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Global climate change and its impact on the productivity of Muga silkworm (*Antheraea assamensis* Helfer) in Assam (India)

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Abstract:

The North-Eastern India has been recognized as the centre of Seri-biodiversity in India. The Muga silkworm Antheraea assamensis Helfer., is a multivoltine semi-domesticated insect and largely reared on commercial scale in the Brahmaputra valley of Assam. The temperatures in the commercial crops remain within optimum limit 20°C to 31°C and relative humidity 65% to 95%. Therefore, the percentage of moth emergence, the fecundity, and hatching percentage, and cocoon yield is higher compared to the seed crops. Fluctuations from the optimum standards may lead to a poor yield of the crop. The changing global climate seems to have profound effect on lepidopterans and other insects and have already started to receive some attention. Global climate seems to be changing with the evidence that increase in global mean surface air temperature over the last century range between 0.3°C-0.6°C, the recent years being particularly warm. The highest cocoon yield was observed 86/dfl in the year 1995 and lowest record was observed 65/dfl in 2007. The highest moth emergence was observed in the year 2006 during the spring rearing when the temperature conditions were between 17°C to 31 °C, RH between 66.7 % to 91.6 % and rainfall 178.3 mm. The lowest moth emergence was observed in the year 2008 during the autumn crop when there was the highest variation between the maximum and minimum temperature (range 22°C) and the lowest rainfall for the autumn period occurred.

From the study conducted it was observed that the fecundity, hatching percentage, moth emergence, and cocoon yield have declined with the rise of temperature over the years. The study was carried out to analyze the impact of temperature rise on fecundity, hatching percentage, moth emergence, and cocoon yield of Antheraea assamensis Helfer in Brahmaputra valley of Assam during 1995 to 2008.

Key words: Commercial crop, Cocoon yield, Fecundity, Global Climate, Multivoltine.

1. INTRODUCTION:

The muga silkworm *Antheraea assamensis* Helfer. (Insecta-Lepidoptera), a multivoltine sericigenous insect which produces the golden yellow muga silk is native North East India. Since the worms are reared outdoor, breeds collected from different regions may not be able to adjust to the new environment (Singh & Maheshwari, 2003). The abiotic and biotic factors of the environment during different seasons greatly influence the growth and development of muga silkworm in the form of cocoon weight, pupal weight, shell percentage, potential fecundity, reelability and denier of the silk (Chiang, 1985; Yadav and Goswami, 1989; Yadav *et. al*. 2000). Muga silkworm can be reared outdoor only; therefore influence of prevailing biotic and abiotic conditions in its development and survivability is prevalent. The muga silkworm can undergo six crop cycles per annum, especially the pre-seed and seed crops preceding the two commercial crops 'Jethua' – Spring (April – May) and 'Kotia' – Autumn (October-November) face vagaries of nature, like fluctuations of temperature, humidity, rainfall, photoperiodism and attack of season specific pests, predators and diseases that causes a decline in production and productivity (Sahu, *et. al.*, 1998). The climatic conditions during the commercial crops should remain within optimum limit between 20°C and 31°C and relative humidity between 65% -

95%. Cocoon productivity in muga for seed multiplication is measured in terms of productivity potential realized from egg layings laid by a particular mother moth and thus is the most important factor for both commercial and seed rearers in any crop (Chaudhuri, 1999). Dependence on muga cocoon yields on environment was reported by Chaudhuri (2003).

The growth of silkworm and their host plants are largely controlled by the surrounding climate. The variability in temperature and relative humidity has been experienced in the state as a result global warming has been indicated by Zhou, X. *et al*. (1996). The global temperature is rising every year and a series of record-breaking weather events are causing havoc the world over. Global land surface temperatures in January and April were more than 1^0 C higher than the average for those months (Anon, 1996).

The present paper deals with a study to analyze the effect of global temperature rise on fecundity, hatching percentage, moth emergence, and cocoon yield in *Antheraea assamensis* in Brahmaputra valley of Assam.

2. MATERIAL AND METHODS:

The comparative study was carried out on the basis of temperature parameters obtained from 1995 to 2008 and the resultant fecundity, hatching percentage, moth emergence and cocoon yield obtained during the two commercial crops in these years.

Data on rearing performance during the two commercial crops from 5 different prominent muga growing areas of Assam was obtained from Department of Sericulture, Govt. of Assam from 1995 to 2008. The meteorological data during the rearing season for these years was obtained from Department of Agro-Meteorology, Assam Agriculture University, Jorhat. Apart from the secondary data, extensive field work is carried out during 2006-2008. Rearing performance with special reference to fecundity, hatching percentage, larval mortality during rearing, moth emergence and cocoon yield during the two commercial crops vis-à-vis prevailing meteorological factors were correlated and the effect of climatic change on muga silkworm rearing was established. Data were collected on six various parameters as described in Table-1, executed and analyzed statistically using MS Excel.

Table-1: Parameters considered for the study

Sl. No.	Parameter	Abbreviation	Unit	Remarks
1	Cocoon yield	cdfl	No.	Cocoon yield/No. of eggs laid by a single mother moth
2	Fecundity	Fec	No.	No. of eggs laid by a single mother moth
3	Hatching percentage	Hp	%	No. of worms hatched/No. of eggs laid by a single mother moth X 100
4	Moth emergence	emergc	%	No. of moths emerged/No. of cocoons obtained X 100
5	Year	yr	-	1995 to 2008 coded as 1 to 14
6	Crop Season	crop	-	S: April-May, A: Oct-Nov

3. RESULTS:

3.1 Temperature variation:

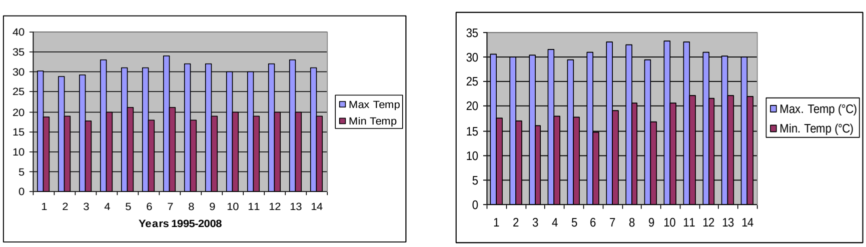
From the study it was evident that the mean maximum temperature of the period observed to be 29.1±1.66 (SD) and the range was 5.1 between 28 ºC and 33.1 ºC, while the minimum temperature was 19.77 ± 3.44 (SD) with the range from 17.7 ºC to 23.4 ºC (Table-2). The minimum temperature (17.5ºC) for the spring crop rearing was observed in the year 2002 and minimum temperature during the autumn crop (15ºC) was observed in the year 2000. The maximum temperature for the spring crop rearing (34.2ºC) was observed in the year 2001 and maximum temperature during the autumn crop (33.6ºC) was observed in the year 2004 (Fig.1a & 1b).

3.2 Humidity variation:

The study reveals that the mean maximum RH was 92.8 ± 6.14 (SD) and the range was 5.6 between 89.9% and 95.5%, while the mean minimum RH was 71.87 ± 4.74 (SD) and the range is 66% to 78.4% (Table-2). The minimum RH for the spring crop rearing (67.5%) was observed in the year 2002 and minimum RH during the autumn crop (65%) was observed in the year 2001, while the maximum RH for the spring crop rearing (94%) was observed in the year 2007 and maximum RH during the autumn crop (96%) was observed in the year 2001. The highest variation between the max. and min. RH (range 24%) was observed in the year 1995 during the spring crop (Fig- 2a & b).

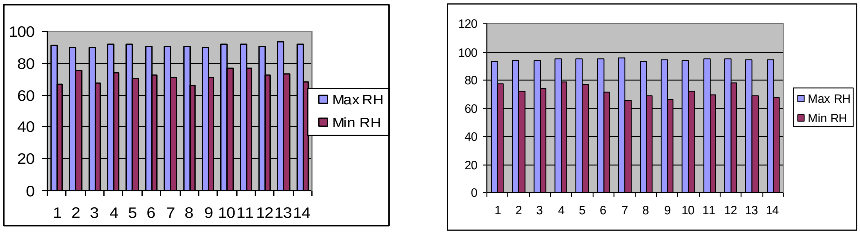
Table-2: Estimates of descriptive statistics

Parameter	Mean (SD)	Range	Minimum	Maximum
Max.Temp	29.1 ±1.66	5.1	28	33.1
Min. Temp	19.77 ± 3.44	5.7	17.7	23.4
Max.RH	92.8 ± 6.14	5.6	89.9	95.5
Min. RH	71.87 ± 4.74	12.4	66	78.4
Total Rainfall	223.37 ±144.2	415	2	417
Rainy days	16.75 ± 6.16	25	2	27



(a) (b)

Fig- 1(a) & (b): Maximum and minimum temperature during the rearing period of spring crop and autumn crop respectively during the study period, 1995-2008.

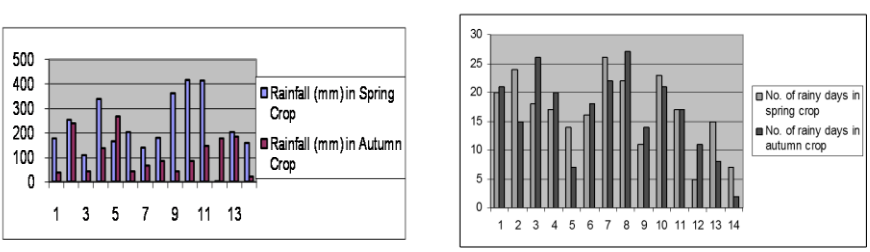


(a) (b)

Fig- 2a & b. Relative humidity (max.% and min .%) during the rearing period of spring and autumn crop respectively during the study period, 1995-2008.

3.3 Variation in rainfall and number of rainy days:

The study reveals that the mean rainfall was 223.37 ± 144.2 (S.D) and the range was 415 between 2 and 417 *mm*. The mean no. of rainy day is 16.75±6.16 (S.D) and the range was 25 with a minimum of 2 days and a maximum of 27 days of rains. The highest rainfall of 417 *mm* was observed in the year 2004 during the spring rearing. The minimum rainfall of 2mm was observed in the year 2005 during the spring crop. During the autumn crop maximum rainfall was observed in the year 1999 and least rainfall was observed in the year 2008. The maximum no. of rainy days was observed in the year 2002 during the autumn crop. And minimum no. of rainy days was observed in the year 2008 during the autumn crop (Table-2; Fig. 3).



(a) (b)

Fig.-3: (a) Total rainfall (*mm*) and (b) total no. of rainy days respectively during the rearing period for two crop seasons.

3.4 Evaluation of the biotic component in relation to the abiotic components:

(a) Fecundity: Fecundity was highest during the autumn in 1996 when the temperature conditions were between 18°C - 28 °C, RH between 72% -91% and rainfall 250.6 *mm*, and lowest fecundity was noticed in 2006 and when the temperature was between 22°C - 32 °C. It was observed that the mean of fecundity is 146.37 ±32.57 the range between 95 (minimum fecundity) and 193 (maximum fecundity) (Fig.-4). The 4th and the late stage worms when exposed to high temperature continuously during the rearing period found to lead male sterility. In the female worms an increase in temperature affects the rate of ovulation so the fecundity directly gets affected.

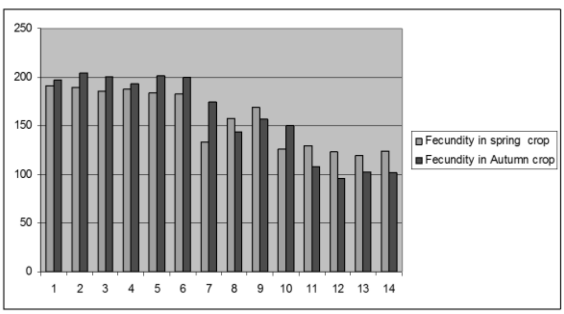


Fig.- 4: Fecundity percentage of muga silkworm during spring and autumn crop.

(b) Hatching percentage: Hatching percentage was studied by taking into account 10 dfls and showed a remarkable decline over the years, the recent years being subsequently warm (Fig.-5). Hatching percentage is effected by high temperature and higher humidity and an increase in temperature results a decline in hatching percentage. Again, rise in temperature and humidity affects the mating behavior in moths, which may cause a lesser transfer of sperms resulting in increase in number of unfertilized eggs. Rise in temperature also affects the pre-hatching embryonic mortality. A higher increase in temperature causes damage of the embryo, thus affecting the hatching percentage. From study it was observed that the mean hatching percentage is 68.9±16.44, the range was 31 between 83 (maximum) and 52 (minimum). The highest record in hatching percentage was observed in the year 1996 during the spring rearing when the temperature conditions were between 18-28 °C, RH between 72 -91 % and rainfall 250.6 mm. The lowest record was observed in the year 2003 during the autumn crop when there was the highest variation between the spring and autumn crop rainfall. The crop which continued from the spring rearing could not withstand such a high fluctuation so showed poor performance.

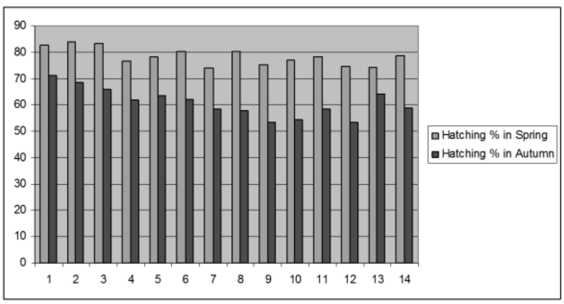


Fig. -5: Hatching percentage of muga silkworm during spring and autumn crop.

(c) Cocoon yield: The present study reveals that the mean cocoon yield was 61.57±4.72 (S.D) and the range was 31 between 76 (maximum) and 45 (minimum). The highest cocoon yield was observed in the year 1995 during the spring rearing (Fig.6). The minimum cocoon yield was observed in the year 2008 during the autumn crop. This accounts that the highest cocoon yield was obtained when the temperature conditions were between 17-31 °C, RH between 66.7 -91.6 % and rainfall 178.3mm. It can be seen that the cocoon yield during the autumn crop showed a declining trend over the years with increasing temperature and humidity. The overall low production was due to wide fluctuations of temperature, relative humidity, heavy rainfall.

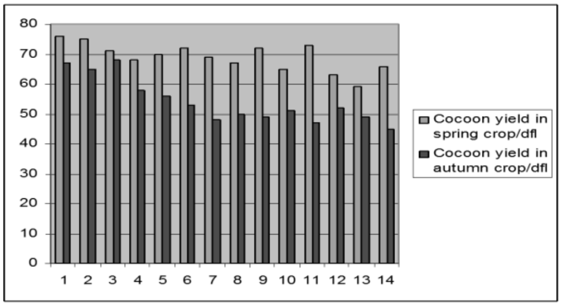


Fig.- 6. Cocoon yield /dfl during the spring and autumn crop, 2008-2011.

A lesser fecundity and hatching percentage will ultimately results in low cocoon yield. A higher cocoon yield is predicted with higher minimum temperature and humidity in the ambience during period right from hatching till 2nd moult. High rainfall during the period from 3rd to 4th instar could result in low yield. But lower humidity during the period from 3rd to 5th instar and higher humidity during spinning are indicative of good harvest.

(d) Moth emergence: The mean moth emergence rate is 84.04±6.17 the range was 21.36 between 75.34 (minimum) and 96.7 (maximum). The highest moth emergence was observed in the year 1995 during the spring rearing (Fig.7) when the temperature conditions were between 17-31 °C, RH between 66.7 -91.6 % and rainfall 178.3mm. The lowest moth emergence was observed in the year 2000 during the autumn crop when there was the highest variation between the max. and min. temperature (range 22ºC) and the lowest rainfall for the autumn period occurred. From Fig.7 it can be seen that the percentage of moth emergence showed a declining trend over the years with increasing temperature and humidity. The overall low production was due to wide fluctuations of temperature, relative humidity, heavy rainfall. A higher temperature and humidity affects moth emergence. When the temperature and humidity is high pupal growth gets effected and may also result in pupal mortality. High temperature and humidity affects the activity of moths. When the temperature is high the moths shows a lesser activity resulting in emergence of damaged moths and even the moths show lesser coupling tendency resulting in declining rate of healthy eggs .

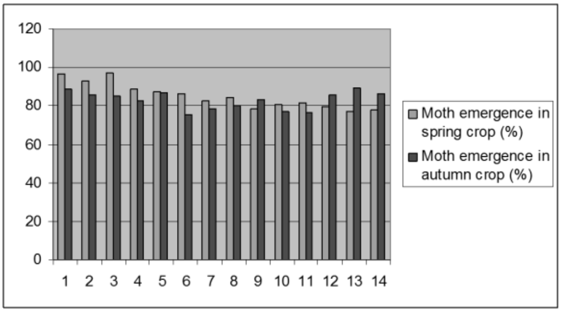


Figure- 7. Moth emergence (%) during the spring and autumn crop, 2008-2011.

4. DISCUSSION:

Climate change is recognized as a major threat to the survival of species and integrity of ecosystems world-wide. Although considerable research has focused on climate impacts, relatively little work to date has been conducted on the practical application of strategies for adapting to climate change. Adaptation strategies should aim to increase the flexibility in management of vulnerable ecosystems, enhance the inherent adaptability of species and ecosystem processes, and reduce trends in environmental and social pressures that increase vulnerability to climate variability. Uncertainty exists in the response of species and ecosystems to a given climate scenario. While climate will have a direct impact on the performance of many species, for others impacts will be indirect and result from changes in the spatiotemporal availability of natural resources. In addition, mutualistic and antagonistic interactions among species will mediate both the indirect and direct effects of climate change. The knowledge of climate variability over the period of instrumental records and beyond on different temporal and spatial scale is important to understand the nature of different climate systems and their impact on the environment and society. Most of the observational and numerical simulation studies on climate are based on the instrumental records of about a century which are aimed at the understanding of the natural variability of climate system and to identify processes and forcings that contribute to this variability.

Until recently, the main concern of many insect ecologists working on the impacts of climate change has been in applying existing theory, models or laboratory experiments to the long-term changes predicted from the various GCMs. Although this has marshalled a great deal of useful background information (often obtained for other purposes) on this question, it has also provoked some cynicism stemming from the conflicting nature of many of the predictions and the inability to test them within a reasonable timescale. For example, many predictions are concerned with possible changes by the end of the twenty-first century. If predictions are not, in practice, testable it is very difficult to go beyond the general statement that some species will benefit and others will not. We do have evidence that climate is changing, both globally and locally, and that recent changes, in mean temperature in particular, are greater than the fluctuations normal over the last few centuries. Whatever the cause of these changes in climate it now seems appropriate to put much more effort into direct monitoring in order to understand and assess the effects as they occur. This is not going to be easy because it is costly and time consuming, requires longterm resource commitments (which are increasingly difficult to obtain and then maintain) and ideally should be carried out in a coordinated way over large areas and across political boundaries. The general lack of historic data for such purposes has been recognized and long-term networks to obtain such biological datasets are being set up. However, even in the well studied and taxonomically tractable Lepidoptera, a much wider geographical approach to monitoring will be required if we are to assess the importance of changes in populations, distributions and phenology as and when they occur.

In muga silkworm, effect of climate change is more intense and it affects the economy directly. Hence long term sustainability measures needs to be taken. Conservation measures both in-situ and ex-situ accounts a vital role in maintaining the muga silkworm sustenance.

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