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Dates: Received: 16 September, 2015; **Accepted:** 09 December, 2015; **Published:** 11 December, 2015

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www.peertechz.com

ISSN: 2455-815X

Keywords: *Antheraea assamensis*; Indoor rearing; ERR; Cocoon weight; Shell weight

Research Article

Comparative Study on the Rearing Performance of Muga Silkworm under Indoor and Outdoor Rearing Conditions

Abstract

Muga silkworm, *Antheraea assamensis* Helfer, generally reared outdoor on standing host trees for which it is always under pressure of vagaries of weather conditions causing substantial loss. Attempts were made to rear the silkworm under indoor conditions during different seasons. In first attempt, the worms were reared from brushing till spinning and in second, worms were first reared under indoor conditions up to 2nd in star and then transferred to outdoor condition. Rearing performance, larval and cocoon parameters were compared with complete indoor and outdoor conditions. Throughout all the seasons, survival per cent of worms, effective rate of rearing, mature larval weight, cocoon weight, pupal weight and shell weight was significantly higher when the worms were reared for first two instars under indoor conditions compared to either complete indoor or outdoor rearing. The study suggests that, it is beneficial to rear muga silkworms inside up to second instar and then rear outside for reducing mortality of worms during chawki instars and for production of higher and good quality cocoons.

Introduction

Muga silkworm *Antheraea assamensis* Helfer belongs to Lepidoptera of Saturniidae family and, geographically isolated only to NE region of India. Geographical isolation of this silkworm is indicative of its special requirements for geo-climatic conditions that prevail in this region i.e. high humid temperate climate and forest vegetation of primary and secondary host plants. Thus this species is phylogenetically less adaptive reaching its ecological isolation that is indicative of being on verse of extinction. Although Muga silkworm since time immemorable has been reared for Muga silk still it is purely an outdoor culture in host plant under natural conditions. Only cultural specificity is being managed and took care by Muga rearers. Being exposed to natural environment Muga culture practice encounter lots of problems right from brushing of worms to spinning of cocoons. Outdoor silkworm larvae are invariably expose to nature's vagaries such as seasonal climate change, rainfall, strong wind, soaring temperature, besides pests, predators and pathogens inflecting heavy loss particularly in early three instars. Prophylactic measures adopted for pest and disease in outdoor rearing became fruitless due to cross infestation by both pests and pathogens are common in open conditions. In an average in all seasons more than 50% larval loss has been reported by many scientists. Sengupta et al. [1], reported that during summer more than 50% loss was due to abiotic factors and 80% of the total loss of muga silkworm occurred in second/third instar only. Several workers experimentally practiced indoor rearing of muga silkworm applying different types of rearing devices and, some of them reported effective over outdoor rearing. Singh & Barah [2], conducted partial indoor rearing up to third stages with Som and Soalu twigs in bottle, iron tray and wooden and, reported larval mortality could be reduced marginally as compared to outdoor rearing. Cellular rearing technique developed by So, keeping in view of the present constrains faced by muga silkworm cultivation in outdoor conditions, the present comparative studies were undertaken to evaluate wooden tray device in indoor rearing practice of *A. assamensis* Helfer.

Muga silkworm culture is a traditional outdoor rearing practice adopted by people of North Eastern States mainly Assam. Rearing being outdoor, the success of crops are always bestowed on the mercy of environmental conditions. Out of the 5-6 broods of rearing in a year, the commercial crops fall in favorable period while all the other during the period of extremities of temperature, humidity, rainfall etc. The Aghenua crop which is pre-seed crop for Chatua seed crop falls during December-January. Low temperature prevailing during this season emanated to lengthening of larval duration and outbreak of fungal diseases mainly muscardine leading to heavy larval mortality. The resultant in turn is low rate of seed multiplication affecting availability of seed to Chatua Seed and subsequent multiplication for Jethua Commercial crops. Similarly, seed supply for Katia Commercial crop is also become inadequate as the seed multiplication rate of its preceding pre-seed and seed crops i.e. Aherua and Bhadia is very low. These two crops fall during unfavorable climatic conditions characterized by high temperature, high humidity and high rainfall (Figure 1). High temperature prevailing during this period has adverse effect on gonad development in the larvae causing inadequate fertilization of the female embryos during coupling. This leads to low hatching of eggs. High temperature associated with high humidity favors higher incidence of bacterial diseases causing substantial crop loss. The possibility of using prophylactic measures to contain diseases as practiced in mulberry sericulture is also not feasible under the outdoor condition of rearing.

Citation: *Neog K, Dutta P, Changmai A, Goswami D, Choudhury B (2015) Comparative Study on the Rearing Performance of Muga Silkworm under Indoor and Outdoor Rearing Conditions. Int J Agricultural Sci Food Technology 1(1): 020-024. DOI: 10.17352/2455-815X.000006*

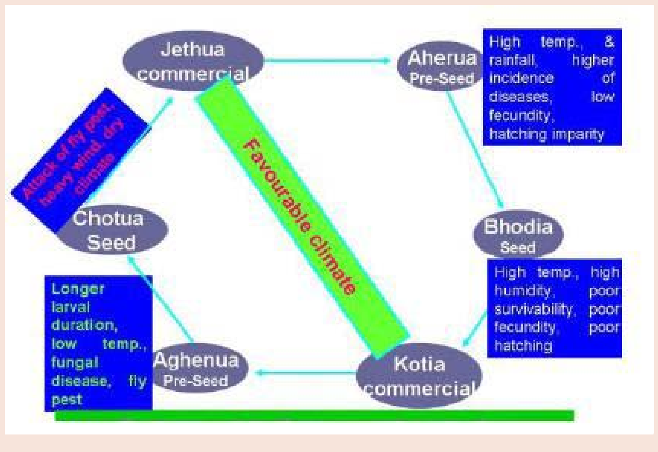

Figure 1: Graphical representation of environmental effect on seed production of muga silkworm.

Several workers tried indoor rearing of muga silkworm to avoid early instar loss, unfavourable seasons of extremities of temperature, humidity and rainfall. Thangavelu and Sahu [3], conducted indoor rearing of muga silkworm by cellular method and found that rearing in Soalu plants was suitable during different seasons for improvement in ERR, but female cocoon weight and fecundity were found significantly higher on 'Som' plant. Bhuya N et al. [4], reported that indoor rearing in iron tray (3" x 4" x 4") with water and sand bed covered with slotted cover containing 'Som' twigs showed better ERR (58.8%) compared to control (51.3%). Singh and Barah [2], conducted partial indoor rearing up to third stages with Som and Soalu twigs in bottle, iron tray and wooden and, reported that larval mortality could be reduced marginally compared to outdoor rearing.

Barman and Rana [5], conducted Muga silkworm rearing under indoor condition on wooden tray device up to 2nd in star on Som and Soalu leaves as feed throughout all rearing seasons. They reported larval weight, larval duration and larval survival differed in Som and Soalu leaves from their indoor and outdoor counterparts. Indoor rearing on detached twigs in wooden tray did not vary significantly from outdoor rearing on trees.

Barman and Rajan [6], reported use of Nutrient Supplemented Phago-stimulant resulting to increased leaf nutrient quality, arrested larval movement and increased feeding rate which reflected in the higher biomass growth in comparison to treatment without it use. Spraying of 0.5% streptomycin sulphate solution in the indoor reared Muga silkworm, minimized the bacterial infection thereby contributing to larval survivability.

The present paper describes the comparative rearing performance of muga silkworm under indoor and outdoor rearing conditions. The experiments were conducted with an objective to standardize the indoor rearing practice of muga silkworm to avoid early instar loss and adverse climatic conditions.

Materials and Methods

The experiments were conducted in the indoor rearing laboratory and experimental rearing fields of Central Muga Eri Research & Training Institute, Central Silk Board, Lahdoigarh, Jorhat, Assam, and India. The rearing was conducted with three treatments, 1) complete indoor rearing up to spinning of worms (T-1); 2) indoor rearing up to 2nd in star and then transferring the worms to standing trees (T2) and 3) complete outdoor rearing (Control). In each treatment, 5 dfls were brushed with three replications for five season's viz. Chatua (Feb.-March), Jethua (April-May), Aherua (Jun-July), Bhadia (Aug-Sept) and Katia (Oct-Nov) during 2013 and 2014.

Collection of muga eggs

Muga silkworm eggs (seeds) certified as disease free layings (dfls) were obtained from the Seed Technology Laboratory of the institute which were kept in incubator at 25 ± 1°C and 75-85% Relative Humidity till hatching.

Disinfection of the indoor rearing room

Disinfection of the indoor rearing room was one by closing the doors and windows of the rearing hall and made air tight 5-7 days before brushing of worms. Disinfection was done by spraying of 2% formaldehyde or 5% bleaching powder solution on the walls and larger appliances inside the hall. The smaller appliances were dipped in 5% bleaching powder solution. Spraying of 2% formalin with slaked lime mixture @ 1 ltr. / 2.5 sq. m. area and fumigation of the hall with 10% formaldehyde was done and the hall was left closed for 24 hours. The whole process of disinfection was completed at least 3-4 days before arrival of seed consignment and left the door and window open for proper aeration.

Selection of leaf for indoor feeding

The best preferred food plant of muga silkworm, som (*Persea bombycina*) were pruned 3 months ahead of conducting indoor rearing. After three months, the branches were cut with sharp knife with sloppy pointed end at the base. The diseased, deformed, mature and very tender leaves were removed from the branches and washed the branches in clean running water so as to remove dusts and any debris. The branches was kept dipping in a bucket containing 5 ppm of a chemical formulation at least one hour before brushing so that the branches remain fresh for at least 12-18 hours.

Brushing of muga silkworms

When hatching of worms is observed from the eggs kept in perforated paper bags containing only 1 or maximum 2 dfls per bag. The hatched worms along with the bags were kept in rearing tray (Size: 3 ft x 2 ft x 0.5 ft.) keeping them on the top of tables (5 packets per tray) containing two to three som branches. The worms crawled out and move to the branches. After completion of brushing, the trays were covered with polythene sheet in such a way that the worms cannot come outside the tray. Next day, separate trays were taken for brushing the worms for second day hatching and brushing was done for 3 days only for each dfl. Brushing in standing trees (control) was done as usual practice [7].

Feeding of leaves in trays

After brushing on first day, on next day if the leaves were completely eaten, then another 2 or 3 branches were put and the left out leaves and branches were removed daily. If necessary, the worms were transferred to new trays. Trays were covered with polythene sheets after putting the branches. During summer, the polythene sheets were removed for 2-3 hours if the temperature was went beyond 33°C. Good aeration was provided in that case by keeping the doors and windows open. For rearing of 1st and 2nd instar worms, feeding was done with mixture of tender and semi-mature leaves; for 3rd and 4th instar worms, mixture of semi-mature and mature leaves and for 5th instar worms mature leaves. During summer and rainy seasons, when the RH recorded was above 85%, the floor of the room was dusted with slaked lime 100 g per sq. m. The worms were not disturbed or put branches on them when they settled for moulting. New branches were given as and when completely eaten.

Transfer of worms to outdoor trees

When the worms came out 2nd instar completely the worms were transferred along with the branches to standing trees outside in between 4-5 PM during winter and 5-6 PM during summer. Care was taken so that the worms do not get direct sunlight.

Management of diseases and pests

If in any tray, diseased worms were observed, the diseased worms were separated and the healthy worms were transferred immediately to another tray properly disinfected and dried. The tray having the diseased worms were taken out, washed properly with disinfectants as mentioned above, well dried under strong sunlight. The diseased worms were disposed of immediately putting them in 5% bleaching powder solution and buried in soil up to a depth of 2 feet. For avoiding attack of ants, the legs of the table were dipped under water in a small pan so that ants cannot move up through the legs.

Collection of data

Data were collected from each treatment for all the seasons for two years on survival percent of muga worms during 1st to last instar for complete indoor rearing (T-1), 1st to 2nd instar for T-2 and Effective Rate of Rearing (ERR) i.e. total number of mature worms collected out of total number of worms brushed for control. Body weight of mature larvae, cocoon weight, shell weight and Silk Ratio percent (SR%) were recorded in all the seasons.

Statistical analysis

All experiments were replicated and the data including environmental parameters i.e. temperature, relative humidity and rainfall during the crop seasons (Figure 2) were recorded in Microsoft Excel and analyzed by Statistical Analysis System (SAS). Standard error and significant differences between values were determined using Duncan's multiple range test ($P < 0.05$), following one-way ANOVA. Graphs and diagrams were presented with the help of statistical software program 'Origin Pro 8'.

Results and Discussion

The data collected during different seasons under different treatment in the whole experimental period was statistically analyzed and presented below.

Survivability of larvae in different instar: Survival percent of muga larvae during different seasons under treatment No. 1 (T-1) and under treatment No. 2 (T-2) are presented in Table 1 and Table 2, respectively. From Table 1, it has been observed that, the highest survival of worms was obtained during Katia crop (94.33%) and on an average of all seasons, more than 90% worms survived after first moult. After 2nd moult, more than 82% worms survived, being highest during Katia crop (87.49%). Average survivability of worms after 3rd moult was 66.23%, being the highest during Katia crop (73.86%) and the lowest during Bhadia crop (57.52%). After 4th moult, 54.75% worms survived, highest during Katia (61.36%) and lowest during Aherua crop (44.35%).

Under treatment no. 2 (T-2), on an average, more than 89% worms survived after first moult in different seasons, the highest recorded during Katia crop (94.14%) and lowest during Bhadia crop (83.47%). After 2nd moult, the highest survivability of worms was recorded during Chatua crop (85.29%) and lowest during Aherua crop (74.40%) with an overall survival percent of 80.59% (Table 2).

Effective rate of rearing: The total number of mature healthy worms collected in different treatments during different seasons for two years is presented in Figure 3. From the figure, it is evident that,

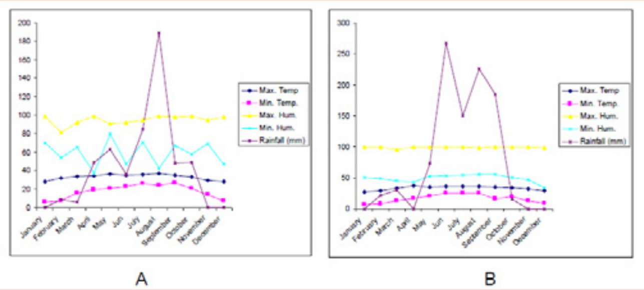

Figure 2: Temperature, relative humidity and rainfall during 2013 (A) and 2014 (B) in different the crop seasons.

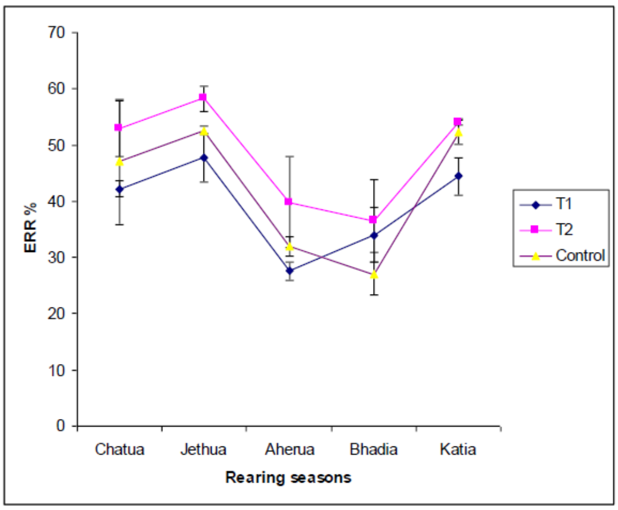

Figure 3: Pooled average values of effective rate of rearing (ERR) of muga silkworms under different rearing conditions during different seasons.

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maximum numbers of mature worms were collected when the worms which were released to trees outside after 2nd moult for all the seasons and, it has been observed that, it is beneficial to rear worms inside up to second moult and the rearing outside compared to rear under total indoor or outdoor conditions.

Larval, cocoon, pupal and shell weight: Weight of mature female larvae was recorded the highest under T-2 (15.884 g) during Aherua crop followed by Katia crop (15.526 g). Larvae from control plots recorded the lowest weight during Katia season (6.789 g) (Figure 4A).

Significantly highest female cocoon weight (7.353 g) was formed by larvae which were reared indoor during chawki stages and then transferred to outdoor host plants during Bhadia crop (T-2) (Figure 4B). On the other hand, the highest pupal weight was recorded from Katia crop under T-2 (6.817 g) and the lowest from Jethua crop under T- 1 (3.461 g) (Figure 4C). Shell weight was recorded maximum (0.547 g) during Jethua crop under T-2 (Figure 4D).

In case of male, larval weight was maximum during Katia crop under T-2 (12.334) followed by that recorded Bhadia crop (12.250 g) (Figure 5A). Significantly the lowest larval weight was recorded from Chatua crop under T-2 (5.461 g), followed by that of control plots (5.496 g).

Larvae which were reared indoor for first two instars exhibited significantly higher male cocoon weight in all the seasons, being the highest during Katia crop (6.670 g) (Figure 5B). Pooled value also indicated that, cocoon weight was minimum with complete indoor rearing treatment (3.922 g) during Aherua crop compared to control also. Similarly, male pupal weight was recorded significantly the highest (6.100 g) under partial indoor rearing compared to T-1 and control (Figure 5C). Shell weight of male cocoons was maximum during Aherua crop under T-2 (0.453 g) and minimum during Katia crop (0.316 g) under T-1 (Figure 5D).

Thus, from the present study it has been observed that, by conducting indoor rearing of muga silkworm for first two instars

Table 1: Pooled average values of survival percent of muga silkworms in different moulting stage under complete indoor rearing condition during different seasons.

Sl. No.	Moulting stage	Chatua	Jethua	Aherua	Bhadia	Katia	Average	S.D. (±)
1.	1st moult	92.75	92.97	89.83	84.92	94.33	90.96	3.75
2.	2nd moult	85.50	87.01	75.17	77.64	87.49	82.56	5.74
3.	3rd moult	68.50	73.04	58.25	57.52	73.86	66.23	7.89
4.	4th moult	59.00	59.44	44.35	49.61	61.36	54.75	7.39

Table 2: Pooled average values of survival percent of muga silkworms up to 2nd moult stage under partial indoor rearing condition during different seasons.

Sl. No.	Moulting stage	Chatua	Jethua	Aherua	Bhadia	Katia	Average	S.D. (±)
1.	1st moult	91.08	93.13	86.64	83.47	94.14	89.69	4.04
2.	2nd moult	85.29	83.47	74.40	77.05	82.76	80.59	6.15

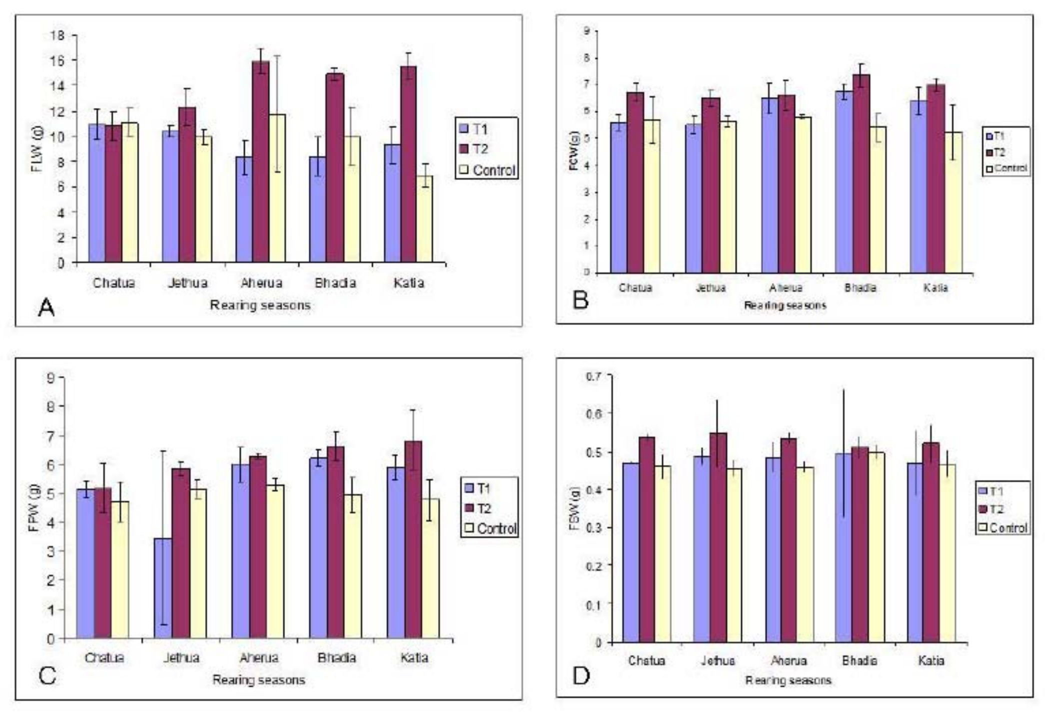

Figure 4: Pooled average values of female larval weight (FLW), female cocoon weight (FCW), female pupal weight (FPW) and female shell weight (FSW) of muga silkworms under different rearing conditions during different seasons.

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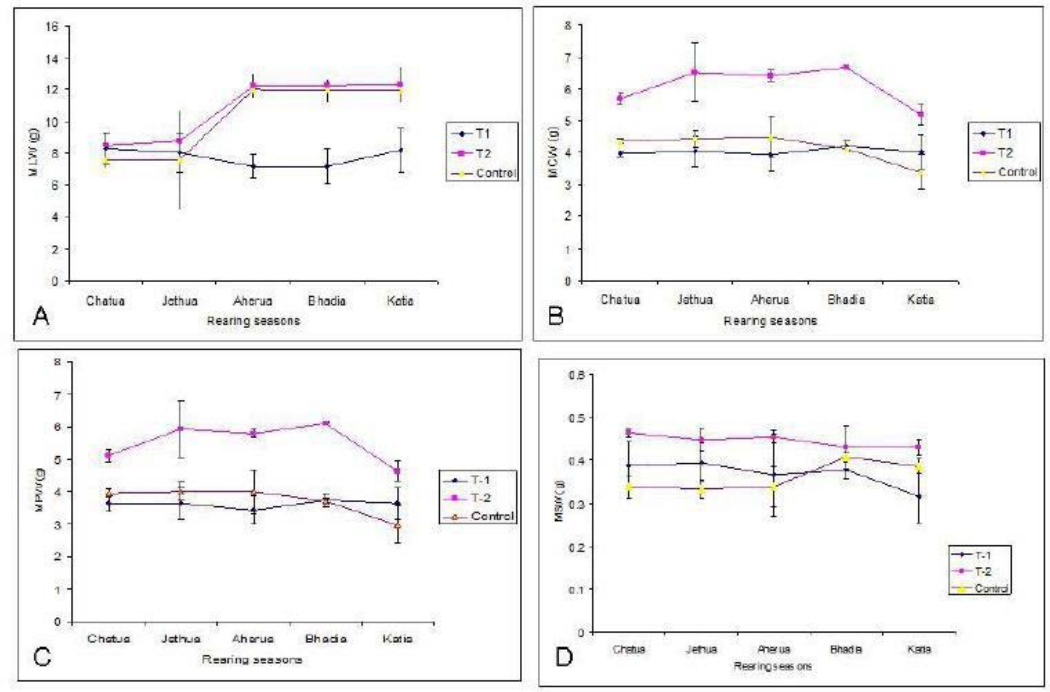

Figure 5: Pooled average values of male larval weight (MLW), male cocoon weight (MCW), male pupal weight (MPW) and male shell weight (MSW) of muga silkworms under different rearing conditions during different seasons.

it is possible to reduce early instar loss of muga silkworm which is reported to be more than 30% [8]. Sengupta et al. [6], also reported that during summer more than 50% loss was due to abiotic factors and 80% of the total loss of muga silkworm occurred in second / third instar only. This loss can be minimized by rearing the muga worms even up to 3rd instar if climatic conditions remain unfavourable during the larval period.

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