
MUGA SILKWORM, *ANTHERAEA ASSAMENSIS* HELFER (LEPIDOPTERA: SATURNIIDAE) - AN OVERVIEW OF DISTRIBUTION, LIFE CYCLE, DISEASE AND CONTROL MEASURE

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ABSTRACT: Muga silkworm, *Antheraea assamensis* Helfer is an endemic species to Assam state and some parts of northeastern India. In this area, environmental and climatic conditions are very much favorable for the cultivation of muga silkworm. Cultivation of muga silkworm is called muga culture and as well as it is part of the culture of the Assamese peoples. Muga silkworm mostly wild, called semi-domesticated. It is a polyphagous insect and multivoltine in nature. The Muga silkworm generally produces the golden yellow colour of silk. Presently the production of muga silk is very less due to the high incidence of disease, natural enemies, and change in climatic conditions, farmers are using the traditional method for practicing the silkworm and poor seed quality. Generally, muga silkworm is mainly distributed in the Northeastern part of India and especially the Brahmaputra valley of Assam. Moreover, the *Antheraea assamensis* species has been reported from some parts of India. In Asia occurrence of the this species in Bangladesh, Sri Lanka, Indonesia, Nepal. This review mainly focuses on Muga culture including the distribution, life cycle, disease, and control measure of muga silkworm.

KEY WORDS: *Antheraea assamensis*, disease, control measure, Lepidoptera, muga silkworm, rearing technology, Saturniidae

Sericulture or silk farming, it is the rearing of silkworm to produce the silk. Sericulture involves various activities, it includes cultivation and maintenance of host plants, silkworm rearing, cocoon production, reeling and spinning of cocoons and production of fabrics. There are different commercial species of the silkworm, such as mulberry silkworm (*Bombyx mori*), tropical and temperate tassar silkworm (*Antheraea mylitta* & *Antheraea pernyi*), muga silkworm (*Antheraea assamensis*), eri silkworm (*Samia ricini*). Among these 5 commercial species, muga silkworm is one of the most important silkworms in the sericulture industry and muga silk its having high economic demand in the market. Generally, muga silkworm belongs to the order Lepidoptera and family Saturniidae. These species are polyphagous and multivoltine (5 to 6 generation in a year) in nature. In the family Saturniidae having 1200 to 1500 species all over the world (Nassig et al., 1996). According to Arora & Gupta (1979), India having about 40 species of the silk moth. In Asia and Africa, about 80 species are used as commercial species for the production of silk (Jolly et al., 1975).

North-Eastern India especially in Assam having too many natural resources (Goswami & Das, 2018). Among these one of the important natural resources is

Muga silkworm *Antheraea assamensis* Helfer. In this area, climatic and environmental condition is suitable for muga silkworm cultivation. As well as in other parts of India (West Bengal, Sikkim, Uttarakhand, Andhra Pradesh) farmers are cultivating the muga silkworm but they are not getting a high amount of crop like Assam, North-East India (Singh et al., 2013) due to geographical location, climatic and environmental condition. The silkworm is largely cultivated in Assam and East Garo Hills of Meghalaya. Farmers have reared 5 to 6 crops the year [Autumn (October-November; Kotia crop commercial), winter (December-January; Jarua crop, pre-seed), early spring (February-March; Chotua crop, seed), Spring (April-May; Aherua crop, pre-seed) and late summer (August-September; Bhodia crop, seed), Summer (May-June; Jethua crop commercial)] (Kumar & Rajkhowa, 2011). Generally, muga silkworm feeds on the leaves of different kinds of trees but Som (*Machilus bombycina*) and Soalu (*Litsea polyantha*) are the primary food plants. Other host plants dighloti (*Litsea salcifolia*), mejankari (*Litsea citrata*) are secondary and *Cinnamomum obtusifolium*, *Cinnamomum glaucescens*, *Actinodaphne obovata*, *Michelia champa*, *Zizyphus jujube*, *Xanthoxylem rehsta*, *Celastrus monosperma* are tertiary in nature (Neog et al., 2005). In Assam, muga silk production is more than 95% (Singh et al., 2013). Sericulture being an agro-based Industry, it provides employment to the peoples of rural and semi-urban areas.

DISTRIBUTION OF MUGA SILKWORM

Muga silkworm *Antheraea assamensis* Helfer, it is distributed in the Brahmaputra valley in Assam. As well as it is distributed other North-Eastern states such as Meghalaya (East and West Garo Hills), Nagaland (Dist-Kohima, Wokha, Mokokchung), Arunachal Pradesh (Lohit and Dibang valleys, Chanlang and Papumpare districts), Manipur (Tamenglong District) and south Tripura (Tikader et al., 2011). In other parts of India, it occurs in the West Bengal (Singh & Mishra, 2003) and Sikkim, Himachal Pradesh, Uttar Pradesh, Gujrat, Pondicherry (Das et al., 2000). In Asia, muga silkworm occurs in Nepal, Indonesia, Northern Myanmar, Sri Lanka, Bangladesh (Singh et al., 2013). In Brahmaputra valley, it occurs on Jorhat, Sivsagar, Dibrugarh, Golaghat, Goalpara, Kamrup, Lakhimpur, Kokrajhar, Darrang districts and moreover it is distributed in North Cachar Hills, Karbianglong districts of Assam (Tikader et al., 2011).

LIFE CYCLE OF MUGA SILKWORM

Muga silkworm is multivoltine in nature (5 to 6 generation in a year). It is a polyphagous insect and feeds on primary food plants som (*Machilus bombycina*), sualo (*Litsea polyantha*). They complete their life cycle of four different stages, it includes egg, larva, pupa, adult (moth) (Konwar et al., 2017). The duration of the life cycle is different in various seasons. In winter (December-February), they complete their life cycle within 79-85 days, and post-monsoon (September-October) duration of the life cycle is 53-63 days. When feeding on sualo they complete their life cycle in 65.34 days and in case of som, they complete their life cycle in 63.86 days (Singh et al., 2013). The details of the four different stages are as follows.

Egg

The egg is dorso-ventrally flattened, oval, bilateral, symmetrical. The colour of the egg is creamy and brownish grey, after washing it looks like light green or creamy in colour. On average, the weighs of the egg is 0.0075 mg. As well as the size of the egg is 2.3 to 2.8 mm in length and 2.4 mm in width. Generally, eggs are covered with dark brown adhesive secretions (Singh et al., 2013). The micropyle of the egg is situated at one end and chorion separate patterns of follicular imprints corresponding to different zones such as streak zone, disc, and edge zone (Jolly et al, 1975). The duration of the egg stage is 7 days (including egg-laying and hatching) in summer and 15 days in winter. Generally, eggs are hatched after 7 to 10 days and hatching occurs in morning times. It is completed in 3 days. The hatching is more on the first day (about 75%), remaining eggs are hatching in the next two days (Rajkhowa & Kumar, 2011).

Larva

After hatching, larvae are searching the leaves and migrates towards the leaf for feeding. The larval stage completed with four molts and pass through five instars.

(a) First Instar: The body colour of the first instar larvae is black, it has distinct yellow lines in the intersegmental region. The weight of the first instar larvae is approximately 0.0065 to 0.008 gm and body length (0.7 cm to 1.2 cm), breath (0.2 ± 0.025 cm) (Sing et al., 2013). The Larval head is small and black in colour. Generally, lateral lines are not clear in first instar larvae. Larvae have six tubercles in this instar. The duration of the first instar larvae is 3 to 4 days in summer and 6 to 8 days in winter (Sahu, 2005).

(b) Second Instar: After the first molt larvae enter into the second instar. The second instar larvae are about 1.5 cm to 1.9 cm in length and weight approximately 0.082 to 0.092 gm (Rajkhowa & Kumar, 2011). The colour of the second-star larvae is light yellow. After the molt the larval body turns green, head remains brown and tubercles are bluish in colour. This instar duration is 3 to 5 days in summer and 7 to 10 days in winter (Sahu, 2005).

(c) Third Instar: Larvae enter into the third instar after the second molt. The length of the third instar larvae is about 1.9 cm to 2.7 cm and weighs approximately 0.445 to 0.635 gm (Jolly et al, 1975). The tubercle is violated in colour and the lateral line is visible in this instar. Larvae have some additional pairs of tubercles. Clasper is yellow-green in colour and it is triangular in shape. The length of the third instar larvae is 5 to 7 days in summer and 10 to 14 days in winter (Singh et al., 2013).

(d) Fourth Instar: After the third molt larvae enter into the fourth instar. The fourth instar larvae, it measures about 2.7 cm to 3.5 cm in length and weighs approximately 2.5 gm to 3.7 gm (Singh et al., 2013). The larval body colour of the dorsal surface is dark green. As well as the ventral surface of the body is light green in colour. Generally in this instar, tubercles are red in colour and provided with setae. The head and clasper triangular in shape, black colour eye spot situated on the lateral side of the head. Lateral lines are visible and yellow in colour. The duration of the fourth instar larvae is about 8 to 10 days in summer and 13 to 16 days in winter (Sahu, 2005).

(e) Fifth Instar: After the fourth molt larvae enter into the fifth instar. The length of the fifth instar larvae is about 4.5 cm to 5.5 cm and weighs approximately 4.25 gm to 5.75 gm. The larval body colour of the dorsal surface is

light green. As well as the ventral surface of the body is deep green in colour (Sahu, 2005). The head is triangular in shape and tubercles are brick red in colour, provided with setae. The lateral line is noticeable, it is situated from the posterior part to the anterior part of the body. The head is brown in colour and spiracles are nicely visible. The clasper is triangular in shape and chocolate in colour. In this instar, three pairs of thoracic and four pairs of abdominal legs are present. Legs are well developed and visible. The duration of the fifth instar larvae is 11 to 12 days in summer and 17 to 20 days in winter (Sing et al., 2013). Overall, fifth instar larvae are well developed and fully grown larvae translucent green in colour. At the end of this instar, larvae become matured and stop feeding (Tikader, 2012). The weight of the fully matured larvae is about 10 to 15 gm and 8 cm to 10 cm in length.

Pupa

Generally muga silkworm completes the five larval instars on a specific outdoor host plant. After fully matured, larvae are crawling down from its host plant at the time of evening. Farmers are collect the matured larvae in wooden or plastic basket and bring them to room. Larvae are placed indry leaves of Mango, Jackfruit, Som and Sualo etc (Sarmah et al., 2010). They spin cocoon surrounding their body with silk filament, it taking time 3 days in summer and 7 days in winter to complete the cocoon. Inside the cocoon, the larvae are transformed into a pupa through an intermediary stage. It is called a pre-pupal stage. In this stage, the dissolution of the larval organs takes place and it is followed by the formation of adult organs. The weight of the pupa is about 6.5 gm and 4.5 ± 0.125 in length (Jolly et al., 1975). The colour of the pupa is copper brown. In the pre-pupal stage, the concentration of the juvenile hormone increasing and the ecdysone hormone decreasing which results in the transformation of external, internal organs. The colour of the prepupa is light green but later turns into dark brown in colour. In the pupal stage, sex markings are visible and it is very easy to determine the sex male or female pupa (Singh et al., 2013). In the case of female pupa has a fine longitudinal line on the eighth abdominal segment but it is absent in the male pupa. In this stage food is not required, the body is filled with fatty. Before the winter pupa is undergone diapause as a withstand mechanism. The size and weight of cocoon, shell thickness, pupal weight, thread length is different in a different season. The duration of the pupal stage is around 14 days in summer and 60 days in winter depending on the temperature, relative humidity condition (Rajkhowa & Kumar, 2011).

Moth

Inside the cocoon, the pupa transforms into a moth by own itself, moth are emerging out from the cocoon during the evening time and continue it is up to the next morning (Kakati & Benchamin, 2000). The male and female moths are easily identified because of their colour, wings, size of the abdomen, size of antenna (Singh et al., 2013). The body length of moths is 3.5 cm (female) and 3 cm (male). Generally, male moths are more active compare then female moths. The male moths are coupled with female moths at the time of evening and during the coupling time, they prefer dark environment. The time duration of the coupling is 8-10 hours (Goswami & Singh, 2012). It has two pairs of wings such as the fore and hind wing (Arora & Gupta, 1979). In the case of males, antennae are larger than female moths. The antenna is consists of regions; scape and pedicel

(contains sense organs and Johnston organ). Moth has three pairs of jointed legs, it is situated on the abdomen. After the 8 to 10 hours of coupling the female moth lay an egg on the khorika (it is made up of straw, in Assamese is called “Sang Kher”) (Sarmah et al., 2010). The female moth lays eggs up to 6 days, but the lays egg on the first three/four days are good for rearing purpose. During this stage, they are not eating anything, and finally, they die within 7 to 10 days (Jolly et al., 1975).

DISEASE OF MUGA SILKWORM

Every disease has different symptoms and characteristics. Generally, muga silkworms are affected by four types of diseases, it includes Flacherie, Grasserie, Muscardine, and Pebrine (Singh et al., 2013).

Flacherie

It is one type of bacterial disease and caused by *Streptococci bacillus*, bacteria (Chaudhury et al, 2002). Generally, the disease incidence is more during rainy summer months (July to August). It occurs due to feeding of wet leaves, feeding of contaminated leaves, high relative humidity and high temperature, poor sanitation. The symptoms of the flacherie disease are slow in larval movement, vomiting of fluid, loss of appetite, loss of clasping power, body softened, thorax black in colour, and shrinkage of the abdominal segment (Ranjana & K, 2009).

Control measure: Use disinfected good quality seeds for rearing purposes. Maintain proper sanitation in the rearing site. Before rearing, the disinfection of the rearing site with 2% formalin solution is necessary. Collect disease infected worms and burying with 5% formalin solution. Maintain hygienic during rearing time and do not allow late age worms to feed tender leaves (Singh et al., 2013).

Grasserie

It is a viral disease and caused by Nuclear Polyhedrosis Virus (NPV), Cytoplasmic polyhedrosis (CPV), infectious flacherie (Anonymous, 2007). Among these NPV is a major viral disease. In Assamese, it is called “Phularog” (Singh et al., 2013). The disease occurs throughout the year but disease incidence is more during rainy summer months. It occurs due to feeding of polyhedral contaminated leaves, feeding of tender & wet leaves, poor sanitation, high temperature, and high relative humidity, accumulation of faeces. The symptoms of grasserie disease are skin becomes shiny and turns, rectal protrusion, worms restless, loss of clasping power, sluggish movement, intersegmental swelling, hang upside down (Anonymous, 2007).

Control measure: Maintain clean and hygienic conditions in the rearing site. Disinfect the rearing house before brushing. Collect disease infected, weak larvae, and destroy by burying them. Extra disinfection with 0.3% slaked lime solution (Singh et al., 2013).

Muscardine

It is a fungal disease and caused by *Beauveria bassiana* (Ranjan & K, 2009). Green and white muscardine are common muga in silkworm. It occurs due to low temperature, high humidity, poor sanitation, contamination of disease-infected larvae and the disease incidence is more during winter months (Ranjana & K, 2009). The symptoms of muscardine disease are loss of appetite, slow in

movement, infected larvae become stiff, chalky and mummified. Larval body become hard after died (Ranjana et al., 2014).

Control measure: Maintain proper sanitation in the rearing site. Collect disease infected worms and burnt. Avoid dusty leaves. Maintain hygienic conditions during rearing time (Ranjana and K, 2009).

Pebrine

It is a protozoan disease and caused by protozoan parasite *Nosema bombycis* (Singh et al., 2013). Locally it is known as "Phootuka" in the Assamese (Singh et al., 2013). In the early stage, the infected early-stage worms do not show any symptoms. The disease occurs due to poor egg surface sterilization, feeding spore contaminated leaves, inadequate disinfection of rearing house & appliances. It can identify through a microscopic examination in which the spore stage of the pathogen present or not. During late age, infected larvae show symptoms such as the silkworm larvae loss appetite, molt irregularly, retarded in growth, larvae become pale in colour, black irregular spots on the skin (Jolly et al., 1975). Generally, the disease is transmitted through two processes, one is primary and another is secondary infection. In primary infection, disease is transmitted from infected mother to offspring and secondary infection, healthy larvae are infected through contaminated with infected larvae.

Control measure: Proper egg surface utilization. Maintain sanitation and hygiene. Avoid feeding contaminated leaves. Proper disinfection of rearing house, appliances & equipment. Strict microscopic examination (Anonymous, 2007).

CONCLUSION

Sericulture is an agro-based industry which the end product of raw silk. In India, natural silk has high demand in the market, and as well as it has a high status in traditional culture. This silk divided into two categories such as mulberry and non-mulberry silk, together it is called natural silk. Among these, the golden colour of muga silk is one of the beautiful and costliest silk. The muga silkworm is distributed in only some parts of India, especially in Assam and some areas of the Northeastern region. As well as this species occurs in very few countries in Asia. Muga silkworm is semi-domestic in nature, they complete its life cycle in indoor and outdoor conditions. However, constant support from government agencies and scientific communities is very much needed to solve the problem of muga culture and make it economically profitable and financially viable while rearing.

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