International Journal of Zoology Studies
ISSN: 2455-7269
Impact Factor: RJIF 5.14
www.zoologyjournals.com
Volume 2; Issue 5; September 2017; Page No. 52-55

Effects of temperature and relative humidity on commercial product of silkworm (*Bombyx mori* L.) in Indore region of (M.P.) India

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Abstract
Silk is considered to be queen of textiles which is proteinecious in nature. Rearing of silkworm for the production of silk fibre is called sericulture. Present investigation was carried out to evaluate the best environmental conditions for commercial cocoon production of *Bombyx mori.* Temperature and R.H. % (Relative Humidity) plays vary vital role on silkworm growth and development and it leads to cocoon quality. In the present investigation the appropriate temperature for silkworm rearing was 25º C and appropriate R.H. % was 75-80%. Bi-voltine silkworm is registered for best grades and high quality cocoon production. Present study was carried out to see the influence of varying temperature on development of pupa from larvae of silkworm *Bombyx mori.* It is observed that mortality rate is less at temperature 25ºC. Rearing is suggested in suitable environmental conditions.

Keywords: silkworm, *Bombyx mori*, temperature, R.H%, pupa, larvae

Introduction
Sericulture is one of the agro based industries in India. India occupies second place of Mulberry raw silk production in the world. Mulberry silk comes from the cocoons of *Bombyx mori (L).* The fact that the Silkworm, *Bombyx mori* is domesticated for nearly four thousand years ago is well established. It is well documented that all insects require proper environmental conditions for normal life [1]. The environment influences the activities of the organism directly or indirectly. This is true for domesticated insects like *Bombyx mori.* Due to continuous domestication for many years, the silkworm has lost many of its natural activities as sense of smell, flight etc. and it is completely under the protection of the silkworm growers [2]. Though the number of generations in a year is controlled genetically in the silkworm, environmental conditions like photoperiod, temperature, humidity etc., are known to influence during the entire life cycle of the silkworm [3]. Studies on the effects of environmental factors, especially temperature on the physiology are sporadic [4]. Mulberry silkworm is an economically important domesticated insect for luxuriant silk production, extensive studies on growth rates associated with photoperiod [5]. Photoperiodic mechanism has been demonstrated to be mostly influenced by the other environmental factors such as temperature and humidity. Developmental events that occur once in the life cycle of an individual insect have long been known to express at a specific part of the day to manifest a population rhythm [6]. Present study was carried out to see the influence of varying temperature on development of pupa from larvae of silkworm *Bombyx mori*. Rearing is suggested in suitable environmental conditions.

Material and Methods
Study Area
Present investigation was conducted to determine the effect of change in temperature and humidity on larvae of *Bombyx mori* to enhance silk production. Present work was carried out at Government Resham Kendra, Indore region (Sanwer, Mhow and Sonkatch) (M.P.)

Experimental Species
Productive bivoltine silkworm hybrid (CSR2 × CSR4) is obtained from Central Sericulture Research and Training Institute (Mysore, India) was used as a study material. This hybrid is suitable to rear during favourable season (August–February). The hybrid is preferred because of high survivability, yield, and silk ratio. Young age silkworm rearing was conducted by providing fresh tender leaves of mulberry variety [7]. The temperature was 20, 25, 30 and 35 °C and humidity 70-75, 75-80, 80-85 and 85-90% was maintained during young age rearing.

Rearing method
The rearing of silkworm was done by method of [8]. However, the chawki (young age; 1st and 2nd instar larvae) rearing was conducted according to [9] to maintain uniformity in induced climatic condition all through the experimentation. Hatched out larvae from the DFLs (disease free laying), collected in to pre-disinfect rearing trays and were daily fed four times (06:00, 10:00, 16:00, and 22:00 h) on fresh mulberry (Morus spp. V1 variety) leaves except during moulting. While cleaning the unconsumed leaves, two times during 1st and 2nd instar and once every day after the 2nd moult, the larvae were transferred into separate pre disinfected rearing trays. The larvae under moult, however, were not disturbed.
Twenty larvae in replicates were separated and kept at different temperature and humidity treatments conditions in a Sericatron. Sericatron is an environmental chamber with precise and automatic control facilities for uniform maintenance of temperature and humidity. Mortality rate,

weight of pupa and shell were recorded.

Temperature conditions
Four different types Temperatures, viz. 20, 25, 30, 35°C were maintained in the laboratory throughout experimentation, using an Environmental chamber.

Humidity conditions
Four levels of relative humidity (R.H.%), viz. 70-75, 75-80, 80-85 and 85-90% were induced for the study on the three experimental silkworm breeds/hybrids, all through the experimentation.

Result and Discussion
Cocoon characters, Cocoon weight
Cocoon characters, Cocoon weight of CSR2 × CSR4 bi-voltine breed is summarized in table 1.
At 20ºC temperature 1.687, 1.756, 1.693 and 1.595 gm cocoon obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.
At 25ºC temperature 1.823, 1.839, 1.701 and 1.536 gm cocoon obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.
At 30ºC temperature 1.511, 1.697, 1.605 and 1.478 gm cocoon obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.
At 35ºC temperature 1.321, 1.439, 1.214 and 1.204 gm cocoon obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.
The maximum cocoon weight obtained was1.839 grams at 25ºC and 75-80% humidity whereas minimum cocoon weight obtained was 1.204 grams at 35ºC and 85-90% humidity.

Table 1: Cocoon weight (grams) at different temperature and humidity

Race:- (Csr2 × Csr4)		
Temperature (ºc)	**Relative Humidity (%)**	**Cocoon Weight (Grams)**
20	70-75	1.687
	75-80	1.756
	80-85	1.693
	85-90	1.595
25	70-75	1.823
	75-80	1.839
	80-85	1.701
	85-90	1.536
30	70-75	1.511
	75-80	1.697
	80-85	1.605
	85-90	1.478
35	70-75	1.321
	75-80	1.439
	80-85	1.214
	85-90	1.204

Pupal weight
The results on pupal weight in the breeds/ hybrids of the silkworm *(Bombyx mori)* are furnished in table-2.
At 20ºC temperature, 1.445, 1.487, 1.412 and 1.390 gm pupae obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.
At 25ºC temperature, 1.512, 1.532, 1.502 and 1.478 gm pupae obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.
At 30ºC temperature, 1.373, 1.432, 1.344 and 1.301 gm pupae obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.
At 35ºC temperature, 1.201, 1.209, 1.080 and 1.002 gm pupae obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.
The maximum pupae weight obtained was 1.532 grams at 25ºC and 75-80% humidity whereas minimum pupae weight obtained was 1.002 grams at 35ºC and 85-90% humidity.

Table 2: Pupal weight (grams) each value is the average of 20 Observation

Race:- (Csr2 × Csr4)		
Temperature (ºc)	**Relative Humidity (%)**	**Cocoon Weight (Grams)**
20	70-75	1.445
	75-80	1.487
	80-85	1.412
	85-90	1.390
25	70-75	1.512
	75-80	1.532
	80-85	1.502
	85-90	1.478
30	70-75	1.373
	75-80	1.432
	80-85	1.344
	85-90	1.301
35	70-75	1.201
	75-80	1.209
	80-85	1.080
	85-90	1.002

Pupa mortality
In silkworm *Bombyx mori*, appropriate temperature and humidity is needed for the healthy growth of Pupae. Many times when pupae are subjected to extreme temperature and humidity, they have to sacrifice their life. In the present study the best optimum relative humidity was 75-80%. The mortality rate of silkworm pupae is shown in table 3. Fifty larvae were taken for the present experiment and kept at different temperature viz. 20, 25, 30 and 35 ºC but at constant humidity i.e. 75-80%
At 20ºC temperature, 37 pupae were formed out of 50 larvae and the mortality rate was 25 % respectively.
At 25ºC temperature, 43 pupae were formed out of 50 larvae and the mortality rate was 12 % respectively.
At 30ºC temperature, 41 pupae were formed out of 50 larvae and the mortality rate was 17 % respectively.
At 35ºC temperature, 38 pupae were formed out of 50 larvae and the mortality rate was 22 % respectively.
The higher mortality rate was observed at temperature 20ºC i.e. 25% and lower mortality rate was observed at temperature 25ºC i.e. 12%.

Table 3: Effect of temperature on pupa mortality at 75-80 % relative humidity

S. No.	Larvae	Temperature	Pupa Formed	% Of Pupa Mortality
1.	50	20°C	37	25%
2.	50	25°C	43	12%
3.	50	30°C	41	17%
4.	50	35°C	38	22%

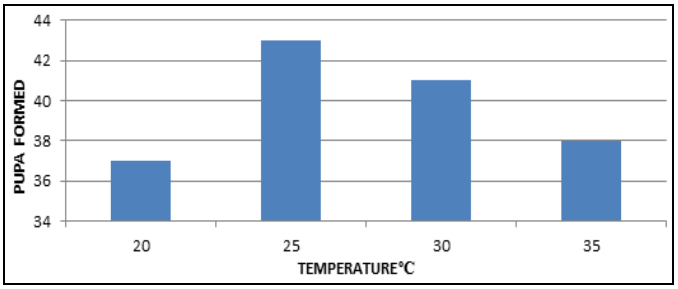

Fig 1: shows the effect of temperature on mortality of pupae.

Reelable silk thread length

The results of reelable silk thread length in the breeds/hybrids of the silkworm are summarized in the table-3.

At 20ºC temperature, 576, 650, 512 and 478 meters silk is obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.

At 25ºC temperature, 729, 800, 625 and 578 meters silk is obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.

At 30ºC temperature, 645, 700, 601 and 545 meters silk is obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.

At 35ºC temperature, 313,450, 300 and 256 meters silk is obtained on 70-75, 75-80, 80-85 and 85-90% humidity respectively.

Thus the silk thread was longer in bivoltine CSR2 × CSR4 at temperature 25°C and humidity 75-80% i.e. 800 meters and smaller at temperature 35°C and humidity 85-90% i.e. 256 meters.

Table 4: Reelable silk thread length (meters) each value is the average of 20 observations

Race:- (Csr2 × Csr4)		
Temperature (ºc)	**Relative Humidity (%)**	**Silk Thread Length (Meters)**
20	70-75	576
	75-80	650
	80-85	512
	85-90	478
25	70-75	729
	75-80	800
	80-85	625
	85-90	578
30	70-75	645
	75-80	700
	80-85	601
	85-90	545
35	70-75	313
	75-80	450
	80-85	300
	85-90	256

Discussion

The influence of temperature and humidity on the growth and development of a bivoltine *Bombyx mori* hybrid, least significant difference (5°C) temperature exceeds 35 °C, metabolic function become erratic, resulting in poor growth of silkworm, which affects the growth of the silk gland and health status of the larvae. Similarly, when temperature falls below 20 °C, metabolic functions become inactive again. The present study indicates that, temperature affects both the growth and development of silkworm. The low values were obtained at high temperature and Pupa weight was recorded lower at higher temperature. Fluctuations of temperature prevent insects from attaining their potential physiological performance. The growth and development were higher when optimum temperature and humidity was maintained. The greater growth and development subsequently affected the cocoon traits [10].

In the present study, Larvae were treated at varied temperature i.e. 20,25,30 and 35° C with varied humidity 70-75, 75-80, 80-85 and 85-90% and the best result were obtained at temperature 25°C and 75-80% R.H.

Temperature plays a vital role on the growth of the silkworms. As silkworms are cold-blooded animals, temperature have a direct effect on various physiological activities. The temperature has a direct correlation with the growth of silkworm; wide fluctuation of temperature is harmful to the development of silkworm [11].

Physiological activities, food intake and economic parameters were influenced by the body temperature of silkworm [12]. Water is an essential requirement for metabolic activity and optimum growth. At higher temperature, probably evapo-transpiration at body surfaces and respiratory epithelium of tracheal system significantly increases. The problem of water balance in silkworm at ambient temperature is further complicated by poor moisture content of the leaf, which finally affects the growth and productivity of silkworm [13]. The present study indicates that greater growth and development of silkworm larvae obtained under the optimum environmental conditions comprises of temperature 25 °C and 75-80% RH, thus help to improve the productivity of silk in sericulture industries.

Conclusion

The results thus suggest that the CSR2 × CSR4 Bi-voltine silkworm should be reared only at 25°C and humidity 75-80% for profitability in silkworm rearing. Humidity has greater effects on the bi-voltine silkworm rather than multivoltine breed. Therefore, bi-voltine rearing in Madhya Pradesh is in general and Indore region in particular should be restricted for good seasons (August to February) only.

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