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Silkworm Survival Secrets: How Nutrition and Environment Impact Growth and Efficiency

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Abstract

To assess growth and dietary effectiveness, bivoltine silkworm race (CSR2 x CSR4) fifth instar larvae were raised under a variety of nutrient and environmental stress settings. Data were compared with a control group that received conventional food and was raised in ideal conditions of humidity and temperature. The control group had significantly higher levels of nutritional indices such ingesta, digesta, approximate digestibility %, and reference ratio as well as measurements of larval weight, silk gland weight, cocoon weight, shell weight, and other weights. The majority of these factors were much lower in larvae raised in high-temperature, low-humidity environments. However, treated batches had higher values for the majority of feed conversion efficiency measures as well as the ingesta and digesta needed to create one gramme of cocoon and shell. This may be the result of the larvae's physiological response to various stress circumstances.

Keywords: Bivoltine silkworm, Bombyx mori, stress factors, silkworm growth, nutritional efficiency, nutritional indices

Introduction

The primary source of silk manufacturing is the poikilothermic insect known as the silkworm, Bombyx mori. Environmental elements including temperature, humidity, light, air, feed quality, and quantity have a significant impact on the growth and development of an organism. Understanding how insects adapt to their surroundings is made easier by their consumption and use of food. The atmospheric temperature and humidity present at the time of crop rearing are the two most significant factors that affect food consumption and utilisation (Benchamin & Jolly 1986). Additionally important and directly affecting the physiological processes of the silkworm is humidity. According to Ueda and Suzuki (1976) and Junliang Xiaoffeng (1992), the rate of leaf to silk conversion reduces as temperature rises (20° to 30°). Studies (Sumioka et al. 1982, Ueda & Suzuki 1967, Singh & Ninagi 1995, Meenal & Ninagi 1995) on the relationship between food ingestion, digestion, and body weight gain in silkworms under restricted feeding conditions revealed that feed conversion efficiency measures were higher under restricted feeding levels. Ingestion, estimated digestibility, and the effectiveness of food conversion were all found to be directly correlated with the water content of the feed (Paul et al. 1992). In the current study, an effort was made to examine how different environmental and dietary parameters commonly encountered by Indian farmers affected the growth and dietary effectiveness of bivoltine mulberry silkworms.

Resources and Procedures

In the current study, a new, productive bivoltine hybrid silkworm (CRS2 x CRS4) that can be raised under ideal conditions in India from August to February was used. Rearings were carried out using fresh leaves of the VI mulberry variety in accordance with the new standard packaging and suggestion (Rajan, 2001). The 5th instar larvae were the only ones included in the feed utilisation study because this instar consumes 80-85% of the whole leaf mass. When growing the 5th instar, 50 larvae were divided into three replicates and kept in a sericatron (an environment chamber with exact and automatic control facilities for consistent maintenance of temperature and humidity) under varying temperature, humidity, and feeding settings (treatments). Treatments included: T1 – high temperature (36°C), low humidity (40%) and standard recommended feed quantum; T2 – low temperature (20°C), high humidity (90%) and standard recommended feed quantum; T3 – optimal temperature (25°C), optimal humidity (70%), and 30% less feed quantum; T4 – optimal temperature ((25°C), optimal humidity (70%) and standard recommended quantum of over-mature mulberry leaves. Optimal conditions were set for T5 (control) at 25°C, 70% humidity, and the usual suggested feed quantum. Three times each day, known amounts of fresh mulberry leaves were given to the silkworms while taking great care to keep the leaves as moist as possible (Rajan et al., 2001). For the purpose of determining the dry weight of the ingested material, a sample of the mulberry leaves utilised for each feeding was placed in a separate tray. To determine the dry weight and subsequently the daily increment in larval weight, additional larval batches of each treatment were maintained in parallel (Maynard & Loosli 1962). Each replication's healthy larvae were tallied every day, and the unhealthy and dying larvae were taken out and replaced with new ones from different batches. On the following feeding days, the litter was carefully gathered. In the litter, the waste and remaining leaves were carefully sorted and baked to dry. For the purpose of calculating nutritional efficiency, dry weight of leftover leaf, excreta, larval weight gain, cocoon weight, and shell weight were recorded for all the replications of each treatment. Observations on larval growth, larval duration, and silk gland weight were also noted. According to Waldbauer (1968), nutritional indices such as ingesta, digesta, approximate digestibility% (AD%), reference ration (RR), efficiency of conversion of ingesta and digesta to larval body, cocoon, and shell, and ingesta and digesta per gramme (l/g and D/g) of cocoon and shell were calculated from these data. Three times the experiment was run, and the data were statistically analysed to determine the significance.

Conclusion and Discussion

Tables 1 and 2 illustrate the variables related to larval growth, cocoon, nutritional indices, and feeding effectiveness.

Growth and cocoon parameters for larvae

5th instar larvae were found to have considerably reduced larval duration in T1 (136 hours), and greater larval duration in T2 (170 hrs) and T4 (167 hrs). This is a result of the silkworm raising bed's greater humidity levels. The growth of the silkworm and the success of silkworm rearing are greatly influenced by humidity and temperature (Kenten, 1955). Similar to that, T1 observed a much lower larval weight (32.25g) for 10 fully grown larvae. Significant weight differences between the control (T5) and other treatments and the larvae were observed (Table 1). The control treatment (13.86 g) had much more silk gland weight than the other treatments, and T1 (11.40 g), where larvae were raised in high temperatures, had the least amount. Between the control and all of the treatments, with the exception of T2, there were significant variations in Single cocoon (Table 1). T1 had the smallest single cocoon weight (1.29g), whereas T2's (1.73g) was comparable to the control's (1.72g). A temperature that is higher or lower than 25°C acts as a stress factor and makes silkworms more vulnerable to viral infection and poor cocoon production (Steinhaus 1958). A substantial difference in just one shell weight was observed between the control and all treatments compared to the cocoon's real silk content (Table 1). Control (0.447g) had a much larger shell weight than T1, which had the lowest weight (0.31g). Similar to this, the shell ratio was significantly higher in the control group (25.98%) and much lower in the larvae raised in T2 (23.29%) under high humidity circumstances. The poikilothermic insect's metabolic reactions to temperature are directly correlated; the findings are consistent with earlier research by Venugopala & Krishnaswamy (1987).

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Nutrition-related index parameters

According to Takeuchi (1964), there is a rise in mulberry leaf intake during the late stage with a reduction in rearing temperature. Significant

Table 1. Larval growth, cocoon and nutritional indices parameters of fifth instar larvae of bivoltine silkworm hybrid reared under various stress conditions.

Treatments	Larval Duration (Hrs)	Larval Weight (g) (10 nos)	Silk Gland Weight (g) (10 nos)	Single Cocoon Weight (g)	Single Shell Weight (g)	Shell Ratio (%)	Ingesta (g)	Digesta (g)	Approximate Digestibility (%)	Reference Ration
T1 (Temp. 36°C, Humidity – 40%)	136	32.25**	11.40**	1.29**	0.310**	24.03**	3.04**	0.850**	27.99**	1.392*
T2 (Temp. 20°C Humidity – 90%)	170	43.25	13.25*	1.73	0.403*	23.29**	4.45	1.320*	30.11**	1.370*
T3 (30% less quantity feeding)	165	29.35**	12.65**	1.47**	0.345**	23.46**	4.11**	1.141**	27.79**	1.380**
T4 (over matured leaf feeding)	167	34.15**	11.85**	1.35**	0.330**	24.44**	3.52*	0.987**	28.12**	1.378**
T5 (Temp. 24°C Humidity – 70%)	148	43.00	13.86	1.72	0.447	25.98	4.41	1.436	32.44	1.480
Control										
CD @ 5%	6.16	2.612	0.525	0.068	0.032	0.229	0.1067	0.110	1.798	0.064
CD @ 1%	6.76	2.917	0.695	0.094	0.051	0.285	0.1107	0.141	1.990	0.094
SE±	1.12	0.287	0.892	0.021	0.002	0.125	0.054	0.032	0.721	0.019

**Significant at 1% level **Significant at 1% level CD - Critical difference
Values of food intake are expressed in gm/larva/5th instar

Table 2. Dietary efficiency parameters of fifth instar larvae of bivoltine silkworm hybrid reared under various stress conditions.

Treatments	ECI Larva (%)	ECD Larva (%)	ECI Cocoon (%)	ECD Cocoon (%)	ECI Shell (%)	ECD Shell (%)	I/g Cocoon (g)	I/g Shell (g)	D/g Cocoon (g)	D/g Shell (g)
T1 (Temp. 36°C, Humidity – 40%)	15.48**	55.29**	18.27**	65.26**	8.94**	31.96**	5.47**	11.17**	1.53**	3.13**
T2 (Temp. 20°C Humidity – 90%)	21.86**	72.61**	16.91	56.16**	8.60**	28.57	5.91	11.62**	1.78*	3.50
T3 (30% less quantity feeding)	15.02**	54.76**	17.85**	62.27**	8.91**	31.48**	5.32**	10.95**	1.45**	3.16**
T4 (over matured leaf feeding)	16.65**	58.21**	17.98**	63.57**	8.85**	31.56**	5.42**	11.05**	1.47**	3.21**
T5 (Temp. 24°C Humidity – 70%)	20.90	64.43	16.86	51.98	9.17	28.28	5.92	10.89	1.92	3.53
Control										
CD @ 5%	1.551	5.538	0.521	4.352	0.113	2.25	0.1158	0.2313	0.121	0.1157
CD @ 1%	1.752	6.016	0.845	4.672	0.181	2.65	0.1570	0.4210	0.241	0.181
SE±	0.241	1.98	0.224	2.12	0.092	1.12	0.071	0.091	0.018	0.041

**Significant at 1% level **Significant at 1% level CD - Critical difference
ECI - Efficiency of conversion of ingesta; ECD - Efficiency conversion of digesta; I/g Cocoon - ingesta per gram cocoon; I/g Shell - Ingesta per gram shell; D/g Cocoon - Digesta per gram cocoon; D/g Shell - Digesta per gram shell

With the exception of T2, changes in ingesta were seen between the control (4.41g) and all other treatments (Table 1). The amount of T2 consumed (4.45g) was comparable to the control, and the least amount (3.04 g) was seen when larvae were raised at a higher temperature. Hidashi et al. (1982) and Sumioka et al. (1982) claim that when the worms are fed with less feed during their fifth instar, the amount of intake and digestion reduces.However, a sizable difference in digesta was seen between the

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control and all treatments. Significantly, T1 (0.850g) had the least digesta. Intakes in the T2 therapy were comparable to those in the control, but there was a noticeable difference between the two (Table 1). This might be caused by the accessibility of fresh leaves, constant feeding, or a lack of time to properly digest the food. Higher meal intake has the tendency to mobilise stomach contents more quickly and leave less time for food absorption and enzyme activity, resulting in low digestive efficiency (Walbauer 1994).Similar to this, there were notable variations in approximate digestibility (AD%) between all of the treatments and the control. When larvae were grown under conditions where they were fed on over-matured leaves (27.79%), the AD% was noticeably lowest (Table 1). Lack of nutrients, an unbalanced diet, a high crude fibre content, or a water shortage in the meal all affect how easily it can be digested (Waldbauer, 1964). Given that larger food consumption does not always translate into higher digestibility, the higher absorption efficiency or approximate digestibility is unquestionably a racial characteristic (Magdum et al. 1996). Reference ration was significantly higher in the control group (1.480) and significantly lower in the T2 group (1.370). Reference ration (RR) is a tacit measure of food assimilation and absorption. Additionally, it stated how much food must be consumed for every unit of excretion. Higher RR values indicate faster rates of food digestion and absorption.

Dietary effectiveness metrics

Particularly in an economically relevant insect like Bombyx mori, nutritional efficiency during the larval stages considerably effects the subsequent pupa, adult, and production of silk (Takano & Aral 1978; Aftab Ahamed et al. 1998). The hybrids showed significant differences in how effectively food substance is absorbed and transformed into larval body matter. According to reports, hybrid silkworms were more effective in turning food into larval body matter (Trivedi & Nair 19). When compared to other treatments, ECI to larval body matter was significantly greater in T2 (21.86%) and significantly lower in T3 (15.02%) (Table 2). Similar to ECD to larval body matter, ECD to T2 (72.61%) was recorded significantly higher. This might be caused by the treatment's heavier larval weight. However, nutritional efficiency variables related to the cocoon, such as ECI and ECD, recorded considerably higher values in T1 (18.27 and 65.26%). The results demonstrate that more efficient conversion of ingested food to cocoon shell occurs when larvae were reared under ideal temperature and humidity conditions (Table 2). The efficiency of conversion of ingested food to shell was recorded higher in control (9.17%) and least in T2 (8.60%). The amount of feed consumed and the moisture content of mulberry leaves directly influence dietary water intake. The two efficiency parameters, ECI and ECAD to cocoon and shell, are of utmost significance in real-world sericulture (Trivedi & Nair 1999). Low moisture leaf fed to silkworms had poor ECI and ECD, according to Paul et al. (1992).ECD was greater in T1 (31.96%) and lower in control

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(28.28%; Table 2) for the conversion of digested meal into shell. According to Muthukrishnan and Pandian (1987), insects have developed a range of techniques to obtain and store energy from nutrients and water from food under specific environmental conditions. According to Singh and Ninagi (1995), less-fed silkworm batches exhibit higher ECI and ECD to cocoon and shell. This might be as a result of the physiological adaptations that occur when there is a limited selection of feed (Nath et al. 1990; Tzenov 1993).When larvae were under stress (T1 and T3), a much lower value of ingesta was measured to create one gramme of cocoon. This outcome demonstrated the silkworms' ability to adapt to challenging circumstances. However, the amount of food consumed (l/g shell) was higher in T2 (11.62g) than in T1, possibly as a result of the treatment's lower shell weight. The amount of digesta needed to make one gramme of cocoon was significantly larger in the control (1.92g) than it was in the unfavourable (T1 and T3) conditions in which the larvae were raised. Similar to this, D/g shell measurements were greater in the control (3.53g) and T2 (3.50g), while T1 (3.13g) and T3 (3.16 g) had considerably lower D/g shell measurements.

Conclusion

The larvae should be raised under ideal temperature and humidity conditions and fed with appropriate quantity and quality mulberry leaf with adequate leaf wetness for a successful bivoltine silkworm production. In the current study, it was evident that when larvae were reared under the ideal temperature and humidity with an acceptable amount of feed, as per the prescription, larval growth, cocoon quality, and nutritional index parameters were recorded significantly higher. However, when worms were raised at a high temperature with 30% of the meal, the majority of feed conversion efficiency characteristics were reported to be greater. When larvae were raised under varied stress circumstances, the amount of ingesta and digesta needed to generate one gramme of a cocoon and shell was also seen to be higher. Therefore, during the final phases of silkworm larvae development, somewhat lower temperature and humidity are advised together with greater aeration and a sufficient quantity of high-quality leaves.

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