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ENTOMOLOGY

Management of Nutritional and Climatic factors for Silkworm Rearing in West Bengal: A Review

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ABSTRACT

The development and reproduction of insects are greatly influenced by a variety of nutritional and climatic factors. These factors may exert their effects on insects either directly or indirectly. Under natural conditions organisms are subjected to a combination of nutritional and climatic factors, and it is this combination that ultimately determines the distribution and abundance of a species. Frequently the effect of one facto modifies the normal response of an organism to another factor. For example climatic factor light, by inducing diapauses may make an insect unresponsive or unaffected by temperature fluctuations. Major silk producing insect *Bombyx mori* L is also not an exception. *Bombyx mori* L is a domesticated and delicate insect. Improper maintenance of nutritional and climatic factors affect the genotypic expression in the form of phenotypic output of silkworm crop such as cocoon weight, shell weight, and cocoon shell ratio. Besides it is not easy to manage silkworm rearing in West Bengal due to prevalence of high temperature and high humidity most of the time during the silkworm rearing. These climatic factors also influence the various nutritional factors. As per example humidity in the rearing room may affect the types of leaf fed to silkworm larvae in different instars. The present review paper discuss in details about the role of various nutritional and climatic factors on growth and development of silkworm and it also indicates future strategies to be taken for the management various climatic and nutritional factors for successful cocoon crop in West Bengal.

Highlights

- Silkworm is a major economic insect of India, which produces silk, considered as queen of textile fibre.
- This paper discusses and reviews the role as well as management of different nutritional and climatic factors affecting the growth and development of silkworm during silkworm rearing.

Keywords: Nutritional factors, Climatic factors, Silkworm, Rearing

Sericulture has been fully recognized as an important rural industry in India and elsewhere and is practiced as a house hold industry. It is a labour intensive, export oriented cottage industry, generating high employment and income per unit area of land. Matured silkworm extrudes a semi liquid mixture of protein, coated with a gummy substance called sericin from its spinneret. The liquid is thus ejected at a rate of about a foot per minute and transformed into fiber when exposed to air. This fibre is known as silk which is considered as queen of textile fibre (Chattopadhyay and Sarkar 2008). India is the second largest silk producing country of the world and has the unique distinction of being the only country that cultures four commercial varieties of silk i.e. Mulberry, Tasar, Eri and Muga. West Bengal is the major traditional state of sericulture in India. There is a long tradition of Sericulture in West Bengal. It is the third largest silk producing state of our country.

The growth and development of silkworm larvae and economic characters of cocoons are influenced largely by the nutritional and climatic factors. Matsumara *et al*. (1958) reported that out of the various characters responsible for success of cocoon crop mulberry leaf stood first (38.2%) followed by climate (37%), rearing techniques (9.30%), silkworm race (4.02%), Silkworm eggs (3.10%) and other factors (9.60%) etc. Nearly 70% of the silk protein produced by the silkworm is directly derived from the protein of the mulberry leaves (Fukuda *et al*. 1959). Hence, choice of mulberry leaves suitable for healthy growth of silkworm is one of the important factors in sericulture. Mulberry leaves suitable as food for silkworms must contain several chemical constituents such as water (80%), protein (27%), carbohydrate (11%), minerals and vitamins and must have favourable physical features such as suitable tenderness, thickness, tightness etc. in order to render them acceptable by silkworms (Rajan & Himantharaj 2005).

It is clear from the above that mulberry leaf is more viable than any other factor and rearing of silkworm requires specific stages of leaf. Though in West Bengal which belongs to tropical condition mulberry can be grown throughout the year but quality of mulberry leaves are still not upto the merit particularly at farmers' level. Quality of leaf is one of the major problems behind the problems of silkworm rearing in tropics (Suranayanana 1988; Nomani 1988) and the poor quality of leaf is one of the important factors attributed to the poor productivity of silk per unit area (Nagarajan and Radha 1990).

The quality of mulberry leaf *varies* significantly with the factors such as soil fertility, agronomical practices, planting system, environmental condition (Bongale *et al*. 1991; Datta 1992). The quality of leaves is reported to depend upon age of leaf on the shoot, succulency and nutrient content (Krishnaswami 1986; Benchamin and Nagraj 1987). The nutrient contents of mulberry leaves are known to vary according to the season, variety, age type of harvesting (Krishnaswami 1978: Das and Vijyaraghavan 1990; Liaw *et al*. 1991; Sarkar *et al*. 1992 and Rajan and Himantharaj 2005). In addition, feeding with mixed varieties leaves and feeding frequencies are also known to influence the health of the silkworms (Machii and Katagiri 1990; Barman 1992; Sarkar *et al*. 2011). Apart from nutritional factors, climatic factors also influence rearing of silkworm larvae. In West Bengal rearing season is divided mainly in two parts i.e. favourable season and unfavourable season. November to April comes under favourable season and May to October comes under unfavourable season. During favourable season, generally dry summer is predominant and during unfavourable season wet summer is predominant. Mulberry is the sole food plant of *Bombyx mori*. Mulberry crop span is 70 days. So five leaf harvests as well as five rearings of silkworm are done in a year. November crop (winter or Agrahani), February crop (spring or Falguni) and April crop (summer or Baishaki) come under favourable season (dry summer) where June-July crop (Rainy or Shrabani) and August-September crop (autumn or Aswina) come under unfavourable season (wet summer). It is comparatively easier to rear crossbreed (M×Bi) during favourable season because crossbreeds with bivoltine components cannot with stand high temperature and high humidity (Das *et al.* (1994, 2006), Chattopadhyay *et al*. 2004; Chattopadhyay and Sarkar 2006 and Sarkar *et al.* (2008, 2012, 2016). During favourable season particularly in November and February comparatively less temperature and less humidity are prevailing in West Bengal. On the other hand during wet summer (unfavourable season) due to prevailing of high temperature, high humidity and heavy fluctuation of climatic condition it is better to rear multivoltine and their hybrids. Because multivoltine and their hybrids are more resistant to high temperature and high humidity as compare to crossbreeds (M×Bi) (Krishnaswami 1978; Benchamin and Jolly 1986 Tazima 1991; Murakami 1989). But multivoltines and their hybrids are comparatively low yielder and their cocoons are inferior in nature which do not suit to produce quality silk (Sarkar *et al.* (2008, 2012, 2016). But Sarkar and Majumdar (2017) has showed a remarkable change in the scenario of rearing various silkworm breeds in recent years in West Bengal. According to them in November, February and April crop share of rearing of Nistari× (SK-6×Sk-7) is almost 80-85% where as share of Nistari× NB4D2 is only 5 to 10 %. According to them Bivoltine hybrids SK-6× SK-7 have also slowly emerged as a suitable material for rearing in favourable season. Share of rearing of Nistari× (Sk6×SK7) is only 10% where as share of rearing of Nistari× M12 (W) is around 85% in unfavourable season. Their study clearly indicates ensuring of full swing of supplying of Dfls of three way cross Nistari× (Sk6×SK7) and bivoltine hybrids SK-6× SK-7, it will end the era of rearing of traditional low yielder in West Bengal in terms of rearing of silkworm breeds. This is possible upto some extent due to adoption of different measures to popularize dross breed reaing in West Bengal even in unfavourable season (Sarkar *et al*. 2008; Sarkar *et al*. 2011; Sarkar and Moorthy 2012 and Sarkar and Majumdar 2016). But ultimately growth and development of any organism depends on nutritional and climatic factors present surrounding of that organism (Sarkar *et al*. 2015; Bhattacharyya *et al*. 2017). Major economic insect of our Country, Silkworm is also not an exception.

This paper discusses the role of different nutritional and climatic factors affecting the growth, survivability, productivity, and disease incidence in silkworm. The paper also discusses the optimum conditions of nutritional and climatic factors required for higher productivity in sericulture and, further, the paper also reviews the results and findings of various researchers who studied the effect of these factors on growth, development, feed conversion, reproductive potential, and post cocoon parameters of silkworm during silkworm rearing.

Nutritional Factors

The silkworm *Bombyx mori* is essentially monophagous and survives solely on the mulberry leaves (*Morus* spp.). Mulberry is a highly heterozygous and vegetatively propagated species that is prone to prolonged juvenile period. Since the quality of silk production is directly proportional to the quality of leaves used as the exclusive feed for these worms, leaf quality is of utmost importance in sericulture. Sarkar *et al*. 2008 and 2012 suggested that in S-1635 mulberry variety which considers as ruling mulberry variety in West Bengal tender leaves contained 79.59% leaf moisture, 82.41% moisture retentions capacity after 6 hours, 49.78 mg/gm of total soluble sugar and 30.82 mg/gm of total soluble protein followed by medium leaf which contained 72.92% leaf moisture, 74.91%moisture retentions capacity after 6 hours, 47.22 mg/gm of total soluble sugar and 28.67 mg/gm of total soluble protein. Mature leaf contained 67.13% leaf moisture, 70.02% moisture retentions capacity after 6 hours, 45.34 mg/gm of total soluble sugar and 27.63 mg/gm of total soluble protein respectively. This study suggested that tender leaf is more nutritious than other maturity level of leaves. The nutrient quality of mature leaf is very poor. This observation is almost similar to the observations laid by Rangswamy *et al.* (1976), Bongale *et al.* (1991**)** and Patil (2002). According to them the top tender leaves are nutritionally richer compared to medium matured and matured leaves. They also reported that the maximum values of leaf moisture, protein, sugar contents and moisture were recorded with tender leaves, which gradually depleted at varied degrees with increasing maturity levels among the varieties. It is well known fact that silkworm cannot drink water separately; it takes water only from leaf.

On the other hand, protein is important because it helps in synthesis of silk and helps in production of silkworm eggs. Carbohydrate acts as a source of energy in Silkworm and it also helps in synthesis of fats. So feeding of tender leaves to silkworm larvae assumes greater importance. But in tropical and subtropical belt of India particularly in West Bengal at farmers' level there is a trend to feed silkworm with medium to mature leaves by clipping the top tender leaves particularly in late stages. There is a strong belief is working behind the activity. The belief is that tender leaf feeding during late age causes grasserie disease. Even same belief was also reported from some certain scientists (Sivaprakasham (1996) Basarajappa and Savanurmath (1997) Elumalai *et al.* (2001)) but Sarkar *et al*. 2008 and 2012 clearly proved that there is no relation between tender leaf feeding and occurrence of grasserie disease. He also suggests that tender leaf fed batch showed highest effective rate of rearing and lowest melting percentage particularly in dry summer in West Bengal. Actually the main reason behind the occurrence of grasserie disease is not clear till date. Kawakami, K (2001) suggested that high (28-35°C), low (10-20°C) temperature and humidity (below 70%) as well as drastic changes in temperature and humidity during the rearing may cause grasserie disease in silkworm. On the other hand Nataraju *et al.* (2005) suggested that silkworm *Bombyx mori* appears normal and shows no symptoms or change in appetite during more than two third of incubation period in case of grasserie disease of silkworm (Caused by *Bombyx mori* nuclear polyhedrosis virus). He also suggested that the signs and symptoms caused by the nuclear polyhedrosis virus in general are not apparent for several days. Usually the first symptoms appear 5-7 days post infection. But in the present investigation author found grasserie infected larvae even in 1st instar itself. So who knows grasserie may occur due to transovarial transmission? Sarkar *et al*. 2008 clearly suggested that November to April when humidity is relatively lower in the environment, it is better to feed silkworm with succulent tender leaves. Tender leaves contain more moisture, more soluble sugar, more soluble protein and having more moisture retentions capacity will be helpful for silkworm rearing to maintain more moisture in the rearing bed. Sarkar *et al*. (2012) again suggested that tender leaf fed batch significantly showed better performance in respect of all the characters, he suggested that profuse use of tender leaves during dry summer increased the cocoon yield/100 DFLs (55.72 kg) significantly than control batch (47.26 kg) for the cross breed N×NB4D2. As a whole the study results concluded that filament length could be increased if the worms are fed with the leaves of good moisture and protein content. This result is supported by the findings of Narayanan (1967); Basu *et al.* (1995); Raja Shekhar Gouda and Laksmikanth (1998), Vage and Ashoka (2000) and Rahamathulla (2003).

It is true that it is not possible to provide huge amount of tender leaves in late instar. But efforts should be taken to irrigate mulberry land frequently to keep maximum moisture in the mulberry leaves. This study also revealed that by using tender leaf we can save 20% of tender leaves in late instar particularly in dry summer which is generally clipped by Sericultural farmers of tropical and subtropical belt of India as well as in West Bengal in late larval instar before providing mulberry shoots to silkworm larvae. So it definitely helps for sustainable development in Sericulture Industry. Sarkar *et al.* 2008 and 2012 also suggests Feeding larvae with leaves which were water dipped and dried for entire larval instar and feeding larvae with leaves which were water dipped and dried in late larval instar showed significantly better performance than conventional leaf feeding method in dry season. It clearly suggested that high moisture in leaf significantly improve quantitative character of cocoons. This observation is also similar to the observation laid by Naryanprakash *et al.* (1985) who reported that assimilated food converted into body tissue and conversion efficiency decreased with decreasing dietary moisture content in mulberry leaves and also shell weight and fibroin content of the cocoons increased with increasing dietary moisture. Paul *et al.* (1992) also reported that absolute consumption and growth rate per day per larva, the quantity of dry matter consumed and digested, the values of efficiency of conversion of ingested and digested food and final larval weight increased with increasing percentage of leaf water and approximate digestibility increased progressively upto 70% leaf moisture but was reduced at the control dietary water level (76.6% leaf moisture). It was found that when the leaves were water dipped for 15-20 minutes its moisture percentage was increased even upto 2-3%. Sarkar and Majumdar (2016) also reported that Shoot feeding is always beneficial than individual leaf feeding particularly in latter stage.

In case of individual leaf feeding, particularly in latter stages when silkworms become much bigger try to crawl on individual leaves for feeding and leaves virtually go lower side due to pressure of silkworm and silkworm cannot fully utilize the leaves. It has also been observed that feeding silkworm with shoot in late stage has many advantages. It can save labour, time, leaf, number of bed cleaning and rearing space in late stage. Mathur (1997) suggested that a total of 27 man days can be saved for 100 DFLs rearing and approximately 54.86% cost on cocoon production can be reduced by adopting shoot feeding method. In case of shoot feeding silkworm larvae crawl on shoot one above another and in this way they can get rid from diseased larvae, litter, waste leaves etc.

In this way shoot rearing also helps to maintain hygienic condition in the rearing bed. But reverse trend is usually seen in unfavourable season in West Bengal particularly in wet summer where feeding silkworm larvae with water treated leaves and tender leaves in late age become detrimental to silkworm larvae. Ueda (1982) indicated that during late instars silkworms started to release water and 50% of released water used in solidification of silk. According to him 4th and 5th instar of silkworm larvae considered as stage of water releasing. He also reported during spinning a great amount of water is discharged. Amount of water released during 3 days before the end of silk spinning is 46liter by 20,000 larvae (7.8 liter for urination, 4.5

liter in the form of fecal matter, 10.7 litre through respiration and 23 liter for silk solidification) so in wet summer where humidity is usually higher in the rearing room, it is important to feed silkworm larvae with medium to mature leaves which contains comparatively less moisture and it is also necessary to maintain comparatively less humidity in the rearing room and as well as in mounting room. This may also considered as combined effect of nutritional as well as climatic factors. In wet summer there is always probability of wetting of mulberry leaves due to heavy rain, in this case Sarkar *et al*. (2008) suggested that to feed silkworm larvae by just shaking the water from surface of the leaves or by drying the leaves for few minutes.

The study also reveals that if wet leaves are dried for some time, it helps to increase the moisture percentage of leaves. It is also helpful to improve the cocoon characters. But both in dry summer and wet summer whatever the conditions newly hatched larvae should fed with tender leaves. Because Ueda (1982) again reported that newly hatched larvae content only 72% moisture but within II instar water content of the body rises up to more than 80%. So it is very important to feed chawki worms with very high moister content mulberry leaves. Only feeding of high moisture content leaves can help chawki worms to raise its body water content from 72% to 80% or above. High moisture in the body help chawki worms to digest the food. Besides that in rainfed Zone where leaf yield of mulberry is comparatively less and comparatively higher spacing is maintained between mulberry plants, (Setua 2006) marginal and sub marginal farmers can advocate the technique of intercropping (growing of two or more crops simultaneously on the same area of land for increasing the returns per unit area of land) to make Sericulture more remunerative. Sarkar *et al*. (2015) suggested that there is no negative effect of using *Amaranthus* spp. as intercrop of mulberry on the quality of mulberry leaf. Bioassay indicated that mulberry leaves harvested from the plots where mulberry was grown with *Amaranthus* spp. did not affect the growth of silkworm larvae and yield of cocoon significantly and it was possible to earn an excess of ₹ 4700 in one ha of land without affecting the quality of leaves and as well as health of silkworm larvae. The study also indicated that intercropping of mulberry with *Cajanus cajan* increased the fertility of soil and could generate an income of ₹ 20000/ha/year without affecting the leaf yield and larval health. Varshney (1985), Gurunadaha Rao (1986), Satapathy *et al.* (1987) also reported that intercropping of mulberry with various leguminous crop not only increase the income but also increase the fertility status of soil as well as nutritional quality of mulberry leaves.

CLIMATIC FACTORS

The success of the sericulture industry depends upon several variables, but climatic factors are of particular importance.

(a) Temperature

Among the abiotic factors, temperature plays a major role on growth and productivity of silkworms (Ueda *et al.* 1975; Benchamin and Jolly 1986). Starting from Silkworm egg production to harvesting of cocoon, all the physiological activities are affected by temperature. Mathur *et al*. 1988 suggested that in the silkworm, *Bombyx mori*, maximum ovulation and fecundity with minimum retention were observed at temperature 25.36 ± 0.17°C and any fluctuation from this level decreased ovulation, oviposition, fecundity and increased retention of eggs. Krishnaswami, 1973 and R.K. Datta 1992 stated that there is ample literature stating that good quality cocoons are produced within a temperature range of 22–27°C and that cocoon quality is poorer above these levels. Sarkar *et al*. 2008 suggested that 24–28°C temperature is ideal for the growth of silkworm larvae (Table 1).

Table 1: Optimum temperature and humidity requirements of silkworm during various Stages

Stage	Temperature (°C)	Relative Humidity (%)
Incubation	25	75-80
Ist	28	90
2nd	27	85
3rd	26	80
4th	25	75
5th	24	70
Spinning	23-25	65-70
Cocoon Preservation	25	80

He also suggested that silkworm larvae require comparatively higher temperature in first two instars. Silkworm larvae actually consume only 1% of mulberry leaves in first two instars and ingestion percentage is also relatively less in first two instars. Due to less consumption and ingestion of mulberry leaves, activities of enzymes in breakdown of food becomes less so generation of temperature also becomes less, it is the major reason behind the maintaining of comparatively more temperature in the rearing room in first two instars. But reverse trend is observed in 4th and 5th instars where silkworms consume almost 94% of total mulberry leaves (Krishnaswami 1978; Rajan and Himanthara 2005,) and subsequently it increases activity of enzymes in the breakdown of food and it ultimately increases generation of more temperature in the silkworm body and amount of CO_2 gas also excreted increase with the rise of the temperature. So it is important to maintain comparatively lower temperature in the rearing room.

Table 2: Ingestion and Digestion percentage of silkworm larvae in first three instars

Instar	Ingestion	Digestion
I instar	25%	63%
II instar	40%	51%
III instar	50%	40%

Fujii, 1936 (Text Book of Tropical Sericulture, pp 430) reported that the amount of ingesta and digestion is increased with the rise of the rearing temperature (Table 3).

Table 3: Rearing Temperature and the amount of ingesta & digesta

Temperature	Amount of ingesta (per 10 hrs)		Amount of digestion (per 10 hrs.)	
	4th instar	5th instar	4th instar	5th instar
22°C	100	100	100	100
26°C	153	157	207	162
30°C	205	160	255	162

Fujii (1936) also reported that the metabolic rate in the silkworm body is increased with the rise of the rearing temperature in the range from 22°C – 30°C, that is the amount of nutrients preserved in the body, the uric acid excreted and the carbohydrate consumed per 100 gm of body weight in 10 hrs are increased with the rise of the rearing temperature mentioned above. Rahmathulla *et al.* 2002 also describes effect of different temperature and humidity conditions on nutritional indices of silkworm in case of CSR hybrids (Table 4).

Table 4: Effect of different temperature and humidity conditions on nutritional indices of silkworm

Environmental Condition	Ingesta (g)	Digesta (g)	Approximate digestibility (%)	*ECI Cocoon (%)	ECI Shell (%)
Temp 36 °C and humidity 40%	3.04	0.850	27.99	18.27	8.94
Temp 20 °C and humidity 90%	4.45	1.340	30.11	16.91	8.60
Temp 25 °C and humidity 70%	4.41	1.430	32.44	16.86	9.17

**ECI- Efficiency of conversion of Ingesta.*

But the metabolic rate increase with temperature upto an optimum. At higher temperature, still within the upper lethal limits, metabolic rate is reduced because at higher temperature the enzymes are destroyed rapidly. According to Matsumura, the activity of analysis in gastric fluid in increased with the rise of the temperature from 20°C – 60°C. Tyrosine is most active at 24°C and its activity decrease with the powering and rising of temperature; catalase activity is strong at 15°C - 25°C and it decrease with the rise of the temperature. The sudden drastic change of rearing temperature is harmful to the physiology of Silkworms. The resisting power of Silkworm against the sudden change of the temperature in variable according to the sex difference of Silkworms and the age of them, that is male larvae are resistible than the female ones; the young larvae are resistible than the grown one. During the each stadium the moderate eating aged larva is most resistible, the various aged one ranks in the next, molting one is least resistible. The mounting larvae are resistible and after that they became weak and the larvae at the pupation age became most weak against the sudden change of the temperature. So it is important to maintain proper temperature in the rearing room. However, polyvoltine breeds reared in tropical countries are known to tolerate slightly higher temperature and adjust with tropical climatic conditions (Hsieh *et al.* 1995).

In order to use bivoltine races in a tropical country like India, it is necessary to have a stable cocoon crop in a high temperature environment. High temperature adversely affects nearly all biological processes including the rates of biochemical and physiological reactions (Wilmer *et al.* 2004) and can eventually affect the quality or quantity of cocoon crops in the silkworm and subsequently silk produced. Ueda *et al*. 1962; Shirota 1992; Tazima and Ohuma 1995 demonstrated that silkworms were more sensitive to high temperature during the fourth and fifth stages. Various methods can be advocated to reduce temperature in the rearing room like Sand bed is prepared in the rearing house and moistened periodically by water, Fixing of wet gunny cloth in the windows of the rearing room and moistened periodically by water, using of wet foam pad along with paraffin paper even upto fourth instar and hanging of wet gunny cloth in front of rearing racks. These methods usually increase the humidity in the rearing bed. But it is estimated that increasing of 4% relative humidity can decrease 1°C of temperature. Though late instars are susceptible to high humidity but in dry summer increase in humidity in late instars may helpful in silkworm rearing and the only way to reduce temperature in the rearing room (Sarkar *et al.* 2008 & 2012; Sarkar *et al*. 2016).

(b) Humidity

Humidity also plays a major role in the growth and development of silkworm larvae. Ueda, 1982 reported that changes in body water content associated with growth show characteristics penomenon at the 1st & 5th instar, the lowest water content in the newly hatched larvae continues to increase after shedding up to the first molting stage. At the end to 4th instar, the water content remains almost constant, but at the 5th it decreases from the highest content in newly exuviated larvae to the lowest content in mature larvae. In other words, the 1st instar larvae requires physiologically much water, and accumulate water at a higher content than water content of ingested mulberry leaves. On the contrary, the 5th instar is a stage which requires releasing water to a level lower than the water content of mulberry leaves. High humidity for the 1st instar and low humidity with air current for the 5th instar and are regarded suitable for rearing (Table 1), because mulberry leaves supplied at the early instar are ready to wilt, while large quantities of food ingested and of silkworm feaces at the 5th instar spoil the air. Reelability of cocoon is affected by various conditions during cocooning, especially humidity is most influential. Amount of water released during 3 days before the end of Silk spinning is 46 liter by 20,000 larvae (7.8 liter in form of Urine, 4.5 liter in form of water in feaces, 10.7 liter though respiration, 23 liter through silk solidification.) Latter two is released in form of vapors, it makes mounting room wet so it is very necessary to maintain low humidity during spinning. According to Matsumara, 1958 the amount of ingestion, digestion and digestibility are increased with the rise of the relative humidity. The amount of CO_2 expiration increases with the rise of relative rearing humidity. The effect of the relative humidity upon the increase of CO_2 expiration is larger in the 5th instar than the 4th instar, and it is larger at the high temperature. The body temperature of the 5th instar becomes higher with the rise of the relative humidity. Some investigator, however, insisted that the expiration amount of CO_2 is not affected by the change of the temperature. Gamo (Text Book of Tropical Sericulture, pp 434) reported that PH value of the blood of Silkworm is remarkably lower in the hurried condition (80% - 90% in the relative humidity) than in the dried condition (18% – 51%) in the temp ranged from 10°C to 30°C. He stated that this fact due to the increase of CO_2 proceed in the Silkworm body. According to Ushigome (Text Book of Tropical Sericulture, pp 431) the length of the larvae stage shortens with the rise of the relative humidity in the rearing room.

This tendency is larger in the grown larvae than in the young ones in spring rearing season and the tendency reverses in the autumnal season. Regarding the most favourable humidity for respective instar, he reported that 80 per cent of the relative humidity for the young larvae and 70% of it for grown larvae are favourable for their health. In West Bengal during dry summer particularly during February and April Crop humidity becomes too lower than optimum**,** Sarkar and Majumdar 2016 reported that advocating of box rearing method in chawki stages, preparation and moistened of sand bed periodically by water , fixing of wet gunny cloth in the windows of the rearing room and moistened periodically by water, using of wet foam pad along with paraffin paper even upto fourth instar and using of wrap up method of rearing during chawki stages, hanging of wet gunny cloth in front of rearing racks and adaptation of shoot rearing in late stages helps to increase humidity in the dry summer. On the contrary high humidity in late stages particularly in wet summer may create problems. Sarkar *et al.* (2011) suggested that double feeding may be advocated in the rearing room during wet summer to reduce the humidity in the rearing bed. According to him generation of waste material during latter stages can also be easily handled due to less number of feeding. Besides that due to less entry of persons in the rearing room, chances of contamination also become less.

According to him double feeding is highly economic interms of management of labour and other rearing operations. It also helps to reduce the cost of rearing operations. It is estimated in his study that almost 50% curtle in labour is possible through double feeding method than normal four feeding/ day method. Besides that during wet summer due to frequent rainfall it becomes difficult to feed silkworm larvae with dry leaves, adopting of double feeding may solve that problem upto some extents. His investigation reveals that except larval duration not even a single character varies significantly in the given treatments. Larval duration is slightly higher in case of double feeding method than other treatments.

(C) Air Current

Air current has a great role upon the physiology of silkworm. The effect of the air current upon the physiology of silkworm is remarkable in the condition of high temperature and humidity, i.e. the air current lower the temperature of the silkworm body and the rearing seats. Sarkar *et al.* (2008) suggested that it is always good for physiology of silkworm that silkworm body temperature should be 1.5 °C – 2 °C less than the environment. If there is no air silkworm body temperature will be 1 °C higher than the environmental temperature. If we give proper ventilation temperature decreases will be 3 °C than the previous. So then silkworm body temperature automatically becomes 1.5 °C – 2 °C less than the environmental temperature. In case of late age rearing there are always possibilities of generating more temperature in the silkworm body due to higher metabolic rate and generating of more CO_2 due to respiration process. So, in case of late age rearing proper ventilation is must to lower the silkworm body temperature. Air current has also a great effect on reelability of cocoon (Table 5).

Table 5: Air Current and Reelability of Cocoons

Temperature (°C)	Relative Humidity (%)	Reelability (%) *0 cm/sec	Reelability (%) *50 cm/sec
23	65	92	96
	90	54	91
30	65	85	96
	90	28	83

**Intensity of ventilation.*

Form above Chart it is very clear if you maintain only ideal ventilation in the mounting hall it can improve reelability percentage in spite of high temperature and high humidity.

Light

Light has a remarkable effect upon the dormancy feature and the ecdysis frequency of off springs, that is, when those parental Silkworms are reared under the light condition, lightened more than 8 hours per day during the young stadia, they lay more pigmented and diapauses eggs in comparison with those, which are reared under the dark condition, lightened less than 12 hours per day. In the grown stadium, however, the effect of the lightening upon the diapausing feature of egg is converse. On the other hand, when those parental Silkworms are reared under the dark condition during the young stadia, there occur many three moulters, especially when the rearing temperature is high. According to Kogure and Yamameto (Text Book of Tropical Sericulture, pp 438), Silkworm reared under the violet light lengthen the period of the larval stage and increase the body weight and cocoon shell weight.

Future Strategy

It is true that Sericulture has a rich history in West Bengal but it is also true that due to rapid change of global economy and due to the situation of open market, pattern of each and every Industry is changing rapidly. We are now in an era of Globalization where product ultimately stands for its quality nothing else. Culture, heritage, tradition ultimately leaves nothing in this global village. So it is important to improve the quality of cocoons because Cocoons are the raw material of Sericulture Industry. But in West Bengal it is difficult to rear cross breed and bivoltine hybrid throughout the year due to prevailing of high temperature and high humidity. Even in favourable season, we cannot get proper opportunity for producing quality cocoons.

As per example November is the best season for crossbreed rearing in West Bengal. But for crossbreed rearing in November, it is important to prepare seed crop of its bivoltine component in September, but due to climatic disadvantages it is not possible to rear bivoltine seed crop in September in most part of West Bengal, it is the major disadvantages of sericulture in West Bengal. To overcome from that situation, implementation of bivoltine seed Zone is essential for conducting crossbreed rearing throughout the year and ensures availability of quality raw materials for reeling during lean period. It is important to shift in bivoltine Based Sericulture instead of low yielder multivoltine based Sericulture. For that reason it is important to develop and disseminate high temperature and high humidity tolerant productive breeds. But it is not easier to develop high temperature tolerant silkworm breeds. To achieve greater success in this direction, there is a necessity of understanding the molecular mechanism of temperature tolerance in silkworm, identification of various groups of heat shocking proteins (HSPs), understanding of different expression pattern of various HSPs, in polyvoltine and bivoltine races to locate the genes responsible for the heat inducible HSPs, and subsequent steps to introduce the same into the silkworm genome.

In terms of nutritional factors which are closely related with quality of mulberry leaf, some measures can be taken to improve the quality of leaf. Particularly in dry summer when growth of mulberry plant is limited, frequent irrigation is necessary to maintain proper moisture content in the mulberry field. It also helps to produce profuse quantity of mulberry leaves which are essential for silkworm rearing in dry summer. Though in West Bengal mulberry can be grown throughout the year and soil of West Bengal also favours growth of mulberry but farmers are reluctant to maintain proper planting technique, proper spacing, proper application schedule of manures, fertilizers, water etc. It ultimately hampers quality leaf production. In this direction proper adoption of various Sericultural practices, proper dissemination of newly evolved technologies at farmers' level is important. Besides that strengthening of marketing system, establishment of chawki rearing centre to ensure the supply of robust and healthy chawki silkworm larvae at farmer's level, advocating of intercropping technique particularly in rainfed condition in West Bengal and overall an organized effort is necessary to improve the quality of silk to sustain in the competition with Chinese silk.

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