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## Biology of mulberry silkworm, *Bombyx mori* L. on mulberry, *Morus alba* L.

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### Abstract

The biology of the mulberry silkworm (Mcon-1) was studied on mulberry variety S-30 under laboratory conditions during November 2017 to December 2017. The eggs were laid singly with gummy substance which consists of an average of  $331.30 \pm 29.79$  eggs per female. The eggs hatched in  $8.67 \pm 1.03$  days with  $95.89 \pm 2.83$  percent egg hatching. The larva moulted four times to become fully mature in  $23.77 \pm 0.77$  days. The pre-pupal and pupal periods were  $2.29 \pm 0.46$  and  $10.20 \pm 0.92$  days, respectively. The average pre-oviposition, oviposition and post-oviposition period were recorded  $6.87 \pm 0.83$ ,  $19.73 \pm 2.08$  and  $114.99 \pm 6.79$  hrs, respectively. The average longevity of the female and male recorded  $141.72 \pm 6.73$  and  $111.64 \pm 4.46$  hrs, respectively. The sex ratio was 1: 1.3 (Male: Female). The life span of female found to be relatively more than male moth.

**Keywords:** Biology, mulberry, mulberry silkworm

### 1. Introduction

Sericulture is an agro-based rural industry combining the features of agriculture and village industry. It is an age-old land-based practice in India with high employment potential and economic benefits to agrarian families. It is remarkable for its low investment and quick and high returns which make it an ideal industry or enterprise and fits well into the socio-economic fabric of India. It is also capable of providing continuous income to farmers as it is employment and income generating industry, it is rightly called as the “*Kalpavriksha*” or “*Kamdhenu*” of the poor farmers <sup>[1]</sup>. Silk is the most elegant textile in the world with unparalleled grandeur, natural sheen, and inherent affinity for dyes, high absorbance, light weight, soft touch, high durability and known as the “Queen of textiles” the world over. India silk has enthralled fashion watchers and all categories of all consumers across the world with its vast repertoire of motifs, techniques and brilliant hue <sup>[2]</sup>.

India produced 30,348MT of raw silk during 2016-17 out of which 21,273MT is being contributed by mulberry silkworm, which makes it the second largest producer in the world next only to China. Tasar, Eri and Muga contribute 3268, 5637 and 170MT, respectively. Mulberry silkworm, *Bombyx mori* L. is a monophagous insect that feeds exclusively on the mulberry, *Morus alba* L. foliage for its nutrition and produces the natural proteineous silk <sup>[3]</sup>.

Now, day's sericulture is practiced not only in the five traditionally states like Karnataka, Jammu and Kashmir, Tamil Nadu, Andhra Pradesh and West Bengal, but also it is spreading in other non-traditional states in India. Gujarat is considered as a non-traditional state of sericulture. Sericulture did not gain importance in Gujarat due to alternate cash crops such as sugarcane, cotton, mango, sapota, banana *etc.* <sup>[4]</sup>. However due to international demand to sericultural products, Indian Government is taking keen interest in this business. Thus, the requirements of silk for industries coupled with suitability of mulberry cultivation played significant role in development of sericulture. Some biological studies about biology of mulberry silkworm have done so far in Gujarat but morphological studies was not on Mcon-1 race. The present studies were conducted to study the biology of Mcon-1 race under South Gujarat climate conditions.

### 2. Materials and Methods

An experiment was conducted at Sericulture Laboratory, Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat during November 2017 to December 2017. The Disease Free Laying's of *B. mori* was procured from Central Sericulture Germplasm Resources Center, Central Silk Board, Hosur (Tamil Nadu), India and

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maintained at Sericulture Laboratory, Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari. The rearing of silkworms were conducted as per the technology suggested by Krishnaswami [5]. Eggs were kept for hatching in the laboratory at room temperature. After hatching of eggs, top two full blown leaves of mulberry below the growing bud picked up and chopped into small pieces (0.5 to 1.0 sq.cm) and sprinkled over the newly hatched young larvae, which crawled on the leaves and started feeding from cut edges. Subsequently after 30 minutes the newly hatched larvae together with mulberry food were transferred into the rearing trays with the help of feather and spread on bed with help of chopsticks. The mass rearing was followed during first instars. The food, spacing and cleaning was done as per the stages of the larvae and requirements. The equal quantity of food was given every time, which was thoroughly chopped as per the requirement before feeding. Four feedings of chopped mulberry leaves was given in a day. The timing of feedings was fixed at 8.00 a.m., 11.00 a.m., 15.00 p.m. and 18.00 p.m. in a day. The size of the chopped leaves was regulated according to conditions and size of the larvae. During moulting the larvae were not provided any food and not disturbed. The quantity of food was increased as per the growth of the silkworm. After the full development, the matured larvae identified as they ceased to eat and looked translucent with creamy colour. Such type of larvae were handpicked and kept on the mountage for spinning the cocoon. Larvae were allowed to spin the cocoon for 18-20 hrs. After emergence of adults, tail to tail type mating had done (range 4-6 hrs.). Soon after eggs laid on the egg sheet the surface sterilized using two percent formalin solution (10 minutes) and dry then, the hydrochloric acid (30 minutes) and rinsed in running water and dried under shade. Disinfected eggs of *B. mori* were used throughout the study of biology.

The study on biology of *B. mori* on *M. alba*, the egg period was assessed as a time between date of egg laying and date of egg hatching. The colour and shape of eggs were also observed. With a view to determine the number and duration of larval instars, the newly hatched larvae were transferred and kept individually in the plastic Petri-dishes (110 mm) and fed with mulberry leaves. The size of eggs and each instar larva were measured under microscope with the help of ocular and stage micrometers. The total larval period was calculated from the date of egg hatching to the date of formation of pre-pupa. For the pre-pupal period, the larva was observed from the time when it stopped feeding and became sluggish when it turned to pupa. The duration between formations of pupa to the emergence of adult was considered as pupal period. After formation of cocoon, the length and breadth were measured with help of venire caliper then, it was cut and a pupa was taken out from it. Measurement regarding length and breadth of pupa was also recorded. Adult emergence from pupa was observed for their colour and longevity. Male and female were differentiated on the basis of shape and their abdomen. In order to determine the sex ratio, kept ten set of cocoons from fifteen to twenty five cocoons noted emerge out male and female moth. In order to determine the pre-oviposition period, the newly emerged ten pairs adult moths of *B. mori* were kept separately on starch paper sheet covered with cellulose individually. The period between the emergence of adult female and commencement of egg laying was recorded as the pre-oviposition period. Period between commencement the egg laying and ceasing of the egg laying by individual

female was recorded as oviposition period and period between ceasing of egg laying to death of female was considered as post-oviposition period. Eggs laid by female were collected and counted daily in the morning (8:00 to 10:00 am). The total number of eggs laid during the life span of the adult female was considered as its fecundity. Longevity of male and female moths was calculated separately from the date of emergence to death of adults. Total life cycle was considered as the period between the dates of egg laying to the death of adults. The data on various parameters were analyzed by calculating average values.

### 3. Results and Discussion

The freshly laid eggs by female were oval, ellipsoidal, slightly dig in center of egg at dorsal side and ventral side flat in shape, the colour of eggs was dull white with smooth chorion at the time of oviposition then it turned completely black in colour before hatching. At the time of eclosion, the chorion cracked at one end of egg and larva wriggled out from the eggs. A similar description of eggs was narrated by past workers [6]. The data on morphometrics of length and width of the eggs were  $1.25 \pm 0.05$  and  $1.07 \pm 0.06$  mm, respectively (Table 1). An average length and breadth of eggs was  $1.18 \pm 0.03$  and  $0.99 \pm 0.04$  mm, respectively in PMxCSR2 [6]. The average incubation period was  $8.67 \pm 1.03$  days whereas, the hatching percentage was  $95.89 \pm 2.83$  percent (Table 3). The present findings are close in agreement with the findings of past workers, who reported incubation period from 7 to 11 days with an average  $8.32 \pm 1.18$  days of PMxCSR2 hybrid [6]. However, 98.03 percent hatching observed in NB4D2xKA [7]. The body colour of newly hatched larva (neonate) was yellowish brown in colour with no any marking was observed on larval body. The head was distinctly visible, dark black in colour with shining head capsule, body elongated with numerous hairs arrangement on full larval body. However, second and third instar larva had brown black head with grey-brown body colour, hairs were arranged on full larval body with "C" shape and two round brown spots marking on second and fifth abdominal segments, respectively. A horn like projection on eight abdominal segment and last segment wider than other segments with hairy margin. The fourth and fifth larvae were pure white in colour and same marking characteristics as describe for second and third instar, but it clearly visible. They were found to moult four times and passed through five larval instars. The data on morphometrics of length and width of first to fifth instar larva were  $3.52 \pm 0.19$ ,  $8.93 \pm 0.53$ ,  $13.80 \pm 1.03$ ,  $33.14 \pm 2.95$  and  $57.86 \pm 7.06$  mm and  $0.93 \pm 0.02$ ,  $1.47 \pm 0.12$ ,  $2.99 \pm 0.47$ ,  $4.97 \pm 0.17$  and  $7.15 \pm 0.43$  mm, respectively (Table-1). The instar wise average length and breadth were  $3.35 \pm 0.06$ ,  $12.76 \pm 1.39$ ,  $35.34 \pm 3.22$ ,  $41.36 \pm 3.83$  and  $69.11 \pm 1.69$  and  $1.30 \pm 0.04$ ,  $2.93 \pm 0.09$ ,  $4.82 \pm 0.23$ ,  $5.13 \pm 0.31$  and  $7.72 \pm 0.26$ , respectively in NB4D2xKA [7].

The average larval duration recorded  $3.50 \pm 0.51$ ,  $3.53 \pm 0.51$ ,  $4.47 \pm 0.51$ ,  $5.60 \pm 0.45$  and  $6.60 \pm 0.50$  days for first, second, third fourth and fifth instar larva, respectively with total larval developmental period of  $23.77 \pm 0.774$  days (Table 3). The larval period of first, second, third, fourth and fifth instars lasted for  $3.63 \pm 0.48$ ,  $3.30 \pm 0.58$ ,  $5.30 \pm 0.64$ ,  $6.50 \pm 0.67$  and  $7.50 \pm 0.50$  days respectively, with  $26.23 \pm 1.18$  days of total larval period [7]. The K2 race displayed significantly shorter larval duration of first, second, third, fourth, fifth and total larval duration as 2.27, 3.00, 4.00, 4.20, 7.10 and 20.59 days, respectively [8]. The first, second, third, fourth and fifth instars

larval period were  $3.50 \pm 0.48$ ,  $3.48 \pm 0.42$ ,  $4.42 \pm 1.16$ ,  $5.48 \pm 0.52$  and  $7.56 \pm 0.48$  days respectively, with  $24.44 \pm 1.51$  days total larval period in PMxCSR2 [6].

**Table 1:** Morphometrics of various stages of *B. mori*

Sr. No.	Stages	Length			Breadth		
		Min.	Max.	Av. $\pm$ S.D.	Min.	Max.	Av. $\pm$ S.D.
1.	Egg	1.15	1.36	$1.25 \pm 0.05$	09.95	1.26	$1.07 \pm 0.06$
2.	Larva						
	I instar (mm)	3.08	3.97	$3.52 \pm 0.19$	0.90	0.95	$0.93 \pm 0.02$
	II instar (mm)	8.04	9.79	$8.93 \pm 0.53$	0.98	1.59	$1.47 \pm 0.12$
	III instar (mm)	12.20	16.08	$13.80 \pm 1.03$	1.90	3.79	$2.99 \pm 0.47$
	IV instar (mm)	29.60	38.50	$33.14 \pm 2.95$	4.53	5.23	$4.97 \pm 0.17$
	V instar (mm)	49.89	69.90	$57.86 \pm 7.06$	5.90	8.00	$7.15 \pm 0.43$
3.	Pupa (cm)	1.70	2.20	$1.91 \pm 0.15$	0.60	0.90	$0.73 \pm 0.09$
4.	Cocoon (cm)	3.03	3.45	$3.30 \pm 0.12$	1.63	2.02	$1.82 \pm 0.11$
n= 25							

**Table 2:** Morphometrics of adults of *B. mori*

Sr. No.	Particulars	Female			Male		
		Min.	Max.	Av. $\pm$ S.D.	Min.	Max.	Av. $\pm$ S.D.
1.	Wing span (cm)	3.70	4.10	$3.86 \pm 0.11$	3.30	3.50	$3.41 \pm 0.07$
2.	Length (cm)	1.60	2.10	$1.87 \pm 0.16$	1.50	1.70	$1.60 \pm 0.08$
3.	Breadth (cm)	0.50	0.70	$0.59 \pm 0.07$	0.40	0.70	$0.55 \pm 0.08$
n= 25							

When final instar larva became full grown, it stopped feeding, showed restlessness, become sluggish, and gradually changes in colour from white to light yellow and raise their head in search of support so as to be enabling to start spinning of the

cocoon which indicate that larva ready for mounting on moutange. Freshly formed pupa appeared shining yellow brown in colour which later on became dark brown in colour. Similar description showed by past workers [6].

**Table 3:** Biology of *B. mori* on *M. alba*

Sr. No.	Particulars	No. observed	Periods		
			Min.	Max.	Av. $\pm$ S.D.
1	Incubation period (Days)	30	7.00	11.00	$8.67 \pm 1.03$
2	Hatching percentage (%)	3313	90.93	98.93	$95.89 \pm 2.84$
3	Larval period (Days)				
	I instar	30	3.00	4.00	$3.50 \pm 0.51$
	II instar	30	3.00	4.00	$3.53 \pm 0.51$
	III instar	30	4.00	5.00	$4.47 \pm 0.51$
	IV instar	30	5.00	6.00	$5.60 \pm 0.50$
	V instar	30	6.00	7.00	$6.60 \pm 0.50$
	Total larval period (Days)	30	21.00	26.00	$23.77 \pm 0.77$
4	Pre-pupal (Days)	30	2.00	3.00	$2.29 \pm 0.46$
5	Pupal period (Days)	30	9.00	12.00	$10.20 \pm 0.93$
6	Pre-oviposition period (hrs)	30	5.30	8.30	$6.87 \pm 0.83$
7	Oviposition period (hrs)	30	17.00	24.00	$19.73 \pm 2.08$
8	Post-oviposition period (hrs)	30	87.00	122.60	$114.99 \pm 6.79$
9	Adult emergence (%)	197	60.00	70.00	$64.44 \pm 2.81$
10	Sex ratio (Male : Female)	336	1:1.00	1:1.40	1:1.30
11	Adult longevity (hrs)				
	Female	30	112.50	148.80	$141.72 \pm 6.73$
	Male	30	103.20	120.00	$111.64 \pm 4.47$
12	Total life cycle (Days)				
	Female	30	48.25	64.65	$56.24 \pm 19.62$
	Male	30	47.85	63.45	$50.16 \pm 17.36$
13	Fecundity (No.)	10	283.00	375.00	$331.30 \pm 29.79$
14	Temperature ( $^{\circ}$ C)	-	22.00	25.40	$23.71 \pm 0.64$
15	Relative humidity (%)	-	43.00	63.00	$51.63 \pm 6.06$

The pre-pupal period observed  $2.29 \pm 0.46$  days. The average pre-pupal period was  $2.98 \pm 0.89$  days in PMxCSR2 [6]. The pupal period was recorded  $10.20 \pm 0.92$  (Table 3). The average pupal period was  $11.56 \pm 0.55$  days in NB4D2xKA [7]. The pupal period varied from 10.20 to 11.49 days on mulberry [9]. The length and width of pupa was  $1.91 \pm 0.15$  and  $0.73 \pm 0.09$  cm, respectively. The cocoon was observed to be tough,

single threaded, dull white in colour and oval shaped with one or two layers of tough elastic protein. The length and breadth of pupa were  $3.35 \pm 0.35$  and  $2.10 \pm 0.11$  cm [10]. The average length and breadth of pupa were  $2.57 \pm 0.20$  and  $2.21 \pm 0.11$  cm respectively [11]. The morphometrics of cocoon revealed that length and breadth of cocoon was  $3.30 \pm 0.12$  and  $1.82 \pm 0.11$  cm (Table 1). The length and breadth of cocoon ranged from

3.01±0.13 to 3.12±0.14 cm and 1.63±0.09 to 1.77±0.10 cm in polyvoltine breed <sup>[12]</sup>. The cocoon length and breadth were 3.35±0.35 and 2.10±0.11cm, respectively <sup>[10]</sup>.

Before emergence into adult, the pupa secretes a brown colour alkaline fluid that softens one end of the cocoon and break down of its silk strands take place, feeble crumpled adult squeezes its way out. The male was dirty white coloured moth, antennae were bi-pectinate, ocelli were absent and black compound eyes were present. Males were smaller in size than females and could easily be distinguished with the help of presence of black colour marking on fore and hind wings, also size of abdomen. The female moth was dull white in colour with bi-pectinate antennae. The forewings and hind wings of both the sexes were dirty and dull white coloured, respectively. Adults were sluggish and weak fliers, the entire body and wings were covered with scales, head was small and hypognathous and proboscis was well developed and coiled. A similar description of adults also reported by past workers <sup>[6]</sup>. The wing span was 3.86±0.11cm in female and 3.41±0.01cm in male. The wing span of male and female moth was 3.45±0.05 and 3.93±0.06cm, respectively <sup>[7]</sup>. The length and breadth was 1.87±0.16 and 0.59±0.07cm in female and 1.60±0.08 and 0.55±0.08cm in male moth, respectively (Table 2). The adult emergence was recorded 94.96±3.20 percent (Table 3). The pre-oviposition, oviposition and post-oviposition periods are given in Table 2. It clearly indicated that the pre-oviposition, oviposition and post-oviposition periods were 6.87±0.83, 19.73±2.08 and 114.99±6.79 hrs, respectively. The average pre-oviposition, oviposition and post-oviposition period of mulberry silkworm race, PMxCSR2 were 0.43 ± 0.03, 2.30 ± 0.48 and 3.50 ± 0.53 days, respectively <sup>[6]</sup>. Female lived longer (141.72±6.73 days) than Male (111.64±4.46 days) (Table 3). The mean life span for the female and male were 11.07 and 8.14 days in multivoltine races, respectively <sup>[13]</sup>. The longevity of male and female moth were 5.60 ± 0.70 and 6.23 ± 0.43 days, respectively in PMxCSR2 <sup>[6]</sup>.

Data recorded on fecundity *B. mori* are presented in Table 3, indicated that the female laid 331.30±29.79 eggs during entire ovipositional period. The female laid 269±30.21 eggs during entire ovipositional period <sup>[6]</sup>. The male emerge more than female, so the sex ratio of male to female was 1:1.44 (Table 3). However, the lowest (45.0%) female population and highest (55.0%) male population in breed CSR2 <sup>[14]</sup>. Total life cycle completed in 48.50±1.78 days for female and 47.30±1.76 days for male. The life cycle of *B. mori* completed in 40 days in February to April. They also showed that the life cycle of *B. mori* competed in 40 days at 23.90 to 25.8 °C temperature and 90.9 percent relative humidity <sup>[15]</sup>.

#### 4. Conclusion

The eggs were laid singly with gummy substance and each DFL consists of 331.3 ± 29.78 eggs. At the time of eclosion, the chorion cracked at one end of egg. The duration of incubation was observed 8.67±1.03 days. The average hatching percentage was 95.89±2.83 percent.

The larva passed through five instars and four moults. The freshly hatched larvae were yellowish brown in colour. Clear white stripe between head and thorax of larva, no any marking was observed on larval body. The head was dark black in colour, body elongated with numerous hairs arrangement on full larval body. Freshly moulted second instar larva was brown black head, grey-brown body colour, hairs arrangement on full larval body with “C” shape and two

round brown spots marking on second and fifth abdominal segments, respectively. The third and fourth instar larva looks dirty white colour with well-developed and more clearly visible all body marking. The newly moulted fifth instar larva showed similarity in general appearance to forth instar larva, excluding large size and pure white body colour of larva. The total larval developmental period of was 23.77±0.77 days.

The average larval duration was recorded 3.50±0.51, 3.53±0.51, 4.47±0.51, 5.60±0.45 and 6.60±0.50 days for first, second, third fourth and fifth instar larva, respectively. Total larval developmental period completed within 23.77±0.774 days. The result concluded that the different larval stages indicated a progressive increase in length and breadth of various stages of larva and head capsule after each moulting. The cocoon observed to be tough, single threaded, dull white in colour and oval shaped with one or two layers of tough elastic protein. Pupation took place inside protective cocoon which made up of silk thread and it calls “silk shell”.

The adult emerged out through an opening at the end of the cocoon in about an average 10.20±0.92days after pupation. The mean adult emergence percent was 94.96±3.20. The pre-oviposition period, oviposition period, post-oviposition period were 6.87±0.83, 19.73±2.08 and 114.99±6.79 hrs, respectively. The results revealed that the mean longevity of male and female were 141.72±6.73 and 111.64±4.46 hrs, respectively. The data on fecundity, sex ratio was recorded were 331.30±29.79 eggs per female and 1:1.44 (M: F), respectively. The average total life cycle of female and male completed in 48.50±1.78 and 47.30±1.76 days, respectively.

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