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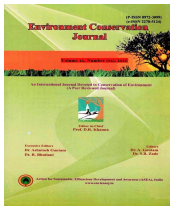

Economic characters of muga silkworm cocoons influenced by regions and commercial seasons

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ABSTRACT

Muga cocoons were procured from Jorhat, Kamrup and Lakhimpur districts in spring and autumn season. The objective was to determine the impact of three regions and commercial seasons on cocoon characters in terms of cocoon size, cocoon weight, pupal weight, shell weight and shell ratio. The experiment was laid out in completely randomised design with three replications. The impact of three regions and two seasons was found to be significant on cocoon parameters. Large sized cocoons were obtained from Kamrup district followed by Lakhimpur and Jorhat in autumn season compared to those obtained in spring season. Cocoon weight, shell weight, pupal weight and shell ratio percentage (5.73g, 0.51g, 5.19g and 8.74% respectively) were found to be significantly higher in Kamrup as compared to Lakhimpur (5.4g, 0.46g, 4.94g and 8.43% respectively) while lowest was recorded in Jorhat district (5.27g, 0.43g, 4.83g and 8.20% respectively) irrespective of the seasons. Considering the seasons, cocoons obtained from autumn were superior in terms of cocoon characters (5.66g cocoon weight, 0.49g shell weight, 5.16g pupal weight and 8.63% shell ratio) than those of spring season. Kamrup district and autumn season have turned out to be the best region and best season clearly indicating that region and season influences the cocoon characters of muga silkworm.

Introduction

The silkworm, *Antheraea assamensis* Helfer is found only in north-east India from which muga silk is obtained. Muga culture is especially practiced in Kamrup, Goalpara, Udalguri, Kokrajhar, Tinsukia, Dibrugarh, Sibsagar, Jorhat, Golaghat, Lakhimpur and Dhemaji districts of Assam (Bayan Borah and Borgohain, 2018). Muga silkworm is polyphagous, semi-domesticated and producing six broods in one year. *Katia* (autumn, September-October) and *Jethua* (spring, April-May) are commercial crops and *Aherua*, *Bhodia*, *Jarua, Chotua* are seed crops (Goswami *et al.,* 2013). The climatic conditions prevailing during the commercial seasons in Assam are favourable for muga culture in comparison to seed crops. The availability of the primary and secondary food plants (*som, soalu* etc.) in the north-eastern India both in the Brahmaputra valley and in the Eastern Himalayan ranges made this region an ecological niche. In India, the total production of muga raw silk during the year 2019-20 was 240.50 MT out of which Assam produced 197.90 MT of muga raw silk (Anonymous, 2020a). The districts selected for the study i.e. Jorhat, Kamrup and Lakhimpur contributed about 27.06% of the total muga production of the state and Lakhimpur scored the

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highest production (41.11MT) with the muga silkworm food plant area of 2238.17 ha engaging 4297 number of families (Anon., 2020b). Therefore, every possibility must be explored to enhance the production in these potential muga growing areas based on the quality.

Cocoon and its standard are the crucial factor which leads to better silk output and sustainability of silk industry. The quality of cocoon is determined through its characters (size and weight of cocoon and shell, shell ratio percentage) which vary as it is reared in outdoor condition. According to Rahmathulla (2012), variation in the environmental elements affect the genotypic constitution in the form of phenotypic output such as cocoon weight, shell weight, shell ratio percentage. Hence, it can be inferred that the cocoon quality and ultimately the quality of raw silk is influenced by wide range of factors starting from climatic conditions that changes with different crops, seasons and regions. The present study was undertaken with a view to study the regional variations in cocoon characteristics of muga silkworm reared in two commercial seasons from three randomly selected regions (Jorhat, Kamrup and Lakhimpur). The cocoon parameters considered during the study were cocoon size, weight, shell weight, pupal weight and shell ratio percentage.

Material and Methods

The experiment was carried out in two commercial seasons *viz*., Spring (*Jethua*) and Autumn (*Katia*) during the year 2018-2020. Freshly stifled cocoons were procured from private rearers of Jorhat, Kamrup and Lakhimpur districts of Assam in spring and autumn season. The cocoons were stored in a well-ventilated wire mesh cage in a properly disinfected insect and rat proof room by following the standard method of Mishra *et al.,* 2016. Inside the cage the cocoons were kept open and spread thinly in a single layer. The cocoons were exposed to sunlight periodically to avoid fungal attack. Muga cocoon shell and pupa are presented in figure 1(A-F).

Cocoon parameters assessment

Cocoons were subjected for assessment of quality.

a) Size of the cocoons: Size of the cocoon is regarded as one of the most important characteristics which indicate the productivity in silk reeling and quality of raw silk (Gowda *et al.,* 2014). Size of the cocoon was calculated by following the standard method of Anonymous, 2021a. The number of cocoons that can be enclosed in a container of one litre indicates the size. The more the number of cocoons the smaller will be the size and vice versa.

b) Cocoon weight: The weight of the cocoons along with the pupa was recorded in grams procured from different locations in different seasons.

c) Cocoon shell weight: The weight of the cocoon shell was measured in grams by cutting the shell and removing the pupa from the cocoon.

d) Pupal weight: Weight of pupa was recorded in gram after removing it from cocoon.

e) Shell ratio: Shell ratio is the ratio of the weight of cocoon shell to the weight of cocoon with pupa. It is the amount of silk present in the cocoon and expressed in percentage. It was calculated by following the standard method of Bashir *et al*. (2014).

$$\text{Shell ratio} = \frac{\text{Shell weight (g)}}{\text{Cocoon weight (g)}} \times 100$$

Statistical analysis of data was performed in Completely Randomised Design (CRD) to study the effect of different regions and commercial seasons on cocoon parameters as described by Panse and Sukhatme (1989). Data taken were mean of three replications. The number of cocoons in each replication was ten.

Results and Discussion

It is apparently manifested in Table 1 that the cocoon size of Jorhat, Kamrup and Lakhimpur regions was significantly different. The number of cocoons per litre ranges between 38.00-44.00 numbers in different regions. Considering the regions, Kamrup (38.50 nos.) registered significantly less cocoon numbers per litre while Lakhimpur (approx. 40 nos.) and Jorhat (42.00 nos.) was observed as more. Between the two commercial seasons, the numbers of cocoon per litre was significantly less in autumn season (39.22 nos.) than the spring season (41.56 nos.). The interaction effect due to region and season was non-significant. The lowest number of cocoons per litre (38.00 nos.) was recorded in Kamrup district in

Table 1: Effect of different muga growing regions and commercial seasons on cocoon size (nos./lt.) of muga silkworm.

Region	Season		Mean
	Spring	Autumn	
Jorhat	44.00	40.00	42.00
Kamrup	39.00	38.00	38.50
Lakhimpur	41.67	39.67	40.67
Mean	41.56	39.22	
	SED (±)	CD (5%)	
Region	0.61	1.34	
Season	0.50	1.10	
Region x Season	0.86	NS	

Data are mean of 3 replications, NS = Non significant, SED = Standard error of difference

Jorhat district (spring season)

Jorhat district (autumn season)

(C) Kamrup district (spring season)

(D) Kamrup district (autumn season)

(E) Lakhimpur district (spring season)

(F) Lakhimpur district (autumn season)

Figure 1(A-F): Shell and pupa of muga cocoon in spring and autumn season.

autumn season whereas the highest (44.00 nos.) was found in Jorhat district in spring season. Less number of cocoons indicated bigger size while small size is denoted by a more number of cocoons. Thus, it can be concluded that the cocoons procured from Kamrup in autumn season were comparatively bigger in size than Lakhimpur and Jorhat district.

Cocoons from different regions showed significant variation in weight (Table 2). The highest cocoon weight was registered in Kamrup district (5.73g) while the lowest was observed in Jorhat district (5.27g). Irrespective of the regions, significantly the highest cocoon weight was observed in autumn season (5.66g) and in the spring season (5.27g) recorded the lowest. But notably, the interaction effect of region and season was found to be non-significant. Table 3 evidently indicate that shell weight of muga cocoons varied considerably in different regions and seasons. Highest shell weight was recorded in cocoons procured from Kamrup while the lowest was observed in cocoons obtained from Jorhat (0.43g). Cocoons harvested in autumn (0.49g) showed significantly higher shell weight in comparison of those harvested in spring season (0.44g). The interrelation between region and season was found to be non-significant. Results pertaining to pupal weight are presented in Table 4. Pupal weight was significantly highest in cocoons obtained from Kamrup district (5.19g) followed by pupal weight in cocoons obtained from Lakhimpur (4.94g) which was found *at par* with the pupal weight (4.83g) of Jorhat district. Irrespective of regions, pupa obtained from the cocoons of autumn season (5.16g) was significantly higher in weight than spring season (4.81g). The study showed that the interaction effect of region and season was not significant. Similar trend was noticed in case of shell ratio percentage (Table 5). The results displayed that shell ratio percentage differed significantly majorly across the regions. Irrespective of the season, shell ratio percentage was maximum in Kamrup district (8.74%) and minimum was observed in Jorhat (8.20%) region. Cocoons obtained in autumn season (8.63%) exhibited significantly higher shell ratio percentage compared to spring season (8.28%). The interaction effect of region and season was trivial to notice. However, the maximum shell ratio percentage was recorded in Kamrup district (8.86%) in autumn season whereas the lowest was observed in Jorhat district (8.01%) in spring season. Cocoon acts as defensive covering for the pupa inside to overcome unfavourable environmental conditions and its natural enemies. It is spun by mature silkworm with the help of protein secretion from silk gland at the end of its larval period. Cocoon is the raw material of silk industry. Size and weight of cocoon and shell, shell ratio percentage are key parameters which help to access the quality of cocoon. Seasonal variations in different silkworm species have been reported by many researchers (Bashir *et al.,* 2014 and Sarkar, 2018 in mulberry; Bhatia and Yousuf, 2014, Chattopadhyay *et al.,* 2017 in tasar; Naik *et al.,* 2010, Chattopadhyay *et al.,* 2017 in eri; Barman and Rana, 2011, Padaki *et al.,* 2014 in muga, respectively) which directly or indirectly influence the silkworm in the form of commercial characters. Literature is also available on effect of host plants on economic traits of silkworm (Bahar *et al.,* 2011, Singh and Goswami, 2012, Deka and Kumari, 2013, Subharani *et al.,* 2017). Rahman *et al.* (2015) observed that environmental conditions play a significant role which influence the quantitative and qualitative characters of silkworm such as cocoon size, weight, length and shell ratio. The contribution of silkworm race is about 4.2% for successful cocoon production (Neog *et al.,* 2016) along with other factors like rearing conditions, environmental conditions during rearing, quantity and quality of leaves, harvesting conditions, all these factors influence the healthy growth of larva which ultimately affecting the size of cocoon (Aruga, 1994 and Lee, 1999). In case of uni/bivoltine mulberry silkworm species, the number of cocoons per litre ranges from 90-120 (Anon., 2021a). Saikia (2008) reported that the cocoon volume of eri silkworm ranged from 52-55 nos., 50-51 nos. and 46-51 nos. reared on borkesseru, borpat and castor, respectively.

The present results are in accordance with Borpuzari *et al*. (2020) who observed that the weight of muga cocoons obtained from autumn (*Katia*) was significantly higher than cocoons produced in other seasons. Bordoloi (1999) while studying the effect of various seasons and host plants on cocoon characteristics of muga silkworm revealed that there is significant variation in regards of cocoon weight (5.53g, 4.96g, 4.89g and 4.81g in

Table 2: Effect of different muga growing regions and commercial seasons on cocoon weight (g) of muga silkworm.

Region	Season		Mean
	Spring	Autumn	
Jorhat	5.15	5.39	5.27
Kamrup	5.49	5.97	5.73
Lakhimpur	5.18	5.61	5.40
Mean	5.27	5.66	
	SED (±)	CD (5%)	
Region	0.06	0.13	
Season	0.05	0.11	
Region x Season	0.08	NS	

Table 3: Effect of different muga growing regions and commercial seasons on shell weight (g) of muga silkworm.

Region	Season		Mean
	Spring	Autumn	
Jorhat	0.41	0.45	0.43
Kamrup	0.48	0.53	0.51
Lakhimpur	0.43	0.48	0.46
Mean	0.44	0.49	
	SED (±)	CD (5%)	
Region	0.01	0.01	
Season	0.01	0.01	
Region x Season	0.01	NS	

Table 4: Effect of different muga growing regions and commercial seasons on pupal weight (g) of muga silkworm.

Region	Season		Mean
	Spring	Autumn	
Jorhat	4.71	4.94	4.83
Kamrup	4.97	5.41	5.19
Lakhimpur	4.75	5.12	4.94
Mean	4.81	5.16	
	SED (±)	CD (5%)	
Region	0.08	0.17	
Season	0.06	0.14	
Region x Season	0.11	NS	

Table 5: Effect of different muga growing regions and commercial seasons on shell ratio percentage of muga silkworm.

Region	Season		Mean
	Spring	Autumn	
Jorhat	8.01	8.38	8.20
Kamrup	8.61	8.86	8.74
Lakhimpur	8.22	8.64	8.43
Mean	8.28	8.63	
	SED (±)	CD (5%)	
Region	0.05	0.11	
Season	0.04	0.09	
Region x Season	0.07	NS	

Katia, Bhodia, Aherua, Jethua respectively), pupal weight (5.12g, 4.50g,4.49g and 4.46g in *Katia, Bhodia, Aherua, Jethua* respectively), shell ratio percentage (7.40%, 9.00%, 8.27% and 7.37 % in *Katia, Bhodia, Aherua,Jethua* respectively) but non-significant effect on shell weight. Kemprai

(2012) also observed that season and host plant significantly influenced the cocoon characters like cocoon weight, shell weight, pupal weight and autumn season were the best season. However, season had non-significant effect on shell ratio percentage. According to Choudhury *et al*. (1998), the plants containing more sugar and less fibre in the leaf were suitable for muga worm and there exist considerable variation in the chemical constituents of som leaf collected from various locations of geo-meteorological areas of Assam and a positive relation has been found between the sugar content of leaf and cocoon weight. Padaki *et al*. (2014) concluded that significant variation was observed among three prominent muga growing regions (Tura, Goalpara and Sonapur) and cocoons of Tura region performed better in terms of cocoon quality in both *Katia* and *Jethua* as compared to other two regions. According to Tikader (2012), the cocoon weight and shell weight of semi-domesticated muga silkworm lies in the range 2.9-7.7 g and 0.18-0.65 g, respectively. Neog *et al*. (2016) found the male cocoon weight and shell weight was higher from larvae fed with *som* leaves while female cocoon weight was higher from *soalu*. The weight of pupa (4.16-6.10g in male and 5.50-8.47g in female) were found to vary among various wild and semi domesticated stock and more in wild accessions (Kalita and Dutta, 2015). Chattopadhyay *et al*. (2018) also reported that the average weight of muga cocoons was 7.10g, shell weight 0.60g and shell ratio 8.50%. As per findings of Kalita and Dutta (2020), significant differences were observed in *Antheraea assamensis* population collected from eleven different regions of north-east India in terms of cocoon colour, weight, shell weight and shell ratio. Sarmah *et al*. (2013) reported that wide range of variation exist in nutrient status of soil under *Persea bombycina* plantation in Jorhat and Lakhimpur district which influenced the nutrient content of *som* leaf and in turn affect overall cocoon production. Borpuzari *et al*. (2020) revealed that the rearing performance as well as biochemical constituents was better in *katia* crop followed by *Jethua* when rearing was conducted on *soalu* plant. The changes in various cocoon parameters may be due to the variations in environmental factors and quality of food plants. Kumar *et al*. (2012) studied the effect of different host plants *viz*., *Terminalia arjuna, T bellirica, T chebula, T tomentosa, L. parviflora and L. speciosa* on cocoon weight, shell weight, silk ratio of *Antheraea mylitta* during July-August under agro-climatic condition of Ranchi and found that the parameters varied with the host plants. Pallavi and Sannappa (2018) concluded that commercial characters of eri silkworm varied significantly among six eco-races (Borduar, Dhanubanga, Khanapara, Kokrajhar, Mendipathar and Titabar) of eri silkworm when reared on castor leaves.

Conclusion

Cocoon has immense commercial importance as it is the raw material of silk industry and is processed after harvesting from the mountage. Size and weight of cocoon and shell, shell ratio percentage are key parameters which help to access the quality of cocoon. These parameters or properties vary from region to region and season to season. Different regions of Assam experience different climatic factors in terms of temperature, humidity, rainfall etc. which has its impact on existing fauna and flora of that particular region as a consequence variation can be noticed on product quality of crops. Soil nutrient quality and quantity also varies in different agro-climatic zones of Assam which may also affect quality of the food plant and ultimately growth and development of muga silkworm and their product i.e. cocoon. From the results, it can be inferred that all the parameters were better in Kamrup as compared to Lakhimpur and Jorhat district. Considering the seasons autumn season was found better in respect of cocoon characteristics. In order to improve the quality of muga cocoons in Lakhimpur and Jorhat district as well as in spring season necessary measures should be taken into consideration. Rearers should also follow proper package of practices regarding host plants and silkworm rearing to enhance productivity as well as quality of cocoons.

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Conflict of interest

The authors declare that they have no conflict of interest.

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