (Walker) parasitoid destroys and consumes the pupae inside the cocoon preventing future multiplication. Hence Brachymeria tibialis can be efficiently utilized as a biological control in Antherea assamensis silkworm rearing (Tikader 2012).

In Indonesia, Beauveria bassiana at a concentration of $5 \times 10^6$ spores suspension resulted in highest mortality of Cricula moth. However it is not effective in Antherea assamensis field (Sjarafuddin and Rahmatia 1999). Parasitoid Blepharipa zebrina infest larvae of Cricula trifenestrata which infest Machilus bombycina (Negi et al. 1993). In Arunachal Pradesh Exorista sorbillans was observed as an endoparasitoid parasitizing the Cricula larvae and causing death at pupal stage during March to mid-September (Sarma et al. 2006). Chalcis cricula and C. etiplaeae parasitises Cricula larvae (Yadav and Kumar 2004).

### Table 1 Host plant diversification of Cricula trifenestrata

| S. no | Botanical name     | Family            | Common name                        |
|-------|--------------------|-------------------|------------------------------------|
| 1.    | Mangifera indica   | Anacardiaceae     | Mango                              |
| 2.    | Persea bombycina   | Lauraceae         | Som Sum, Majti                     |
| 3.    | Anacardium occidentale L |  | Cashew, caju                      |
| 4.    | Arachis hypogea L | Fabaceae          | Peanut, Groundnut, earthnut, monkey nut |
| 5.    | Cinnamomum cassia | Lauraceae         | Chinese cassia, Chinese cinnamon   |
| 6.    | Litchi chinesis    | Sapindaceae       | Lychee, litchi                     |
| 7.    | Camellia sinensis  | Theaceae          | Tea                                |
| 8.    | Amomum subalatum   | Zingiberaceae     | Black cardamom, Big cardamomum, hill cardamom, winged cardamom |
| 9.    | Acrocarpus fraxinifolius |  | Pink cedar, Shingle tree, floral Ash, Indian Ash, Red cedar, Keny coffee shaded |
| 10.   | Bucklandia populnea | Hamamelidaceae     | Dingdah, Ppli, Singliang            |
| 11.   | Careya arborea     | Lecythidaceae     | Patana Oak, Wild Guava             |
| 12.   | Schleicheria trigua | Sapindaceae       | Lac tree, Ceylon oak, Kusum tree    |
| 13.   | Ziaiphus jujube   | Rhamnaceae        | Jujube, red date, Chinese date, Chinese jujube Bogari |
| 14.   | Piper nigrum       | Piperaceae        | Black pepper, kalimirch, golmirch   |
| 15.   | Machilus odoratissima | Lauraceae      | Fragrant Bay,                       |
| 16.   | Persea Americana  | Lauraceae         | Avacado                            |
| 17.   | Mimusops elengi   | Sapotaceae        | Spanish cherry, bullet wood, Maulsari, Bakull, Elengi |
| 18.   | Abelmaschus esculentus | Malvaceae       | Okra, Lady’s finger                |
| 19.   | Altingia excelsa  | Hamamelidaceae    | Rasamala, Oriental Sweet Gum, Shilarasa, Turushka |
| 20.   | Cinchona officinalis | Rubiaceae        | Peruvian bark, quinine              |
| 21.   | Cinnamomum verum  | Lauraceae         | Ceylon cinnamon, Dalchini, true cinnamon, lavanga |
| 22.   | Elaeocarpus floribundus Blume | Elaeocarpaceae   | Indian olive, Jalpai               |
| 23.   | Litsea glutinosa   | Lauraceae         | Soft bolly gum, bolly beech, brown beech |
| 24.   | Luffa aegyptiaca  | Cucurbitaceae     | Sponge gourd, Ghia torai, loofa    |
| 25.   | Ziaiphus maunhiana | Rhamnaceae        | Indian plum, Ber, elandai          |
| 26.   | Syzygium cuminii (L) | Myrtaceae        | Java plum, jamun, black plum, naagai |
| 27.   | Spondias sps       | Anacardiaceae     | Hog Plum                           |
| 28.   | Bischofia trifoliata | Euphorbiaceae  | Bishop wood                        |
| 29.   | Canarium harveyi   | Bucuraceae        | Java almond, pili nut, piceam almond |
| 30.   | Malus floribunda Siebold ex Vanhoutte | Rosaceae | Crab apple, chokeberry            |
Fenvalerate and cypermethrin were the most effective chemical control methods, when treated for 7 days post treatment resulted in 94.44 and 79.16% larval mortality (Munaan 1986). In Maharastra field study has resulted in effective control of Cricula infestation in ground nut by cyhalothrin and Naled at 0.0005 and 0.001% (Deshmukh 1992) chemically infestation can be controlled by endosulphan, deltamethrin and neem based pesticide like azadirachtin (0.003% and 0.015%) has been effective (Ahmed et al. 2012) 0.05% endosulfan and parathion-methyl was used to control (Singh 1992). 0.1% methyl parathion and endosulphan are effective chemical control methods reported (Yadav and Kumar 2004).

Methods
The rearing parameters are reported in varied host plants. Here attempts on exploration of post cocoon parameters are explored for commercial utilization. Cocoons of Cricula trifenestrata which was reared upon consuming Persea bombycinia in the wild were obtained and the pupal and shell weight was determined. The cocoons were stifled in hot air oven at 45 °C for 2 h. Owing to the presence of perforations in the cocoons reeling is a constrain hence it is utilized for spun yarn.

Degumming and cake preparation
The removal of sericin and letting the fibres loose for further processing is called Degumming. Cocoons of Cricula trifenestrata were degummed by boiling in 0.5% sodium carbonate for 45 min. Further rinsing in hot distilled water and distilled cold water. Drying was done in hot air oven at 45 °C for 2 h.

\[
\text{Degumming loss} \% = \frac{W_1 - W_2}{W_1}
\]

where \(W_1\) is the initial weight of conditioned Cricula cocoons samples and \(W_2\) is the weight of degummed as well as conditioned Cricula cocoons sample followed by washing. The individual degummed cocoons were opened in water and sheets are formed and placed
overlapping. Cakes were prepared by overlapping 3–4 cocoon fibre sheets and dried in room temperature (Munshi et al. 2016).

### Spinning

The yarn is spin in a motorized spinning machine. The silk ratio and silk recovery is determined.

### Results

145 cocoons were obtained from the wild (Fig. 5). The post cocoon parameters were observed and analyzed and the results are shown in Table 3.

The total cocoon weight was observed to be 105 gm. wherein total shell weight was 15.5 gm and total pupal weight was 89.5 gm. Single cocoon weight, single shell weight and single pupal weight was 0.72 gm, 0.106 gm and 0.617 gm respectively. The silk ratio % was 14.76%. Shell weight after degumming was 14.5 gm. The degumming loss (%) was found to be 6.45%. The spun yarn weight was found to be 9.8 gm. and silk waste was 4.7 gm. Thereby determining that the silk recovery % was 67.59% and Silk waste % was 32.41%.

### Discussion

Exploring the insights of commercial utilization of *Cricula* silk

The cocoons were oval with tapering ends and contain perforation on the surface. When the cocoons were subjected to degumming the golden lusture was lost implying the affinity of the golden hue was high in the sericin content and not fibroin. Insights on developing an efficient degumming agent which aids in retaining the golden hue in the yarn may result in high demand of the fabric. The silk recovery % was observed to be higher...
than muga which was conventionally around 40–48% and higher yield was 55% in Muga silk.

*Cricula trifenestrata* fibre was reported for the tensile strength and biocompatibility. The modulus elasticity of the single fiber of *Cricula trifenestrata* is about 3681 MPa. The silk can be prepared by degumming method of boiling in 0.01 M NaOH for 1 h. Degumming above the concentration 0.01 M NaOH resulted in hydrolysis of fibre. The ultimate tensile strength is obtained about 162 MPa together with value of failure strain about 0.12 (Nindhia et al. 2014).

Unlike *Bombyx mori*, the pigments are usually deposited in the sericin which gets washed off during degumming process. However when cricula cocoons were degummed with chymotrypsin and the pigment content was observed in fibroin and sericin. It was observed that 1.4 times higher fold the pigment is present in fibroin than sericin (Yamada et al. 2001).

The wild silks in the world are still unexplored for their potential commercial utilization. Previous studies affirm the merits of *Cricula* silk for instance; *C. trifenestrata* silk protein was isolated and studied. The molecular mass of sericin and fibroin were 400 kDa and 350 kDa respectively, however fibroin when later underwent reduction the molecular mass was 180 kDa. The amino acid constituents resembled with higher serine content (Yamada and Tsubouchi 2001) The polar and non polar amino acid ratio in cricula sericin was about 69:31 (Manesa et al. 2020). *Cricula trifenestrata* Sericin has anti-proliferative

| S. no | Post cocoon parameters assessed | Results in gm/% |
|-------|--------------------------------|-----------------|
| 1.    | No. of cocoon                  | 145             |
| 2.    | Total Cocoon weight            | 105 gm          |
| 3.    | Total shell weight             | 15.5 gm         |
| 4.    | Total pupal weight             | 89.5 gm         |
| 5.    | Single cocoon weight           | 0.72 gm         |
| 6.    | Single shell weight            | 0.106 gm        |
| 7.    | Single pupal weight            | 0.617 gm        |
| 8.    | Silk ratio%                    | 14.76%          |
| 9.    | Shell weight after degumming   | 14.5 gm         |
| 10.   | Spun yarn weight               | 9.8 gm          |
| 11.   | Waste weight                   | 4.7 gm          |
| 12.   | Silk recovery%                 | 67.59%          |
| 13.   | Waste%                         | 32.41%          |
activity in feline kidney cells and Sericin-induced apoptosis (Liu et al. 2016). Cricula trifenesstrata cocoon extract when treated on human fibroblasts revealed non cytotoxicity (Sunarintyas et al. 2012).

This study affirms the efficacy of Cricula to be utilized as a spun silk (Fig. 6). The golden cocoons are utilized as artifacts for attractive aesthetic products.

**Conclusions**

Popularization on the artistic utilization of these golden cocoons in fabric designing or any other products may be of high demand in the near future. In the current surge, Cricula sericin also has added biological effects in pharmaceuticals and cosmeceutical industry. Hence more insights are to be explored for commercial product utilization of Cricula silk as a potential biomaterial, fabric, pharmaceutical, food, cosmetics and fuel industry.

**Abbreviations**

MT: Metric ton; NaOH: Sodium hydroxide; kDa: Kilo dalton; MPa: Mega pascal.
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