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Short communication

Phenology and cocoon characters of eri silkworm (*Samia ricini* Boisduvial) affected by temperature and humidity at Jorhat, Assam

SUDIPTA KUMAR DAS, LOHIT CHANDRA DUTTA and RAJIB LOCHAN DEKA[1*]

Dept. of Sericulture, [1]Dept. of Agrometeorology, Assam Agricultural University, Jorhat, Assam

[*]Corresponding author: *rldeka2011@gmail.com*

Sericulture is an agro-based cottage industry which involves the cultivation of host plants, rearing of silkworms, reeling and spinning of cocoons and production of silk yarn. India is the only country in the world to produce all the four varieties of silk among which eri silk is of vital importance. The eri silkworm is a domesticated multivoltine species and can be reared 5 – 6 crops in a year. Depending on climatic conditions, the duration of life cycle ranges from 44 days in summer to 85 days in winter. The success of sericulture industry normally depends upon several biotic and abiotic factors. It was reported that the temperature along with other climatic factors plays a crucial role in reproduction, development, fecundity and longevity of insects and poikilothermic animals (Duraimurugan, 2018). Silkworms being poikilothermic, their body temperature is directly controlled by the temperature outside and with an increase in temperature, the larval growth is accelerated and the larval period is shortened while at low temperature the growth is slowed down and the larval period is prolonged. Similarly, RH directly influences the physiological functions of the silkworm. The present investigation was designed to study the combined effect of temperature and RH on growth and cocoon yield of eri silkworm (*Samia ricini* Boisduvial) in different rearing seasons under the sub-tropical humid climatic conditions of Assam.

The experiment was conducted in the Department of Sericulture, Assam Agricultural University, Jorhat during summer (June-July, 2018), autumn (September-October, 2018), early spring (March-April, 2019) and late spring (April-May, 2019). The healthy seed cocoons of eri silkworm were preserved in well-ventilated cocoon cages and egg laying were prepared following the standard grainage as techniques suggested by Chowdhury (1982). The eggs were incubated in black paper boxes one day prior to hatching *i.e.* during blue egg stage for uniform hatching of the silkworms. The eri silkworm larvae were reared on castor leaves (*Riccinus communis*) in five replications maintaining 50 larvae per replication following completely randomised design. Larvae were fed at a feeding frequency of four times per day except during the time of moulting. The matured larvae were mounted replication wise separately on chandraki (mountage) for the spinning of cocoons. The cocoons were harvested from the mountages for assessment of various cocoon characters *viz.,* cocoon weight, cocoon shell weight and cocoon shell ratio. The duration of phenophases of eri silkworm *viz.* egg laying period, egg hatching duration, larval duration, larval weight and cocoon characters *viz.*, cocoon spinning period, cocoon weight, cocoon shell weight, cocoon shell ratio were recorded. The instar-wise along with total larval growing degree days and cocoon yield during different seasons were recorded and worked out by taking the averages of all the growth parameters in different seasons. During the rearing period, meteorological data *viz.,* room temperature (maximum and minimum) and room RH (morning and afternoon) were recorded with the help of maximum thermometer, minimum thermometer and whirling hygrometer, respectively. The data were subjected to correlation and multiple regression (step-wise) analysis to determine the association and strength of seasonal temperature and RH on growth and yield parameters of eri silkworm following Panse and Sukhatme (1985) and Nebapure *et al*., (2018).

Effect of weather elements on phenophases and cocoon characters of eri silkworm

Results presented in Table 1 revealed that occurrence of different phenophases and cocoon characters of eri silkworm were significantly affected by rearing seasons. The egg laying period (4.1 days) and egg hatching period (3.2 days) were significantly longer in early spring season and shortest during summer season (3.1 days and 2.14 days respectively). The late spring (3.6 days and 2.4 days respectively) and autumn (3.4 days and 2.6 days) were at par in these respects. The early spring season experienced comparatively lower temperature

Table 1: Phenophages and cocoon characters of eri silkworm in different rearing seasons

Rearing season	Egg laying period (days)	Egg hatching period (days)	Larval duration (days)	Larval weight (g)	Cocoon spinning period (days)	Cocoon weight (g)	Cocoon shell weight (g)	Cocoon shell ratio (%)
Summer	3.10[c]	2.14[c]	19.80[c]	5.53[c]	3.04[d]	2.06[d]	0.27[c]	13.10[ab]
Autumn	3.40[b]	2.60[b]	24.20[b]	5.67[bc]	3.94[b]	2.76[c]	0.36[b]	13.04[ab]
Early spring	4.10[a]	3.20[a]	34.00[a]	6.23[a]	4.20[a]	3.85[a]	0.54[a]	14.02[a]
Late spring	3.60[b]	2.40[b]	23.60[b]	5.82[b]	3.50[c]	3.30[b]	0.40[b]	12.12[b]
S.Ed(±)	0.14	0.13	0.47	0.07	0.10	0.09	0.02	0.48
CD at 5%	0.29	0.27	1.00	0.15	0.22	0.19	0.04	1.03

Figures with same letter are non-significant.

Table 2: Correlation coefficient (r) of different phenophases and cocoon characters of eri silkworm with temperature and relative humidity of rearing seasons

Phenophases	Temperature (˚C)		Relative humidity (%)	
	Maximum	Minimum	Morning	Afternoon
Egg laying period	-0.42	-0.58	-0.51	-0.57
Egg hatching duration	-0.38	-0.88	-0.69	-0.96*
Larval duration	-0.63	-0.95*	-0.58	-0.84
Larval weight	-0.69	-0.65	-0.52	-0.34
Cocoon spinning period	-0.91	-0.89	-0.18	-0.66
Cocoon weight	-0.91	-0.96*	-0.31	-0.51
Cocoon shell weight	-0.79	-0.98*	-0.47	-0.69
Cocoon shell ratio	0.12	-0.47	-0.77	-0.94

**Significant at P=0.05 level*

and humidity regimes which slowed down the egg laying behaviour of the silkworm. On the other hand, during the summer season when the temperature and RH were relatively high, the egg laying period reduced to a greater extent. Wanule and Balkhande (2013) found at temperature 31±1ºC, the silkworm moth, *Bombyx mori* were able to lay eggs up to 48 hours and varied according to temperature variations. Rahmathulla (2012) reported that the developmental rate of silkworm embryo was directly influenced by temperature and modified by RH. Temperature was considered as the most important factor for silkworm hatching as reported by Sarkhel *et al*., (2017). The shortest egg hatching duration in summer and longest in early spring was due to the variations in temperature and RH during the rearing seasons. Number of days taken to complete larval period was found to be significantly longest during early spring season (34.0 days) while it was shortest during summer (19.8 days) season. Late spring and autumn seasons were at par in respect of larval weight of the silkworm. In respect of cocoon characters, the cocoon spinning period was significantly longest (4.2 days) followed by autumn (3.94 days), late spring (3.5 days) while the shortest cocoon spinning period (3.04 days) was registered in late spring season. Significantly, the highest cocoon weight (3.85 g) and cocoon shell weight (0.54 g) were recorded in early spring season followed by late spring (3.30 g, 0.40 g respectively), autumn (2.76 g and 0.36 g respectively) while the lowest values (2.06 g and 0.27 g respectively) were recorded in summer season. The shell ratio percentage was significantly highest in early spring (14.02%) while it was recorded lowest in late spring (12.12%) season. Sharma *et al.* (2017) and Morohishi (1969) also reported that the duration of larval period of eri silkworm was the longest during winter season while shortest in summer season.

Relationship between weather elements and cocoon characters, phenophases

Correlation coefficients between different phenophases and cocoon characters of eri silkworm and temperature and RH (Table 2) showed that temperature and RH during rearing period were negatively correlated with all

Table 3: AGDD (day °C) on phenology of eri silkworm as affected by rearing seasons

Rearing season	Instar-wise AGDD					Larval
	I	II	III	IV	V	AGDD
Summer	65.15	59.75^{a}	66.28^{b}	74.72^{b}	109.42^{bc}	375.32^{b}
Autumn	59.92	51.46^{b}	62.16^{bc}	76.72^{b}	119.46^{ab}	369.72^{b}
Early Spring	73.72	58.04^{a}	91.46^{a}	89.94^{a}	124.96^{a}	438.12^{a}
Late Spring	55.10	51.19^{b}	53.62^{c}	78.56^{b}	100.97^{c}	339.44^{c}
S.Ed (±)	6.79	3.26	5.10	3.95	5.70	8.25
CD at 5%	NS	6.96	10.84	8.44	12.13	17.63

Figures with same letter are non-significant.

Table 4: Predictive models for growth and cocoon characters of eri silkworm in relation to temperature (°C) and RH (%) during rearing seasons

Growth parameter	Predictive model	R^2
Egg hatching duration	Y = 5.179-0.032*RH(afternoon)	0.92
Larval duration	Y = 69.480-1.916*Tmin	0.91
Larval weight	Y = 0.109-0.002*Tmin	0.95
Cocoon weight	Y = 8.606-0.243*Tmin	0.93
Cocoon shell weight	Y = 1.247-0.037*Tmin	0.97
Cocoon shell ratio	Y = 6.129+0.018*AGDD	0.95

phenophases and cocoon characters except cocoon shell ratio which has positive correlation with maximum temperature. The correlation coefficient between egg hatching duration and afternoon RH was significantly negative. Larval duration, cocoon weight and cocoon shell had significant negative correlation with minimum temperature during the rearing periods.

Phasic AGDD of eri silkworm in different rearing seasons

Instar-wise accumulated growing degree days (AGDD) of eri silkworm (Table 3) indicted that GDD accumulation by first instar eri silkworm to complete its instar duration was found to be highest during early spring season followed by summer and autumn seasons. During the late spring season, the GDD accumulation was found lowest. However, accumulations of GDD during different seasons were statistically not significant. In second instar eri silkworm, highest AGDD was observed in the summer season followed by early spring, autumn and late spring seasons. On the other hand, highest AGDD by third instar eri silkworm was observed during early spring season followed by summer, autumn and late spring seasons. Highest AGDD to complete fourth instar eri silkworm larva was observed during early spring season and lowest during summer season. Similarly, AGDD was found maximum in fifth instar eri silkworm during the early spring season which gradually decreased during autumn, summer and late spring seasons.

Accumulation of GDD during larval stage of eri silkworm during different growing seasons was significantly different. Highest GDD accumulation to complete the entire larval duration was seen during the early spring season whereas the lowest was during late spring season. Summer season had a total GDD accumulation of 375.32ºC days followed by autumn with 369.72ºC days. It was observed that the AGDD within the instars affected their instar-wise as well as overall larval duration. Chen *et al*. (2015) in his study demonstrated that the changing diurnal temperature could change the degree day accumulation and hence the life history of grape berry moth.

Multiple regression analysis indicated that the minimum temperature alone could explain about 91 to 97 per cent of growth and cocoon characters of eri silk worm except egg hatching duration and cocoon shell ratio (Table 4). Afternoon RH and AGDD was the dominant parameters in determining the egg hatching duration (R^2=0.916) and cocoon shell ration (R^2=0.948) respectively. The results revealed that minimum temperature during rearing period had more profound and negative effect on occurrence of larval phenophases and cocoon characters of eri silkworm. Singh

(2012) also indicated that the batches reared under optimum environmental conditions exerted significant performances in the parameters such as cocoon weight, shell weight, shell ratio percentage, etc. over the batches which were reared without providing optimum conditions.

It may be concluded that eri silkworm can be reared throughout the year under the agro-climatic conditions Assam. The duration of the phenophases of eri silkworm were found to be longest during early spring season followed by late spring, autumn and summer season. Cocoon characters were recorded to be the highest during early spring season due to accumulation of higher GDD during larval period. The phenology and cocoon characters of eri silkworm were largely regulated by the ambient temperature and RH during the rearing seasons. Early spring season was found to be the most suitable for rearing of eri silkworm due to favourable environment to obtain optimum growth and good cocoon yield under Assam condition.

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