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Validation of Consumption, Assimilation and Conversion Efficiency in Selected Bivoltine Silkworm Hybrids FC1 × FC2 and FC2 × FC1

Suraksha Chanotra[1*], Avleen Kour[1], Muzafar Ahmad Bhat[1] and Roopma Gandotra[1]
[1]Lecturer, P.G. Department of Sericulture, Poonch Campus, University of Jammu, (J&K), India.
[2]Professor, Department of Zoology, University of Jammu, (J&K), India.

(Corresponding author: Suraksha Chanotra)*
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ABSTRACT: Silkworm *Bombyx mori* (L.) is one of the most unique holometabolous insect known for production of most versatile silk protein. The growth rate pattern varies significantly from first to last day of the larval period. The current experiment was conducted to assess the exact quantum of food required by silkworm larvae in different instars. For quantification of food required various parameters like growth rate, ingestion and digestion of the larvae for different instars was studied. Selection of silkworm hybrid namely FC1 × FC2 and FC2 × FC1 was made on the basis of its practical demand in most of the bivoltine sericultural area of the country including Jammu and Kashmir. For the current experiment maximum larval growth was recorded during the 5th instar with respect to their weight and length. The data showed that there is logarithmical increase in the larval body weight and length until day 7th of the 5th instar. The maximum larval length was observed on 7th day to be 8.5cm in FC1 × FC2 and 7.4 cm in FC2 × FC1. Significant values for minimum and maximum ingesta were observed for both the hybrid on first day of 1st instar and in 5th instar on 7th day respectively. However, digesta was recorded to be highest in hybrid FC1 × FC2 in 5th instar on 7th day as 93.23g. Growth studies were conducted on bivoltine hybrids which were recorded as growth rate (GR) with maximum and least values as 0.87g and 0.86g and in case of FC1 × FC2 and FC2 × FC1 as 0.13g and 0.13g. The efficiency of conversion of ingesta (ECI) and digesta (ECD) for larval body, cocoon weight and cocoon shell in case of FC1 × FC2 and FC2 × FC1 were recorded as (59.19 and 89.62%) and (53.82 and 86.56%), (1.90 and 1.57%) and (2.70 and 1.64%). Therefore, the current experiment helps to figure out the exact quantum of feed required by silkworm larvae at different instars and the relationship between ingestion and digestion ratio.

Keywords: Silkworm, ingesta, digesta, growth, conversion, cocoon, relationship.

INTRODUCTION

Sericulture is the most important agro-based economic enterprise providing profit making opportunities to rural and marginal farmers (Chutia *et al.,* 2014). Silkworm being monophagous insect feeds only on mulberry leaf because of the presence of morin pigment in addition to other compounds (Anonymous, 2013; Hotta, 2017). Food consumption and assimilation is influenced by various biotic and abiotic factors. Under different environment, feeding and nutritional conditions and with ingestion of the same amount of mulberry leaves, the silkworm shows significant difference in its ability to digest, absorb and convert food to body matter. Hence, influence of season, temperature, humidity on food intake, and assimilation and conversion efficiency of the *Bombyx mori* (L.) is significant. Consumption and assimilation were reported to be significantly higher among the silkworm reared with optimum temperature and humidity ranges, when compared with silkworm exposed to natural climatic conditions of the respective season (Rajan *et al.,* 2001; Rahmathulla *et al.,* 2001; Rahmathulla and Suresh 2012). The requirement of all the macro and micro-nutrients essential for growth and development of silkworm could be made available to the worms in the form of mulberry leaf. Thus the quality of mulberry leaf plays essential role in triggering the appetite of the silkworm larvae and is influenced to a great extent by the agro-climatic conditions and cultivation practices, which in turn decides the amount of food utilized and converted into silk protein by the larvae (Reddy 2011; Qin *et al.,* 2020; Prakash and Sannappa 2018).

Ingesta and digesta required to produce one gram of cocoon/shell can be observed to vary significantly under varied conditions. This can be attributed to the

physiological adaptation of silkworm to different season (Rahmathulla *et al.*, 2004a). Thus, the consumption and assimilation ratio plays significant role in quantification of the feed and fixation of the standard feeding requirement by silkworm larvae at various instars. Generally the maximum amount of total feed utilized i.e. 80-85% by silkworm larvae during its feeding period are consumed in 5th instar of the larval period (Rahmathulla *et al.*, 2004b). Moreover, it has also been stated that the amount of ingesta and digesta is directly proportional to the fresh weight of the leaf consumed by the silkworm larvae (Rahmathulla *et al.*, 2002; Trivedy *et al.*, 2003; Rahmathulla *et al.*, 2005; Sannappa *et al.*, 2013). Therefore, in order to analyses the correlation of the quantum of feed required by silkworm larvae at different instars and to understand the relationship between ingestion and digestion ratio and its conversion by silkworm.

MATERIALS AND METHODS

The silkworm rearing for the current experiment was conducted at Post Graduate Department of Sericulture, Poonch Campus, University of Jammu during spring season (March-April) in the year 2021. The methodology followed for the study has been described under various headings as given below:

A. Feed Utilisation Studies

1. Feed utilization studies, after resumption from 4th moult, 50 larvae each from 3 replications will be separated and would be reared under standard rearing condition of temperature and relative humidity with control batches.
2. Known quantities of fresh quality mulberry leaf to be supplied to the silkworm for three times (three times feeding schedule @ 10 AM, 2PM and 5PM).
3. Samples of mulberry leaves used for each feeding will be placed in trays for estimation of dry weight determination of Ingesta.
4. Additional larval batches of each treatment will be maintained in parallel direction the dry weight for subsequent determination of daily incremental changes in larval weight.
5. Observations on dry weight of left over leaf, excreta and larval weight will be recorded daily after oven drying at a constant temperature of 80°C.
6. Larvae will mounted on plastic collapsible mountage and cocoon would be harvested after 6th day.
7. Dry weight of the cocoon and shell will be calculated for future validation of results.

B. Statistical Analysis

The raw data generated from the current experiment by Completely Randomized Design (CRD) have been pooled and subjected to Analysis of Variance (ANOVA) on Statistical Package for the Social Sciences (SPSS) software Version; 2021, to determine the significant values for the selected parameters.

The formulas for calculation and tabulation of different nutritional parameters include:

- **Ingesta**= dry weight of leaf given – dry weight of the leaf leftover.
- **Digesta**= dry weight of food ingested – dry weight of faeces.
- **Growth rate =** {(G)/ (T×A)}
- **Consumption index** = $\dfrac{\text{Ingesta}}{\text{Mean fresh larval weight}}$
- **Approximate Digestibility Percentage (AD %) =** $\dfrac{\text{Dry weight of food ingested - dry weight of leaf}}{\text{Dry weight of food ingested}} \times 100$
- **Reference ratio** $= \dfrac{\text{Dry weight of excreta}}{\text{Dry weight of food ingested}}$
- **ECI/ECD to larvae (%)** = $\dfrac{\text{Dry weight gained by larvae during feeding period}}{\text{Dry weight of Ingesta or Digesta}} \times 100$
- **ECI/ECD to cocoon (%)** = $\dfrac{\text{Dry weight of cocoon}}{\text{Dry weight of food Ingesta or digested}} \times 100$
- **ECI/ECD to cocoon shell (%)** = $\dfrac{\text{Dry weight of cocoon shell}}{\text{Dry weight of food ingested or digested}} \times 100$
- **Ingesta required to produce 1g of cocoon or cocoon shell**

(Ingesta/g cocoon/ shell) = $\dfrac{\text{Dry weight if Ingesta}}{\text{Dry cocoon or cocoon shell weight}}$

- **Digesta required to produce 1g of cocoon/cocoon shell**

(Digesta/ g cocoon/ shell) = $\dfrac{\text{Dry weight of digesta}}{\text{Dry cocoon or cocoon shell weight}}$

Conversion of ingesta (ECI %) = $\frac{\text{Weight gained (g)}}{\text{Weight of food ingested}} \times 100$

- **Conversion of digesta (ECD %) =** $\frac{\text{Weight gained (g)}}{\text{Weight of food ingested}} \times 100$
- **Conversion of ingesta and digesta to larval body =** $\frac{\text{Weight gained by larvae during feeding period}}{\text{Dry weight ingesta}} \times 100$
- **Cocoon shell ratio** $\frac{\text{Weight of cocoon shell}}{\text{Weight of cocoon}} \times 100$

RESULTS AND DISCUSSION

Various larval parameters studied for food quantification studies have been under following headings:

A. Larval Weight

Rahmathulla *et al.* (2005) reported that the dietary efficiency of silkworm plays a major role in converting mulberry leaf protein into the animal protein i.e., Silk. Weight of the larvae is directly proportional to the amount of food utilized by it during its feeding period. Weight (mg) of the larvae during the present study was measured on a sensitive, digital electronic weighing balance. The various values for larval weight for single larva and 10 larvae of different instars (per day) have been recorded with significant increase with each day (Table, 1-3). The maximum and minimum values for single and 10 larvae ranged from 45.20g to 0.52g and 36.91g to 0.12g in case of silkworm hybrid FC1 × FC2 and FC2 × FC1 respectively on day 7th of 5th instar and day 1st of 3rd instar for both the hybrids. Interestingly, the current results found to be strongly in agreement with that of Craiciu (2011); Cui and Hiratsuka (2019). Similar experiment with respect to feed utilization was earlier reported by Rahmathulla *et al.* (2002); Rahmathulla *et al.* (2005), where the maximum larval weight was recorded for the larvae fed with fresh mulberry leaf. The current findings where maximum larval weight was recorded in 5th instar larvae lies in close conformity to the earlier reports of Rahmathulla *et al.* (2002 and 2005).

Table 1: Values of larval weight recorded for single and 10 larvae from 3rd instar onwards (per day) in silkworm hybrid FC1 × FC2 and FC2 × FC1.

3rdInstar	Days	FC1×FC2	FC2×FC1
Weight of Single Larva (g)	01	0.52±0.02b	0.12±0.11b
	02	0.54±0.04c	0.15±0.22bc**
	03	0.60±0.06c	0.21±0.43c
	04	-	-
Weight of 10 Larvae(g)	01	3.61±1.16b	2.74±1.17b
	02	3.92±1.11c	3.02±1.85bc**
	03	4.01±1.14c	3.22±1.64c
	04	-	-

Means within a column followed by different letters are significantly different at P<0.01
** Highly Significant data at p=0.05

Table 2: Values of larval weight recorded for single and 10 larvae from 4th instar (per day) in silkworm hybrid FC1 × FC2 and FC2 × FC1.

4th Instar	Days	FC1 × FC2	FC2 × FC1
Weight of Single Larva(g)	01	0.62±0.05a	0.24±0.08a
	02	0.78±0.04ab**	0.31±0.22ab**
	03	0.85±0.03ab**	0.38±0.22bc**
	04	0.88±0.07ab**	0.44±0.21c
	05	0.95±0.02a	0.56±0.11d
Weight of 10 Larvae(g)	01	4.21±2.33a	3.27±2.15a
	02	5.2±3.568b	4.12±2.15a
	03	6.42±3.56c	4.72±2.22b
	04	7.07±4.67c	5.56±1.85c
	05	8.12±4.67d	6.25±4.76d

Table 3: Values of larval weight recorded for single and 10 larvae from 5th instar (per day) in silkworm hybrid FC1 × FC2 and FC2 × FC1.

5th Instar	Days	FC1×FC2	FC2×FC1
Weight of Single Larva	01	1.29±0.95a	0.92±0.66a
	02	1.95±0.22ab**	1.21±0.66a
	03	2.01±0.12b	1.48±0.66b
	04	2.65±0.12b	2.02±0.67b
	05	3.07±0.12c	2.18±0.21b
	06	4.21±0.95cd**	3.45±0.14c
	07	4.52±0.11d	3.69±0.13c
Weight of 10 Larvae	01	12.91±0.46a	9.11±0.66a
	02	19.57±0.46a	12.87±11.9b
	03	20.10±0.46b	14.21±16.55b
	04	26.51bc±3.89**	20.23±18.90c
	05	30.71±12.56c	21.65±14.6c
	06	42.11±12.56d	34.51±18.76d
	07	45.20d	36.91d

B. Larval Size

The size of the larvae was measured in centimeter (cm) with the help of dividers and scale when the larva was in fully stretched state taking utmost care, not to disturb them. Similar to larval weight, the larval size was recorded to be significantly variable for different instars and different days.

Table 4: Values of larval size recorded from 3rd instar (per day) in silkworm hybrid FC1 × FC2 and FC2 × FC1.

3rdInstar	Days	FC1×FC2	FC2×FC1
Larval length (cm)	01	2.9±1.11b	2.4±1.55b
	02	3.1±1.16c	2.6±1.97bc**
	03	3.1±1.79c	2.8±1.2c
	-	-	-
Larval width (cm)	01	0.6±0.9b	0.4±0.07b
	02	0.7±0.77b	0.6±0.8c
	03	0.7±0.77b	0.6±08c
	-	-	-

Table 5: Values of larval size recorded from 4th instar (per day) in silkworm hybrid FC1×FC2 and FC2×FC1.

4th Instar	Days	FC1×FC2	FC2×FC1
Larval length (cm)	01	3.0±2.11a	2.8±1.4a
	02	3.2±2.77a	2.8±1.4ab**
	03	3.3±2.77ab**	3.1±1.7b
	04	3.8±2.77b	3.9±1.5c
	05	4.8±2.87c	4.2±2.11c
Larval width (cm)	01	0.4±0.55a	0.2±0.08a
	02	0.6±0.43ab**	0.3±0.05a
	03	0.8±0.76bc**	0.3±0.04a
	04	0.80.19c	0.7±0.66b
	05	1.20.22d	1.0±0.45c

Table 6: Values of larval size recorded from 5th instar (per day) in silkworm hybrid FC1 × FC2 and FC2×FC1.

5th Instar	Days	FC1×FC2	FC2×FC1
Larval length (cm)	01	4.9±2.22a	4.6±3.21a
	02	5.6±2.22a	4.8±3.22a
	03	6.7±2.34b	5.8±3.21b
	04	6.9±2.13b	6.4±3.46c
	05	7.2±2.12c	6.8±3.74c
	06	7.9±2.98c	7.3±3.75d
	07	8.5±2.74c	7.4±3.44d
Larval width(cm)	01	1.5±1.11a	1.2 ±1.11a
	02	1.9±1.44b	1.8±1.43b
	03	1.9±1.44b	1.8±1.43bc
	04	2.0±1.47bc**	2.0±1.43bc
	05	2.1±1.88bcd***	2.0±1.43bc
	06	2.4±1.77cd**	2.1±1.11bc
	07	2.5±1.21d	2.1±1.01c

The maximum and minimum values were recorded as 8.5cm and 2.1cm for 5th instar (Day-07) and 3rd instar (Day-01) in case of silkworm hybrid FC1 × FC2 and 7.4cm and 2.4cm for 5th instar (Day-07) and 3rd instar (Day-01) respectively (Table 4-6), which supports the study of Paul *et al.,* (2016).

C. Ingesta

In sericulture, food is a factor of paramount importance that regulates growth development and ultimate silk yield. Food intake and quantum of silk production in silkworm are very much closely associated to the nutritional values of the leaf supplied to the worm. The ingesta value revealed by the silkworm larvae during the current experiment was determined by the formulae [Ingesta= Dry weight of the leaf - Dry weight of left overleaf] and significant values for maximum and minimum ingesta were observed in case of silkworm hybrid FC1 × FC2 (11.75g and 91.22g), maximum and minimum ingesta were observed in FC2 × FC1 (12.00g and 84.55g) of 5th instar 7th day and 1st instar 1st day respectively (Table 7 and 8). Rahmathulla *et al.* (2004) reported that 97 per cent of the total food intake in silkworm larvae is restricted mainly to the last two instars and the feed utilization study revealed that 80-85 per cent of the total leaves consumed during the whole feeding period is consumed during 5th instar and the silkworm larvae were observed to be metabolically very active at this stage. However, even silkworm from the same genetic stock were found to exhibit varied response when fed on the mulberry leaves of different nutritional quality, its growth being dependent on the efficient utilization and conversion of nutrition into silk substance was reported by Murthy (2015); Mallikarjun *et al.* (2016).

Table 7: Values of Ingesta (g) recorded in silkworm hybrid FC1 × FC2 for subsequent days of different instars.

Sr. No.	FC1×FC2 Ingesta (g)				
	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar
Day 01	17.60±11.01b	11.75±10.31b	87.29±20.11b	77.01±12.43b	50.95±23.54a
Day 02	18.79±10.12b	13.06±11.60b	91.22±12.46b	70.84±23.87b	39.81±12.78a
Day 03	19.62±12.00c	11.97±5.98b	85.33±32.11c	82.98±42.09c	28.47±23.11ab
Day 04	-	12.69±4.33bc	-	68.25±22.13c	22.39±20.09b
Day 05	-	12.74±3.89cd**	-	64.27±6.78d	18.26±12.86b
Day 06	-	12.75±7.77d	-	-	28.89±12.46c
Day 07	-	-	-	-	13.23±10.76c

Table 8: Values of Ingesta (g) recorded in silkworm hybrid FC2 × FC1 for subsequent days of different instars.

Sr. No.	FC2 × FC1 Ingesta (g)				
	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar
Day 01	22.77±10.11b	12.00±8.45b	78.68±34.5b	84.79±33.12b	41.93±12.11a
Day 02	23.91±10.11b	13.31±5.55b	84.55±45.12b	57.56±30.22b	30.99±8.43a
Day 03	24.78±10.11b	12.16±3.56c	78.30±24.44c	61.12±34.11c	29.72±6.12ab**
Day 04	-	12.94±7.69c	-	71.65±30.33c	25.21±12.24b
Day 05	-	13.03±2.99c	-	41.76±30.33d	21.08±12.44b
Day 06	-	13.05±5.99c	-	-	34.40±10.52c
Day 07	-	-	-	-	12.83±10.11c

D. Digesta

The values pertaining digesta parameters for the studied silkworm hybrids were recorded to be highest in case of bivoltine hybrid FC1×FC2 for 5th instar day-07 as 91.06g and lowest for 1st instar day-01 as 10.22g and for FC2×FC1 in 5th instar day-07 as 79.35g and 1st instar day-01 10.79g respectively (Table 9 and 10).

Table 9: Values of digesta (g) recorded in silkworm hybrid FC1×FC2 for subsequent days of different instars.

Sr. No.	FC1×FC2 Digesta (g)				
	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar
Day 01	15.61±4.44b	10.22±8.77b	78.78±45.33b	64.30±21.11b	17.69±10.05a
Day 02	16.80±4.44b	11.53±8.34b	82.26±40.44b	57.84±12.46c	23.88±10.05b
Day 03	17.63±4.44c	10.44±4.65bc**	76.32±41.01c	69.84±12.49bc	27.64±10.04b
Day 04	-	11.16±3.77c	-	53.04±11.85c	42.89±10.32c
Day 05	-	11.21±9.12c	-	46.03±11.21c	66.03±6.32c
Day 06	-	11.22±9.11d	-	-	69.89±6.14c
Day 07	-	-	-	-	91.06±6.33d

Table 10: Values of digesta (g) recorded in silkworm hybrid FC2 × FC1 for subsequent days of different instars.

Sr. No.	FC2×FC1 Digesta (g)				
	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar
Day 01	14.14±6.12a	10.79±5.22b	71.28±12.22**b**	72.08±22.01b	68.67±9.97a
Day 02	22.35±4.44b	12.10±5.98b	76.34±6.07bc**	44.61±15.06b	12.70±4.97a
Day 03	23.17±3.09b	10.85±5.32b	69.38±4.23c	47.98±12.22bc**	26.39±7.05b
Day 04	-	11.73±7.04b	-	56.44±10.04c	40.07±8.04c
Day 05	-	11.82±6.12c	-	23.52±6.08d	63.21±4.97c
Day 06	-	11.84±4.44c	-	-	63.78±5.01c
Day 07	-	-	-	-	79.35±5.05d

Comparatively quite variable digesta among all the breeds might be due to variation in genetic components and agreement on degree of food digestion in silkworm differs from one race to another when fed on same variety of mulberry leaves and significant variation in specific protein type have also been reported in different tissues including haemolymph and larval body as demonstrated by Krishnamurthy and Konala (2011).

E. Approximate Digestibility (AD%) & Refernce Ratio

AD (%) was recorded to be maximum in case of silkworm hybrid FC1 × FC2 for 5th instar Day-07 as 99.86 per cent and minimum for 3rd instar Day-01 as 85.61 per cent .whereas hybrid FC2 × FC1 revealed maximum and minimum values of AD (%) as 89.65 per cent and 99.16 per cent for 5th and 3rd day 7th and 1st respectively (Table 11 and 12).

Table 11: Values of Approximate digestibility percentage (AD %) recorded in silkworm hybrid FC1×FC2 for subsequent days of different instars.

Sr.No.	FC1×FC2 Approximate digestibility percentage (AD %)				
	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar
Day 01	86.87±11.09b	85.61±7.08b	97.11±4.04c	94.26±14.22b	98.33±16.42a
Day 02	93.40±11.09c	97.09±7.08b	98.25±4.04c	98.09±14.22bc**	99.34±16.42ab**
Day 03	97.85±11.09c	87.21±7.08c	98.93±4.04c	98.74±14.22c	95.82±16.42b
Day 04	-	94.08±7.08c	-	98.30±14.22c	93.21±16.42b
Day 05	-	94.81±7.08c	-	98.67±14.22c	89.92±16.42b
Day 06	-	94.58±7.08c	-	-	97.56±16.42b
Day 07	-	-	-	-	99.86±16.42b

Table 12: Values of Approximate digestibility percentage (AD %) recorded in silkworm hybrid FC2×FC1 for subsequent days of different instars.

Sr. No.	FC2×FC1 Approximate digestibility percentage (AD %)				
	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar
Day 01	89.32±11.05a	85.91±8.09a	96.79±6.55b	94.78±13.03b	97.97±12.02a
Day 02	94.82±11.05b	97.14±8.09a	98.11±6.55b	97.65±13.03bc**	99.16±12.02ab**
Day 03	98.30±11.05b	87.41±8.09b	98.86.553±b	98.29±13.03bc**	95.99±12.02bc**
Day 04	-	94.20±8.09b	-	98.38±13.03bc**	93.97±12.02c
Day 05	-	94.93±8.09b	-	97.96±13.03c	91.27±12.02c
Day 06	-	94.71±8.09b	-	-	96.25±12.02c
Day 07	-	-	-	-	89.65±12.02c

Reference ratio is an indirect expression of absorption and assimilation of food. It is also expressed as ingesta required per unit excreta production. The RR value in case of FC1 × FC2 and FC2 × FC1 were recorded to be highest as 10.25 and 21.16 in different instars respectively. On the same hand minimum values were recorded as 0.21 and 0.26 for FC1×FC2 and FC2 × FC1 respectively (Table 13 and 14). AD % and RR indicated the retention efficiency of food reported between 1.56-1.59 as reported Rahmathulla *et al.*, (2004); Rajesh *et al.*, (2015).

F. Consumption Index

Consumption index in nutshell is about the rate at which nutrients enter into digestive system of the worm. This is expressed as consumption per mean larval body weight per day. The values of CI were recorded to be maximum as 192.87g and least 159.89g for FC1×FC2 in case of 5th instar larvae day 7th and 1st respectively. Similarly 159.89g and 503.18g as for FC2 × FC1 in case of 5th and 3rd instar day 7th and 1st respectively (Table 15 and 16).

Table 13: Values of reference ratio recorded in silkworm hybrid FC1×FC2 for subsequent days of different instars.

Sr. No.	FC1 × FC2 Reference ratio				
	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar
Day 01	8.84±0.43b	5.90±2.34b	10.25±6.05b	6.05±4.23aa**	1.53±0.03a
Day 02	9.44±0.22b	6.56±2.34b	10.18±6.05bc**	5.47±8.32bc**	0.91±0.47ab**
Day 03	9.85±0.14b	6.01±2.34bc**	9.47±6.05c	6.31±4.23bc**	0.50±0.44b
Day 04	-	6.37±2.34bc**	-	4.48±4.24bc**	0.34±0.41b
Day 05	-	6.40±2.34c	-	3.52±4.97c	0.21±0.01b
Day 06	-	6.47±2.34c	-	-	0.28±0.03b
Day 07	-	-	-	-	0.40±0.07b

Table 14: Values of reference ratio recorded in silkworm hybrid FC2×FC1 for subsequent days of different instars.

Sr. No.	FC2 × FC1 Reference ratio				
	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar
Day 01	21.16±5.33a	9.91±5.33a	10.63±4.44b	7.56±2.34b	1.39±0.05a
Day 02	14.88±3.03a	11.00±5.33a	10.29±4.44bc**	4.75±2.34bc**	0.79±0.22a
Day 03	15.39±5.78b	10.04±5.33ab**	8.77±4.44c	5.06±2.34bc**	0.56±0.46a
Day 04	-	10.69±5.33ab**	-	5.34±2.34c	0.40±0.02a
Day 05	-	10.76±5.33b	-	3.00±2.34c	0.29±0.77a
Day 06	-	10.78±5.33b	-	-	0.40±0.12b
Day 07	-	-	-	-	0.26±0.09c

G. Conversion of Digesta (ECD %)

The efficiency with which digested food is converted to body substance (ECD) was calculated by the formulae and various values pertaining ECD % have been detailed in Table 17.

$$\textbf{ECD (\%)} = \frac{\text{Weight gained (g)}}{\text{Weight of food ingested}} \times 100$$

H. Conversion of Ingesta and Digesta to Larval Body

Values of ECI/ECD to larval weight was determined by using the formulae

$$= \frac{\text{Weight gained by larvae during feeding period}}{\text{Dry weight Ingesta}}$$

The Efficiency Conversion of Ingesta (ECI) to cocoon and cocoon shell, which otherwise be referred as leaf-cocoon and leaf-shell conversion rate and ultimate indices to evaluate nutritional efficient silkworm breed in terms of the production of cocoon/shell as suggested by Ramesh Rajesh *et al.* (2015). In analogous to the above, the present study major aims to identify nutritionally efficient silkworm breeds with respect to ingesta and with higher conversion rate on to larval, cocoon and shell biomass, are in analogous agreement of the earlier reports of Rahmathulla and Suresh (2012); Manjunatha and Beck (2020) with values of Ingesta: Digesta ratio.

Table 15: Values of Consumption index recorded in silkworm hybrid FC1 × FC2 for subsequent days of different instars.

Instars	FC1 × FC2 Consumption index		
	Weight of single larva		Weight of 10 larvae
	Overall	Per replication	Overall
3rd Instar	479.67g	159.89g	68.70g
4th Instar	448.51g	149.76g	58.40g
5th Instar	578.61g	192.87g	98.78g

Table 16: Values of Consumption index recorded in silkworm hybrid FC2 × FC1 for subsequent days of different instars.

Instars	FC2 × FC1 Consumption index			
	Weight of single larva		Weight of 10 larvae	
	Overall	Per replication	Overall	Per replication
3rd Instar	1509.56g	503.18g	80.77g	26.92g
4th Instar	833.81g	277.93g	66.28g	22.69g
5th Instar	1658.99g	552.99g	85.23g	28.41g

Table 17: Values of Conversion of ingesta (ECI %) of single larval weight recorded in silkworm hybrid FC1 × FC2 and FC2 × FC1for subsequent days of different instars.

Instar	Days	ECI % of FC1×FC2	ECI % of FC2×FC1
3rd Instar	Day 01	59.57±10.02a	56.41±10.32a
	Day 02	59.19±6.07b	53.82±4.44b
	Day 03	70.13±8.08c	64.32±5.21b
4th Instar	Day 01	80.50±7.04a	79.31±3.98a
	Day 02	81.16±4.55b	80.42±5.09b
	Day 03	72.18±7.12c	70.41±6.32c
	Day 04	61.43±4.09c	56.18±5.06c
	Day 05	82.19±5.55c	75.16±9.09c
5th Instar	Day 01	72.19±3.09a	71.43±8.76a
	Day 02	80.48±4.06a	73.49±5.07a
	Day 03	86.19±7.45b	83.62±4.44b
	Day 04	83.28±8.74bc**	84.16±5.81b
	Day 05	81.65±6.09c	79.21±9.87c
	Day 06	88.14±6.33c	84.69±6.50c
	Day 07	89.62±5.92c	85.98±4.08c

Table 18: Values of Conversion of Digesta (ECD %) of single larval weight recorded in silkworm hybrid FC1×FC2 and FC2×FC1for subsequent days of different instars.

Instar	Days	FC1 × FC2	FC2×FC1
3rd Instar	Day 01	65.45±12.22a	62.13±5.09a
	Day 02	69.23±11.45b	66.45±7.67b
	Day 03	76.23±8.74c	72.23±12.21b
4th Instar	Day 01	75.26±23.11a	70.45±10.99a
	Day 02	79.56±12.43b	75.35±12.32b
	Day 03	80.15±5.07c	79.48±12.56c
	Day 04	82.45±8.77c	80.76±12.22c
	Day 05	84.65±12.32c	82.24±8.88c
5th Instar	Day 01	75.45±10.12a	74.48±7.88a
	Day 02	78.56±10.45a	77.87±12.22a
	Day 03	79.34±8.05b	75.76±9.09b
	Day 04	83.34±6.54bc**	81.43±12.55b
	Day 05	85.34±14.05bc**	83.57±18.09c
	Day 06	86.34±19.06c	82.48±3.24c
	Day 07	87.45±12.28c	85.23±8.22c

Table 19: Values of Conversion of ingesta and digesta to larval body of single larva recorded in silkworm hybrid FC1×FC2 and FC2×FC1 for subsequent days of different instars.

Instar	Days	FC1×FC2	FC2×FC1
3rd Instar	Day 01	59.57±5.88a	56.41±1.21a
	Day 02	59.19±8.77b	53.82±6.66b
	Day 03	70.13±5.99c	64.32±8.76b
4th Instar	Day 01	80.50±9.07a	79.31±9.54a
	Day 02	81.16±8.05b	80.42±8.54b
	Day 03	72.18±8.44c	70.41±5.52c
	Day 04	61.43±7.32c	56.18±6.54c
	Day 05	82.19±2.56a	75.16±7.43a
5th Instar	Day 01	72.19±4.76a	71.43±7.31a
	Day 02	80.48±4.09b	73.49±6.54b
	Day 03	86.19±7.86bc**	83.62±3.45b
	Day 04	83.28±9.08bc**	84.16±6.87c
	Day 05	81.65±7.87c	79.21±7.65c
	Day 06	88.14±3.06c	84.69±6.09c
	Day 07	89.62±3.45c	85.98±7.08c

CONCLUSION

Results from the present experiment revealed that there is a strong correlation between the quality and quantity of feed supplied and amount of food utilized by the silkworm. Therefore, the silkworm feeding behaviour is found to be related with the morpho-physiological and biochemical attributes of mulberry leaf. The present investigation serves as an initiating point for rationalization of feed quantities for bivoltine silkworm rearing studies specifically under sub-temperate conditions. The results of the current study could be utilized for standardizing the exact amount of feed to be supplied to silkworm larvae during various days of larval instars.

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