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An attempt forIndoor rearing of tasar silkworm *Antheraea mylitta* Druryon *Terminalia catappa* in the natural atmospheric conditions of Mysuru.

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Abstract: *The non mulberrysilkworm'stasar, eri and mugaare grown in hilly forest regions of north eastern part of India where climatic conditions are favourable and they feed on various wild food plants and many of them grown in plane lands for ornamental purpose. An attempt made to grow tasar silkworm Antheraea mylitta in the natural atmospheric conditions of Mysuru during the rainy season (June-September) by using the secondary food plant Terminalia catappa, resulted in the larval life span of 30 days on an average and the effective rate of rearing of 27%. The results were proved that the survivability ratio and the quantity and quality of the cocoons produced were found to be affected that may due to the new environmental conditions and secondary food plant provided.*

Key-words: Non-mulberry, silkworm, *Antheraea mylitta*, *Terminalia catappa*, larval duration, life span.

Introduction: Non-mulberry sericigenous fauna belonging to the family Saturniidae (superfamily Bombycoidea) are mostly wild silkmoths. Wild silkmoths include tasar silkworm, oak-tasar silkworm, eri-silkworm and muga silkworm. Most of the research and development of technology is confined to China, India, and Japan in Asia and are used as important tools in basic entomological and biotechnological research in various countries. They complete their life cycle of four different metamorphosing phases, egg, larva, pupa and adult (moths). Their cocoons are bigger than those of the domesticated silkworm (*Bombyx mori*). These are medium to very large in size, and this family includes the largest moths. Adults have a wingspan of 3 to 15 centimetres, relatively small heads, and densely hairy bodies. They lay eggs that range in hundreds. Larvae are usually very fleshy, with clumps of raised bristles. Caterpillars or larvae mostly feed on leaves of trees and shrubs of wide variety; some cause severe damage. Pupa develops in silken cocoons. Wild silk moths are reared on wild trees but can also be raised and bred under complete human control (Anonymous, 1979).

India is the only country in the world to produce all the four types of silkworms viz. domesticated mulberry silkworm (*Bombyx mori* L.) and wild type of non-mulberry silkworm's tasar (*A.mylitta*), muga (*A. assama*) and eri (*Samiacynthiaricini*) for their silk. The silk is of immense commercial value in India and abroad due to their traditional and social virtues. India is thesecond largest producer of tasar silk in the world (Shankar rao*etal*., 2004). India had approximately three thousand metric tons of tasar silk production in fiscal year 2019.Tasar silk is a coarse variety of silk largely produced across Bihar, Jharkhand and West Bengal in India (Anonymous,2019). It was harvested by tribals from different species of silkworms largely in wild forests, and hence considered a forest product.The Indian tasar silkworm *Antheraea mylitta* is a natural fauna of tropical India (Anonymous, 1979&2008). Tropical tasar silkworm, *Antheraea mylitta* Drury is known commonly as the tasarsilkworm and Vanya silkworm (Kavane, 2014) is wild and polyphagous and has opted forty five forest tree species as primary, secondary and tertiary food plants (Srivastav and Thangavelu, 2005). It is actually one of a number of tasar silkworms, species that produce Tussar silk, a kind of wild silk different from the silk of domesticated silkworm (Jolly *et al*., 1976). There are 44 eco-races of *A. mylitta* distributed in various regions of India(Srivastava & Sinha, 2012). The races are univoltine, bivoltine and trivoltine in nature and complete one, two and three life cycles in a yearrespectively (Barsagade, 2017). Some ecoraces are

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so well differentiated that they do not interbreed in nature, though they are not genetically distinct and can be bred in captivity(Chakraborty *et al*.,2015). Tasar cocoons are the largest among all the silk-producing insects in the world (Akai, 2000) and its silk fibre has its own distinctive colour, higher tensile strength, elongation and stress-relaxation values than the mulberry silk fibre (Iizuka, 2000).

This species is native to Indiaadapted to varied ecological conditions and food plants. It feeds on primary food plants, viz. *Terminalia tomentosa, T. arjuna* and *Shorearobusta* and dozens of secondary food plants (Anonymous, 2006).The life cycle of A. *mylitta* passes through four stages – egg, larva, pupa and adult. The larvae are voracious feeders while, adult are non-feeders. The weight of first to fifth instar is directly proportional to the feeding and increases from 8mg(length 8mm x breadth1.0mm) to 45mg (length 13.0mm x breadth 2.1mm) (Anonymous, 2006). The fifth instar larva spin the cocoon and pupates inside. The cocoon of *A. mylitta* is tough, made up from single silk thread measuring about 1000m. Since larvae are exposed to nature, they attract various pests and predators causing in increased larval mortality resulting in loss of tasar silk production in India (Barsagade, 2017).Unlike silkworm *Bombyx mori*, this species is also susceptible to pebrine, a disease caused by microsporidian belongs to genus *Nosema*, is lethal to the larvae(Mishra *et al*., 1992). It is also commonly infected with the *Antheraea mylitta* Cytoplasmic Polyhedrosis Virus (AmCPV), due to grasserie disease 20% crop loss has also been reported (Ghorai*et al*., 2010). There are many natural enemies of this silkworm including the uzi fly, *Blepharipazebina*(Rath & Sinha, 2005). Extensive deforestation and the collection of cocoons from wild populationshavethreatened survivability ofmany ecoraces. At present there has not been much work carried out to understand the preference of tasar silkworms for the food plant *T.Catappa*, hence the present study has been carried out to understand the suitability of tasar silkworm rearing in the local environmental conditions with the locally available secondary food plant *T.catappa*.

Materials and Methods: The cocoons of bivoltine tasarsilkworm *Antheraea mylitta*D. were obtained from RSRS, Telangana during the June and kept for emergence of moth in a natural condition of the laboratory without controlled atmospheric conditions at the Silkworm Breeding Laboratory of Department of Sericulture, Yuvaraja's College, University of Mysore, Mysuru.Mysuru enjoys a moderate climate with cool winters and warm summers. The summer in Mysore is from March to June. This season is the driest with May and June being the hottest months. Temperatures during this period range from a minimum of 21º Cand goes up to a maximum of 34º Celsius. The highest temperature recorded during summer was 38.5ºC. The monsoon months in Mysore are from June to September. During this short monsoon period, the city experiences medium to heavy rainfall. The average annual rainfall recorded was 761.9 mm. The winter season in Mysore is from December to February, with December being the coldest month. Winter in Mysore is cool with temperatures ranging from a minimum of 16º C to a maximum of 27º C. The lowest temperature recorded during winter was 9.6º C. Mysore is located at12.30°N 74.65°E and has an average altitude of 770 metres (2,526 ft).

Emergence of moths and coupling:The newly emerged moths showed a tendency to pair immediately after the emergence. Only healthy moths (female & male) emerged on the same day were selected and allowed to mate naturally in the breeding cage. After the successful mating period of 5 to 6 hours the female moths were separated manually from male and allowed to lays eggs on the Kharikas. The laid eggs were counted.

Selections of Disease Free Layings (DFLs):Disease free layingswere prepared by conducting mother moth examination to avoid further multiplication of the pathogens after oviposition for 72 hours (3days continuously).

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Brushing of the larvae and rearing: After seven days of oviposition (egg laying) the silkworm larvae hatched out of the eggs. The newly hatched larvae were brushed carefully with the help of soft hair brush on to the leaves of food plant kept in the conical flask on the trays. The larvae emerged for two days only were selected for brushing. The tender branches of food plant were kept in the conical flask filled with water and their mouth tightly covered by cotton wad/foam pad to avoid the falling of larvae in to the water. The fresh twigs with 12-15 leaves were replaced with old twigs after every 12 hours of intervals during the instars and transfer of larvae avoided during the moulting periods to avoid the loss of larvae. Every time the conical flasks were washed and used to avoid any kind of contaminations. The entire rearing sets were properly covered with nylon nets to avoid uzi fly infestations. Apical leaves of the twigs were removed because latex present in the tender leaves may affect the health of the larvae. During the entire period the natural temperature and relative humidity is maintained.

Food plant: The food plant used in this experiment is a secondary food plant *Terminalia catappa*. [Syn. *Juglans catappa* (L.); *Buceras catappa* (L.); *Terminalia badamia* DC. etc.] is a large tropical tree in the leadwood tree family, Combretaceae is known by the common names Bengal almond, Country almond, Indian almond, Malabar almond, Sea almond and Tropical almond.It is a fast-growing deciduous or semi-evergreen tree, usually growing about 15 metres tall with specimens up to 40 metres recorded. An important, multi-purpose tree, providing food, medicines and a host of other commodities. This is one of the most common trees of many tropical coasts. It is widely cultivated in the tropics, as a shade tree, for ornament and for its edible seeds. It is often planted in avenues as a shade-tree, for which it is suitable because of its very regular shape. (Yadav &Sardesai, 2002;Anonymous,2014).
Recording and evaluation:The duration of each stage is noted down till the formation of cocoon in the laboratory and results were morphologically evaluated.

Results and Discussion: The results of the present study reveal effect of environmental factors and the climatic conditions suitable for tasar silkworm rearing. Out of the 50 cocoons kept for emergence only 35 cocoons were with live pupa inside making the pupation rate 70%.The selected moth'sfecundity (number of eggs layed by a moth) was 150. Out of the total 150 eggs incubated, 108 eggs were hatched resulting inhatching percentage of 72.00. The evaluation of the rearing record and the average values obtained by the measurement of various stages of tasar silkworm are as follows; theeggs laid were weighing 0.010g,and measuring the length of 2.50mm and breadth of 2.20mm.The eggs incubation period was 7 days; Egg laying continued for 3 days; The newly hatched larva weighing 0.07g, and measuring the length of 16.00mm and breadth of 1.50mm. The fully developed fifth instar larvae weighing 18g, and measuring the length of 34.00mm and breadth of 17.00mm. The larval duration for each instar was recorded 4days, 4 days 5 days 7days and 10days during 1^{st}, 2^{nd},3^{rd}, 4^{th} and 5^{th} instars respectively that accounts to be 30days of total larval duration; out of the 108 larvae brushed only 25 larvae could form the cocoons to make Effective rate of ratings 27% due to mortality of larvae in different numbers in successive instars. The cocoon weighed 5.5g, and the length of 36mm and breadth of 18mm (Fig.1-8); the pupa inside the cocoon weighed 5g, the pupal stage recorded 19 days before it come out as adult moth. The female moths measuring a breadth of 120mm with wings expanding and the length of 40mm and males were smaller than females. The life span of the moths recorded 8 days in female and 5 days in males. The total duration of the lifecycle was 61 – 67 days starting from egg to moth.

The most important stage of any silkworms is the larval stage, that is the only stage of silkworms they feed on the leaves of their preferred food plants and the success of the silkworm rearing is depends on the healthiness of larva and the cocoons formed by them. And also, the success of next generation

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crop is depending on the success of the previous crop production that to the healthiness of silkworm larva though care during all the stages is very important. Hence the food plant leaves quality and the palatable natures of the respective silkworms are very important factors need to be considered. The present study revealedan average performance of the *Antheria mylitta* is attributed to the new environmental conditions that varied in the temperature, humidity, rainfall, wind speed, light duration, food plant nutritional aspects and rearing conditions (Kogure, 1933; Ranjan *et al*., 2012;Madhusudhan*et al*., 2017; Ananth*aet al*., 2018). The performance of the tasar silkworms (ecoraces) in their acclimatized regions is found to be superior in indoor rearing as well as outdoor rearing with respect to cocoon characters (Shivakumar & Shamitha, 2013). But they also exhibit weak voltinism, asynchronised moth emergence (35-40%), poor fecundity (165-200), less amenable to human handling and heavy crop loss during late age silkworm rearing stages resulting in low productivity (10-12 cocoons/dfls). However, these genetic resources material is bestowed with superior commercial characters like low denier(7%), high reelability (66%) and higher silk ratio (16.8%) (Renuka *et al*., 2017). The tasar silkworm successfully completed its life cycle in between 65 to 86 days (Chikkaswmy*et al*., 2007). Whereas, the whole life cycle of *A. mylitta* completed in 32 days with equal duration of third to fifth instar larvae i.e., 7 days each (Ranjan *et al*., 2012), which showed a lot of variation in the period at various places. This variation might be due to effect of different ecological conditions, food and races of tasar silkworm used for such studies at different locations (Lalitkumar, 2017).Thangavelu. (1991)recorded the indoor and outdoor larval duration in the range of 32 to 36 days. The larval duration of tasar silkworm on *T. arjuna* was 36.60 ± 0.89 days at Ranchi (Ram Kishor *et al*., 1997)[]. Lalitkumar (2017)recorded the larval duration of 28 to 36 days with an average of 31.80 ± 2.33 days under indoor conditions. In the present rearing the average total larval period recorded was 30 days, which was almost similar to other results obtained elsewhere. Vanitha *et al.,* (2017)reported, *A. mylitta* KE-02 larvae could complete all five instars successfully in 26-31 days on cashew and 25-29 days on *T. paniculata*. Another most important aspect of silkworms is ERR (effective rate of ratings), that is number of cocoons produced out of the number of larvae brushed. Because the quantity of cocoons determines the quantity of silk produced from it. In the present study the ERR percentage was recorded 27%, that may be due the loss of silkworm larvae due to death, that may be attribute to the rearing conditions and type of food plant used. During the entire feeding stage, the larvae looked weak and pale. That corroborates the findings of Madhusuhan*et al*., (2017)who stated that, the mortality rate increased with continuous variation in different a-biotic factors. The larval mortality rate due to pest infestation was severe during the early instars of the silkworm. The disease spread from one larva to another might have occurred through secondary sources of infection. Along with different a-biotic factors existing field condition also plays important role in the survivability of tasar silkworm larvae. The 5th instars larvae were voracious feeders and the survived worms were very active. But the dead worms were found to be sluggish and weak during the same period. The rearing conducted on different food plants like *T. arjuna*, *T. tomentosa*, *T. cattappa*and *Z.jujuba* by Jadhav*et al*.,(2014) recorded similar results where the performances of *A.mylitta* is better in *T.*arjuna than *T.cattapa*.The overall performance of the silkworm was also better in *T.tomentosa* than other food plants.Even it is different in different ecoraces and in same ecoraces reared in different rearing conditions in the same place and even differs in different seasons.

As like the domesticated silkworm *Bombyx mori*, that is the mulberry silkworm, the life span and life cycles (generations) depends on the silkworm strain and it varies with the environmental conditions particularly temperature, relative humidity, light and nutrition (Rohith *et al*., 2015;Umashankara& Subramanya, 2001). The combination of temperature and humidity provide optimum condition for hatching of the eggs. The optimum temperature (28ºC –30ºC) and humidity (75-86%), photoperiod (100-

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242 hours per month) with (11-12.50hours/day) day length was found favorable for the life cycle performance of this species of tasar silkworms on the contrary the average temperature in Mysuru during June- September was 23.5ºC and the humidity of 75.5%. The average rainfall for the said months was 67.21mm and the day length was not the limiting factor (Table-1). The life cycle of the silkworms and growth of the host plants have been under the influence of existing climatic situations of the place of rearing for temperature (Upadhyay & Mishra, 1991), Relative humidity (Mishra & Upadhyay, 1992), Photoperiod (Ranjan & Roy 2009)artificial diet (Iwanvat& Ono, 1969) for the performances of the silkworms. It was observed that decreasing temperature and increasing photoperiod had positive role in the moulting and cocoon formation of the *Antheria mylitta* in the laboratory. The perusal of literature on the life cycle performances of *Antheria mylitta* indicates that no information is available on the controlling factors of the larval duration of this silkworm species (Ranjan*et al*., 2012).

Tables and Figures:

Table 1: Monthly meteorological factors of Mysuru during March 2018 - February 2019

Month	Temp°C			Rainfall mm	No. of Rainy Days	RH (%) Avg.	Wind Velocity Km/hr
	Max	Min	Avg.				
Mar'18	34 °C	18 °C	26 °C	21.31mm	09	43%	9.6 km/h
Apr'18	34 °C	21 °C	27 °C	46.37mm	23	51%	8.1 km/h
May'18	33 °C	20 °C	26 °C	148.92mm	27	66%	8.9 km/h
June'18	30 °C	20 °C	24 °C	79.96mm	26	76%	17.6 km/h
July'18	29 °C	20 °C	23 °C	40.09mm	21	76%	20.0 km/h
Aug'18	28 °C	19 °C	23 °C	50.73mm	26	77%	18.6 km/h
Sep'18	30 °C	19 °C	24 °C	98.07mm	22	73%	9.1 km/h
Oct'18	31 °C	17 °C	24 °C	371.90mm	19	74%	8.8 km/h
Nov'18	30 °C	16 °C	23 °C	168.00mm	15	76%	10.4 km/h
Dec'18	30 °C	14 °C	22 °C	85.40mm	14	70%	9.1 km/h
Jan'19	29 °C	13 °C	22 °C	6.5mm	05	51%	10.1 km/h
Feb'19	35 °C	16 °C	25 °C	4.7mm	06	48%	11.7 km/h

[Source:https://www.worldweatheronline.com/lang/en-in/mysore-weather-averages/karnataka/in.aspx]

Fig. 1: Tasar female and male moths

Fig. 2: Paired moths

Fig. 3: Moth laying eggs on Kharika

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Fig.4 Larvae hatching

Fig.5: Young larvae transferred to food plants

Fig.6: Indoor rearing using nylon nets

Fig.7: Mature larvae feeding

Fig.8: Tasar Cocoons

CONCLUSION: It is evident from the present preliminary study that, the well maintained food plants and the proper care during the controlled rearing conditions of tasar silkworm is very essential along with the local environmental conditions that may be the limiting factors for the successful crop production. Few more studies could give the conclusive results regarding the suitability of wild silkworms grown in new environmental conditions and their success for commercial purpose on par with domesticated mulberry silkworm *Bombyx mori*, which is largest producer of silk in India.

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