New strategy for quality assessment in *Bombyx mori L.(Nistari)* through larval critical weight

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ABSTRACT

Quality and performance of insects is dependent on weight gain from feeding. The unchangeable biological parameter like larval critical weight ***(Lcw)*** *is the basis for developing different criteria for insect quality. The* ***Lcw*** *has been described as a threshold weight above which normal process of pupation occurs. The* ***Lcw*** *in Nistari, Bombyx mori was 938.46 and 1118.15 mg for average sized male and female final instar larvae which were 49.60% and 53.13% of the larval maximum weight* ***(Lmw)*** *of males and females respectively. There was a consistent proportionate decrease in weight of about 0.66 % for males and 0.58% for females from larval maximum weight to the pupal weight of Nistari. There was also a consistent proportionate decrease in weight from the pupa to adult and thus, the total weight decrease from* ***Lmw*** *to adult was about 0.82 % and 0.72% for males and females respectively. A positive correlation was derived between female pupal weight and fecundity. A model representing the various fresh weight changes in relation to the* ***Lmw*** *has been suggested for the Nistari. The results of the study are largely consistent with those carried out on other species of Lepidoptera and using* ***Lcw*** *a new strategy for quality assessment of Bombyx mori has been described. Thus, quality assessment and its control is the key in regulating and sustaining the performance of an insect*

Key Words: Larval critical weight, larval maximal weight, latent feeding period and silkworm.

Quality and performance of insects is dependent on weight gain from feeding (Slansky and Scriber, 1985). Insects are organisms designed to maximize and exploit the available biotic and abiotic resources to their advantage. All insects, irrespective of the habitats they live in, have only one "intended role", which is to maximize their survival ability (reproductive fitness). As such, there is only one type of biological performance and therefore quality that is the success of the individual insect in survival and contribution to the next generation. Biological performance can be defined by how well the organism has contributed to its survival and reproduction in a given ecological system (Ochieng'-Odero, 1990a). The existence of a larval critical weight (**Lcw**) has been established in several insect species (Nijhout, 1975, Nijhout and Williams, 1974, Woodring, 1983, Slansky and Scriber, 1985). The unchangeable biological parameter like larval critical weight is the basis for developing different criteria for insect quality. Thus, quality assessment and its control is the key in regulating and sustaining the performance of an insect. However, no reports for determinations of critical weight in *Bombyx mori* L. and its relation with quality indices are available so far. The present investigation is an attempt to determine the larval critical weight of *Bombyx mori* L. which could be used as a basis for the development of quality indices. Hence, a new strategy for quality assessment of *Bombyx mori* has been described.

Nistari, a popular multivoltine silkworm breed was used for this experiment. The study was conducted at Central Sericultural Research and Training Institute, Berhampore, West Bengal, India for consecutive three years**.** Silkworm rearing was conducted according to the method of standard rearing practices (Krishnaswami *et al.*, 1973).

After fourth moult, 2000 larvae of fifth instars of this breed were used for this experiment. The missing larvae were replaced daily if necessary from the control lot that maintained in the same environment control lot. 200 larvae were sacrificed every day from the first day of V instar i.e. initiation of the V instar to spinning of cocoon. During the study, the body weight of the larva, larval duration, temperature and relative humidity were recorded. Larval critical weight (Lcw), larval maximum weight (Lmw), latent feeding period, were determined from starvation experiment following the procedure of Ochieng'-Odero (1990a, 1990b). **Lcw** was regarded as the weight at which 50% of the silkworms were capable to pupate thereby producing functional adults.

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Pupal critical weight (Pcw) and Adult critical weight (Acw) were calculated as follows:

Pcw = Lcw - (Lcw x Dp) and Acw = Lcw-(Lcw x Da)

Where, Dp = Constant weight decrease from Lmw to Pw (Pupal weight) and Da = Constant weight decrease from Lmw to Aw (Adult weight)

Pcw and Acw are useful as descriptive indices of insect quality for both male and female insect. If the Lcw for a population of insects is taken to be that of medium sized members, quality indices can be derived as

Pupal quality index = Pupal weight / Pupal critical weight

Adult quality index = Adult weight / Adult critical weight

Thus, where the mean pupal or adult weight for the population is equal to critical weights of the medium sized member, the indices would be 1. As the weights increase above the critical weights, the indices would climb to above 1, representing an increase in quality.

Body weights were recorded from freshly hatched larvae and continued till attainment of adult stage of the insect. Weights were also recorded before and after moulting in each instar. Accordingly, initial weight and final weight were obtained. Male and female larvae were separated phenotypically immediately resumed from 4th moult and their weights were recorded till it transformed to adult stage. Sequential model for larval-pupal-adult quality has been suggested following the procedure of Ochieng'-Odero (1990b).

RESULTS AND DISCUSSION

Larval critical weight (LCW)

The Larval critical weight **(Lcw)** was determined from starvation (food deprivation) experiment following the procedure of Ochieng'-Odero (1990a). Starvation stress was applied to the silkworm during 5th larval instar from '0' day onwards to determine the critical weights and subsequently to assess the quality indices of the breed for different seasons.

Biological performances are related to time required to attain critical weight, maximum weight, latent feeding period, etc. In Nistari breed, **Lcw** was found to be about 938.46 mg and 1118.15 mg for males and females respectively (Table-1, Plate-1). There was a consistent proportionate decrease in weight of about 0.66 % for males and 0.58% for females from larval maximum weight **(Lmw)** to the pupal weight. There was also a consistent proportionate decrease in weight from the pupa to adult and thus, the total weight decrease from **Lmw** to adult was about 0.82 % and 0.72% for males and females respectively. The **Lmw** may be defined as the highest level of weight that a larva can attain and it signals the onset of the pre-pupal phase. The period between day of attainment of 5th instar and achievement of **Lcw** is described as the **Pre-Lcw** period. In Nistari the duration is about 2.42 days. The period between day 0 and **Lmw** (**Pre-Lmw** period) is the active feeding phase and the duration is about 5.81 days. The latent feeding is the period between attainment **Lcw** and **Lmw**, the duration is about 3.40 days (Table 2). So, any weight below the **Lcw** will not lead to functional adult. Besides, larval maximum weight **(Lmw),** pupal weight **(Pw)** and adult weight **(Aw)** together with the constant decrease in weight from **Lmw** to **Pw** and **Aw** were also recorded. The constant decrease in weight from **Lmw** to **Pw** marked as **Dp** and from **Lmw** to **Aw** marked as **Da** were recorded (Table-1). The sexual dimorphic nature and variation in **Lcw**, **Lmw**, pupal and adult weight is probably due to the different requirements for the sexes in reproduction.

Lcw as a standard for pupal and adult quality:

The Larval critical weight **(Lcw)** is defined as the threshold weight above which normal processes of pupation are initiated. The **(Lcw)** is the trigger for the release of corpora allata, an inhibiting factor which stops the secretion of Juvenile hormone (Nijhout, 1975) and is dependent on body size. **(Lcw)** is important as it ensures that regardless of different growth rates for different larvae, pupation occurs only when final instar larvae have reached the "required size" and is able to produce a pupa that will emerge to give a functional adult i.e. able to survive and reproduce.

Depending on the quality indices and considering other supporting physiological parameters like body weight, larval, pupal and adult duration, **Dp, Da** etc. a '**Sequential Model '** of wet weight changes in 5th larval instar of the breed *as* expressed as a percentage of the **Lmw** had been established (Fig. 2). Larval body weight is very much affected and controlled by the existing environmental conditions. Thus, it could be presumed that **Lcw**, **Dp** and **Da** were constant in a wide numbers of insects. On the other hand **Lmw** was a population characteristic for the given species i.e. dependent on the initial size of final larval instar, environmental factors and nutrition.

Relationship between **Lmw**, pupal and adult weight can be represented as:

Pupal weight (Pw) = Lmw – (Lmw x Dp)

Adult weight (Aw) = Lmw – (Lmw x Da)

Where, $\mathbf{D_P}$ = a constant weight decrease from **Lmw** to **Pw** and **Da**= a constant weight decrease from **Lmw** to **Aw**.

All durations before **Lmw** are under the direct influence of various factors mainly the quality and quantity of feed and rearing climate etc. affecting physiological activities of silkworm. However, the process / duration of post **Lmw** development was controlled primarily by environmental factors like temperature etc. by affecting the rate of enzyme and hormone action.

Pupal and adult critical weights (Pcw & Acw) from Lcw :

Pupal critical weight (**Pcw)** means it is the lower limit of pupal performance of an insect . Similarly, adult critical weight (**Acw)** is also the lower limit of adult performance. The larvae cannot pupate at weights below **Pcw** or eclose below the **Acw**. Pupal and adult critical weight can be calculated as:

$$Pcw = Lcw - (Lcw \times Dp)$$

$$Acw = Lcw - (Lcw \times Da)$$

Say, in Nistari male:

Pcw = 938.46 – (938.46 x 0.66) = 319.07 mg.

Acw = 938.46 – (938.46 x 0.82) = 168.92 mg.

Larval, pupal and adult indices of quality

The **Lcw, Pcw** and **Acw** are useful as descriptive indices of insect quality for both male and female. If the critical weight for a population of insects is taken to be that of medium sized members, quality indices can be calculated using the formulae:

$$\text{Larval quality index} = Lmw / Lcw$$

$$\text{Pupal quality index} = Pw / Pcw$$

$$\text{Adult quality index} = Aw / Acw$$

Thus, where the mean larval, pupal and adult weight is equal to critical weights, quality indices would be **1**(one). As the weights increases above the critical weight, the values of indices would rise to above **1**, implying an increase in quality. Say for example in Nistari, among the four seasons, the higher larval quality index value was recorded during November (2.23) followed by February (2.11) and comparatively lower larval quality index value was found during August- September (1.97) and May-Jun (1.48) (Fig.-1). The same trend was also observed in case of pupal and adult quality. The higher value of quality index **(QI)** indicates both increase in quality and better season. It is concluded that the best season for Nistari breed is November followed by February in West Bengal conditions compared to other two seasons mentioned above. Thus, it is possible to measure the impact of seasonal variations influencing environmental factors and also variation in rearing facilities on the breed and its rearing performance.

It was worth noting that the total decrease from **Lmw** to pupal weight **(Dp)** and to adult weight **(Da)** was more for males than for females (Table-1), which ensured that the female pupa and adult was always heavier than the male. That was certainly due to more reproductive demands to produce eggs to continue the progeny. In female Nistari when **Pw** is equal to **Pcw**, the number of eggs laid would be 85, the lowest fecundity possible for medium size of the breed. However, an increase in weight above the **Pcw** was reflected in enhanced fecundity. This phenomenon was also regarded as index of the performance quality and this could be useful for predicting the best rearing season of the breed.

In conclusion, the results of this investigation indicate that the quality indices of the breed - Nistari reflected in the survivability, suitability and adaptability to the differential environmental conditions. It could be put forward that quality implies in survivability success. Quality and performance of insect were dependent on the weight gained from feeding (Slansky and Scriber, 1985). The cumulative effects of **Lcw**, **Pcw, Acw**, duration of the obligatory and latent feeding periods, etc. were responsible for quality indices and biological performances in *Bombyx mori* L. The larval critical weight has been established in many insects (Nijhout, 1981; Slansky and Scriber, 1985; Ochieng'-Odero, 1990a) and corroborates with the current inference / observation. **Lcw** was very much prominent and stable regardless of the variable ambient environmental conditions. Thus, larval critical weight could be regarded as a biological marker to assess the quality of *Bombyx mori* as interaction outcome with environmental (rearing) conditions and could be utilized for characterization of region and season specific silkworm breeds of commercial importance.

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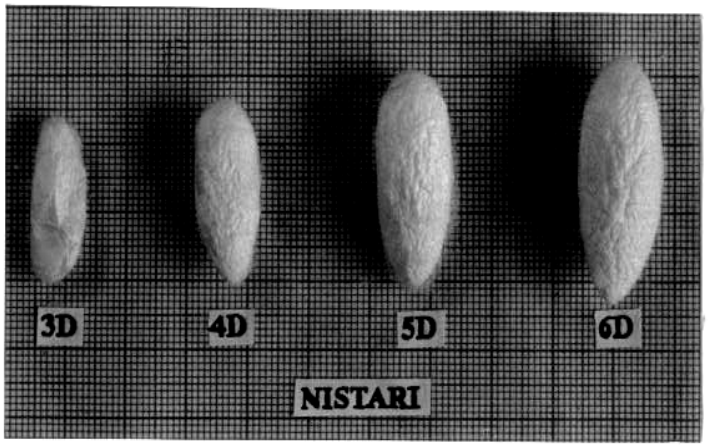

Plate. 1. Cocoons of Nistari multivoltine breed of silkworm, *B. mori* L. after attaining larval critical weight.
1. 3D means day of attainment of critical weight.
2. 4D means 24 hours after attainment of critical weight.
3. 5D means 48 hours after attainment of critical weight.
4. 6D means 72 hours after attainment of critical weight

Fig. 1: Season wise comparative performance of Larval Quality index of Nistari br eed

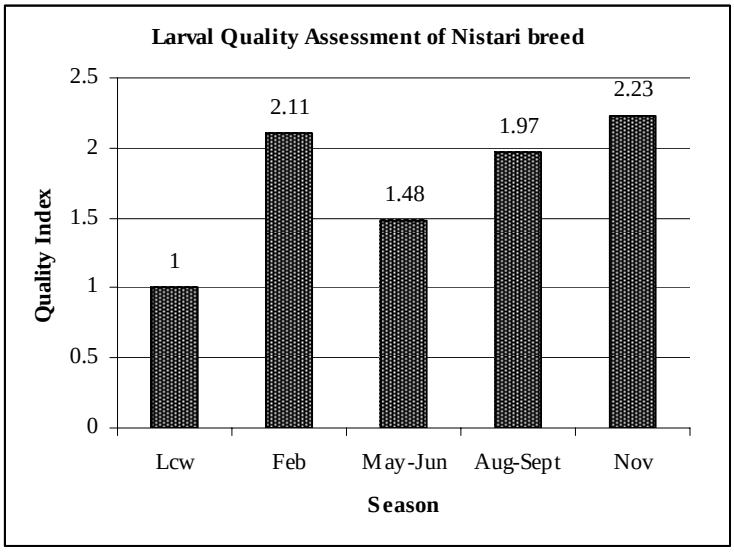

Table 1. Determination of critical weight (mg) and quality indices of different development stages of Nistari breed of *Bombyx mori* L.

Sl. No.	Parameter	Male	Female
1	Larval critical weight (Lcw) (mg)	938.46 ± 2.06	1118.15 ± 6.44
2	Larval mature weight (Lmw) (mg)	1892.03 ± 162.04	2104.45 ± 126.41
3	Pupal critical weight (Pcw) (mg)	319.07 ± 3.78	472.17 ± 4.74
4	Adult critical weight (Acw) (mg)	168.93 ± 1.55	319.86 ±4 .91
5	Pupal weight (Pw) (mg)	638.35 ± 49.69	882.10 ± 58.58
6	Adult weight (Aw) (mg)	333.50 ± 28.03	594.93 ± 30.05
7	Weight decrease from Lmw to Pw (%) (Dp)	0.66 ± 0.00	0.58 ± 0.00
8	Weight decrease from Lmw to Aw (%) (Da)	0.82 ± 0.00	0.72 ± 0.00

Values are presented in mean ± SE.

Table 2. Span of different functional components during 5th instar larval life of Nistari silkworm breed of *Bombyx mori* L.

Sl. No.	Parameter	Male	Female	Mean
1	Time required to attain larval critical weight (days)	2.39	2.45	2.42
2	Latent feeding period (days)	3.07	3.73	3.40
3	Time required to attain larval maximum weight (days)	5.43	6.19	5.81

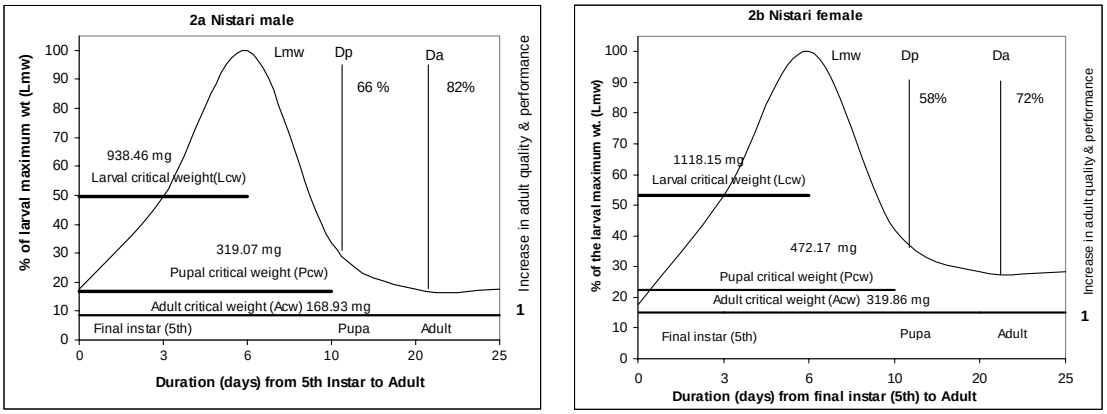

Fig. – 2 : Sequential model of wet weight change from the final instar (5th) to adult of Nistari breed.