

Full Length Research Paper

Evaluating Performance and Production Features in Three *Bombyx mori* Strains Fed a Range of Mulberry Varieties

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In this study, Three strains of domesticated silkworm *Bombyx mori* (L) namely EC₁, EJ₁ and EJ₂ were evaluated for performance in terms of growth and productivity by feeding them with the same variety (S₃₆) of mulberry leaves. Growth performance was based on the length, width and weight of all the developmental stages from the third instar to adult stages. Productivity was based on cocoon weight, shell weight, filament weight and length. Statistical analysis by Duncan's Multiple Range Test at 5% confidence interval was then used to determine if there were significant differences among the strains. The EJ₂ strain showed a higher and consistent growth rates than the other strains for all the developmental stages of the insects. The EC₁ strain which was significantly shorter in length and lower in weight than the other strains gave better silk filament for the parameters evaluated.

Keywords: Silkworm strains, performance, productivity, S-36 mulberry.

INTRODUCTION

Sericulture, also called silk farming is an agro-based industry which involves the rearing of silkworms for the production of raw silk, which is the yarn obtained out of cocoon spun by certain species of Lepidopterous insects. However, the best quality raw silk is produced by the silkworm *Bombyx mori* (L) (Sericulum 2000). The insects feed on mulberry plants for growth and development and they have been domesticated (Anukumar et al., 2006) to the point that they could no longer survive in the wild (Ullal and Narasimhanna, 1994). The major activities of sericulture comprise of food-plant cultivation to feed the silkworms and reeling the cocoons to unwind the silk filament for textile and non- textile uses (Tsukada *et al.*, 2005).

Sericulture has become one of the most important cottage industries in a number of countries like China, Japan, India, Korea, Brazil, Russia, Italy and France. Today, China and Japan are the two main producers,

together manufacturing more than 60% of the world silk production each year. Sericulture in Nigeria is still at the infant stage and the silkworm seeds and mulberry plants used in Nigeria were imported from China and Japan (Anukumar et al, 2006). The importance of silkworm rearing cannot be overemphasised. It can generate employment through various on- farm and off- farm activities ranging from mulberry propagation to silkworm rearing throughout the year and according to Ventaka (1992), women constitute over 60% of those employed in downstream activities of sericulture in sericulturally advanced countries. This is possible because sericulture activities starting from the mulberry garden management, leaf harvesting and silkworm rearing is more effectively taken up by the women folk. Even silk reeling industry including weaving is largely supported by them. As a perennial crop with good foliage and root spread, mulberry contributes to soil conservation and provides green cover and its fruits are rich in minerals and vitamins. Waste from silk rearing can be recycled as inputs to garden. Being a labour intensive and predominantly agro-based, involvement of smoke-emitting machinery is minimal. Apart from the money derived from sericulture silk can be used to produce fashionable

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clothing, lawyers' wigs, rug, teddy bears etc. Silkworm also forms part of an important feed for poultry birds, fish and cattle.

In view of the benefits highlighted above, it becomes very necessary for any country to exploit this opportunity by embarking on silk production. It is also important to establish the performance of the available silkworm strains.

A lot of factors do influence the performance and productivities of silkworm. These range from the strain or hybrid of silkworms (Ghimire, 2000), the variety of mulberry plants on which they feed as well as the nativity (source) (Adolka, 2007), and the environmental conditions under which the silkworms are reared (Rao *et al.*, 2006). This paper examines and compares the growth and cocoon productivity of two Japanese silkworm strains (EJ₁ and EJ₂) and one from China (EC₁) in a bid to recommending the best. The parameters to be used are pre-cocoon performance of the insects as well as characteristics and quality of cocoon produced (Ngukwu *et al.*, 2009)

MATERIALS AND METHODS

The eggs of three varieties (EC₁, EJ₁, EJ₂) of silkworm were supplied by Ekiti State Sericulture Development Project Agency Ado-Ekiti, a town in southern part of Nigeria. On collection from the cold room, the eggs were placed on the acid resistant paper were treated with dilute hydrochloric acid for 70mins in order to break the iapauses state of the egg. After the acid treatment, the eggs were taken to the incubation room maintained at a temperature of 25⁰C and a relative humidity of 80% and photoperiod of 16 hours light and 8 hours darkness.

The eggs are incubated for 9 days during which the colour of the egg changed into blue black. This is called body pigmentation stage.

The eggs at this stage were transferred to dark environment. This is called black boxing of eggs. Here, the eggs were covered with black cloth for 48hrs after which they were exposed to light between 7 – 10am to ensure uniform hatching of all eggs.

The larvae of each of the silkworm strains are placed in separate trays. The worms in each of the trays were then subdivided into four equal parts to make four replicates and fed with S-36 variety of mulberry plants. The larvae molt of every three to four days and the 3rd instar was obtained after the 11th day. Measurements of the length, width and the weight were done on 3rd to 5th instar larvae.

After spinning cocoons, the 5th instar larvae develop into pupae inside them and remained in them for 7 days after which they were harvested.

Studies on the cocoon

The cocoons from each of the replicates were then divided into three parts as follows:

(i) This part was cut with razor blade so as to expose the pupae. The measurements of the length, width and weight of the pupae were the taken.

(ii) This part was allowed to develop into full adults when the adults emerge, the length and weight were measured.

(iii) In this part, the development of the pupae inside the cocoons was terminated just before the adults emerged so as not to destroy the cocoons.

The category in section (iii) above was further divided into two parts.

(a) This first part was used for the calculation of Shell ratio. Here, the following measurements were taken

Weight of cocoon : This was taken by measuring the weight of cocoon together with the pupae

Weight of shell :-This was done by removing the pupae and then weighing the empty cocoons.

$$\text{Shell Ratio} = \frac{\text{Weight of shell} \times 100}{\text{Weight of cocoon}}$$

(b) This part, which was used for the calculation of filament Denier was subjected to reeling analysis which consists of the following :

Oven drying: The pupae within the cocoons were killed by applying a very high temperature for 2 - 3 hours.

(b) Boiling: They were then boiled in hot water in other to make them soft so that the cocoon can be easily reeled.

(c) Reeling: This involves unwinding the silk filament with the use of reeling machine. Each reeled filament was weighed; the length was also measured so as to get the value for filament denier,

$$\text{Denier} = \frac{\text{weight of filament} \times 9000}{\text{Length of filament}}$$

RESULTS

Table 1 shows the pre-cocoon characters of the three strain of silkworms reared on S36 variety of mulberry plants. The results on the larval length showed that all the values got for the three strains were significantly different from each other for the 3rd instar to the fourth instar. The value got for EJ₂ which was lower (1.36±0.10) than that of EJ₁ (1.54±0.06) and EC₁ (1.38±0.09) at the 3rd instar, became higher in the fourth and fifth instar. It also remained higher at the pupal and adult stages. As regards the result for the width measurements, apart from the 3rd instar larvae, all the values produced insignificant difference in the three silkworm strains for 3rd, 4th instar as well as the pupal stages. The mean width of the adults however, showed a higher value of EJ₂ (0.91±0.08) than EC₁ (0.76±0.07) and EJ₁ (0.89±0.08). The result of the insect weight showed insignificant difference in the value

Table 1. Pre-cocoon characters of three strains of silkworm reared on S-36 Variety of silkworm.

Strain of silkworm	Mean length(mm) \pm SD	Mean width(mm) \pm SD	Mean weight(g) \pm SD
(a) 3rd instar			
EC ₁	1.38 \pm 0.09 ^b	0.25 \pm 0.05 ^a	0.05 \pm 0.01 ^b
EJ ₁	1.54 \pm 0.06 ^a	0.24 \pm 0.04 ^a	0.06 \pm 0.01 ^b
EJ ₂	1.36 \pm 0.10 ^b	0.26 \pm 0.05 ^b	0.06 \pm 0.01 ^b
(b) 4th instar			
EC ₁	3.59 \pm 0.16 ^b	0.44 \pm 0.05 ^a	0.58 \pm 0.06 ^b
EJ ₁	3.38 \pm 0.10 ^c	0.43 \pm 0.05 ^a	0.56 \pm 0.07 ^b
EJ ₂	3.73 \pm 0.12 ^a	0.46 \pm 0.05 ^a	0.73 \pm 0.09 ^a
(c) 5th instar			
EC ₁	3.77 \pm 0.16 ^b	0.65 \pm 0.05 ^a	0.97 \pm 0.11 ^b
EJ ₁	3.72 \pm 0.10 ^d	0.64 \pm 0.06 ^a	0.96 \pm 0.09 ^b
EJ ₂	3.91 \pm 0.10 ^a	0.65 \pm 0.05 ^a	1.23 \pm 0.14 ^a
(d) Pupae			
EC ₁	2.64 \pm 0.19 ^a	0.88 \pm 0.08 ^a	1.88 \pm 0.18 ^c
EJ ₁	2.63 \pm 0.17 ^a	0.85 \pm 0.07 ^a	1.33 \pm 0.19 ^b
EJ ₂	2.67 \pm 0.13 ^a	0.85 \pm 0.07 ^a	1.53 \pm 0.15 ^a
(e) Adult			
EC ₁	1.96 \pm 0.08 ^c	0.76 \pm 0.07 ^b	2.41 \pm 0.12 ^b
EJ ₁	2.14 \pm 0.18 ^b	0.89 \pm 0.08 ^a	2.43 \pm 0.11 ^b
EJ ₂	2.26 \pm 0.16 ^a	0.91 \pm 0.08 ^a	2.52 \pm 0.11 ^a

Means followed by the same letter are not significantly different at 5% level of Probability using Duncan's Multiple Range test.

Table 2. Characteristics of filament produced by the three strains of silkworm.

Strains of silkworm	Meancocoon weight(g)	Meanshell weight(g)	Mean shell ratio(%)
EC ₁	1.43 \pm 0.11 ^c	0.32 \pm 0.13 ^b	22.38a
EJ ₁	1.69 \pm 0.26 ^b	0.37 \pm 0.09 ^a	21.89a
EJ ₂	1.89 \pm 0.17 ^a	0.36 \pm 0.03 ^a	19.04b

Means followed by the same letter are not significantly different at 5% level of Probability using Duncan's Multiple Range test.

Table 3. Characteristics of filament from cocoons produced by three strains of silkworm.

Strains of silkworm	Mean length(m) \pm SD	Mean weight(g) \pm SD	Filament Denir
EC ₁	840.69 \pm 95.00 ^a	0.32 \pm 0.02 ^a	3.43a
EJ ₁	598.56 \pm 149.77 ^b	0.25 \pm 0.04 ^b	3.75a
EJ ₂	579.13 \pm 237.99 ^b	0.26 \pm 0.05 ^b	4.01b

Means followed by the same letter are not significantly different at 5% level of Probability using Duncan's Multiple Range test.

recorded for the three stains of silkworms EC, (0.05 \pm 0.01), EJ₂ (0.06 \pm 0.01) and EJ₁ (0.06 \pm 0.01) for all the other silkworm stages except for the pupal stage all the other stages showed a consistently higher values for EJ₂.

Table 2 shows the result of the characteristics of cocoon produced by the three silkworm strains. The cocoon weight of the EJ₂ silkworm strain shows significantly higher value of 1.89 \pm 0.17a than EJ₁, 1.69 \pm 0.26 and EC₁ 1.43 \pm 0.13. The shell weight however

showed no significant difference between EJ₁ and EJ₂ (0.37 \pm 0.09, 0.36 \pm 0.03) but there were differences between the two strains and EC₁ (0.32 \pm 0.13) which were the least of all.

The characteristic of filaments produced by the three strains of silkworm is presented in Table 3. The EC₁ strain has a higher mean length of 840.69cm and mean weight of 0.32g which are significantly different from that of the EJ₁ and EJ₂ strains. The EJ₁ and EJ₂ strains showed no significant difference from each

other in terms of weight and length. For the filament denier, EJ₂ showed the highest value (4.01). The values of EC₁ and EJ₁ were 3.43 and 3.75 respectively.

DISCUSSION

Past researchers have established that S-36 Mulberry variety is recommended for Silkworm rearing. This is because of its high percentage of Total protein (Venkalesh and Seema 2011). According to them, out of about seven varieties tested on *Bombyx mori*, S-36 showed the highest Total protein of 0.317mg/gm. This was also supported by Adeduntan and Oyerinde (2010). In this study, The results for the pre cocoon characters show that there are variations in the performances of all the three strains of *Bombyx mori* used for this study. According to Rangaiah *et al.*, (1995), Rao *et al.*, 1997, Ashoke *et al.*, (1993) and Sheidav (2011), strains of *Bombyx mori* perform in a significantly different ways when they are subjected to the same conditions, some of them performed better than the others. In this study, the pre-cocoon characters of EJ₂ presented a better results generally, when compared with EJ₁ and EC₁ strains.

Cocoon weight and shell weight are the important or main traits evaluated for productivity in sericulture and these characters have been used for breeding for more than half a century (Gaviria *et al.*, 2006). In this study, it was observed that even though the cocoon produced by EJ₂ had the highest value in terms of the weight, the EC₁ hybrid performed better in terms of the shell ratio. The value obtained for shell ratio indicates the amount of raw silk that can be reeled from a given quantity of fresh cocoons that are sold (FAO, 1999). The shell ratio varies according to age and breed of the silkworm. The reference range for hybrid silkworms is between 19% -25% (FAO, 1999). Although, all the tested hybrids performed within this range, the best of them is EC₁ meaning that the market value of EC₁ is better than EJ₁ and EJ₂ (FAO, 1999).

The characteristics of fibres have been found to determine fabric quality (Down, 1999). Testing of silk yarn ensures efficiency and harmony in the production process and the final product is of high quality (SSC, 1995). It is evident in this work that the EC₁ silkworm strain produced the best filament length and weight. The range of total length of silk is from 600-1500m out of which only 80% is reelable (FAO, 1999). Only the EC₁ variety falls within this range, the other hybrids are lower in length. The result also indicates that the filament denier which is the size of silk in terms of its diameter is lowest in EC₁. This is a pointer to the fact that the silk yarn produced by this hybrid is the finest. The cocoons

produced by this hybrid, apart from being fine, was also smooth and oval in shape. This is in line with the findings of Zamatta *et al.*, (2009). Quality silk filament in terms of length and weight as shown by the EC₁ strain are highly inheritable, are affected by additive gene action and allow a better response to selection. (Petkor and Nguyenvan, 1987). Personal communication with Yusuf Bakare of the Ekiti State sericulture Development Agency indicated that it is EC₁ strain they use mostly for silk production in the Agency considering the less number of breaks during reeling in addition to the aforementioned qualities.

REFERENCES

- (SSC) Silk Standards Committee (1995). Raw silk. Manual for testing, classifying, quality limits, grading, Directives, methods, standards, Instrumentation. International Silk Association. Silk Congress Brighton, Great Britain.
- Adeduntan SA, Oyerinde AS (2010). Evaluation of Nutritional and antinutritional characteristics of obeche (*Triphochiton scleroxylon* Scheroxylon) and several mulberry (*Morus alba*) leaves. The Afr. J. Biochem. Res. Vol. 4 (7) 175 – 178.
- Adolkar VV, Raina SK, Kimbu DM (2007). Evaluation of various *Mulberry morus* spp. Moraceae) cultivars for the rearing of the bivoltine hybrids race Shaanshi BV-333 of the silkworm *Bombyx mori* (Lepidoptera: Bombycidae). Int. J. Trop. Insect Sci.; 27 (1): 6 -14.
- Ashoka J, Govindan R, Rayar SG, Raju RN (1993). Evaluation of direct and reciprocal three way cross hybrids of silkworm *Bombyx mori* (L). *Karnataka J. Agric. Sci.*, 6(2): 142-150.
- Down J (1992). Design and technology. Textile Technology to GCSE. Oxford University Press.
- FAO (1999). Silk reeling and testing manual. Agricultural Services Bulletin No 136. Rome Italy. Pp 65- 75.
- Gaviria DAE, Aguilar HJ, Serrano and A. H. Alegria (2006). DNA fingerprinting using AFLP markers to search for makers associated with yield attributes in the silkworm, *Bombyx mori*. *J. Insect Sci.* 6: 1-10
- Ghimire N Sericulture . The context in Nepal. Paper presented at the National Workshop of plant protection Officers, Department of Agriculture, Kathmandu, Nepal
- Nguku EK, Adolkar VV, Raina SK, Mburugu KG, Mugenda OM, Kinbu DM (2009). Performance of six Bivoltine *Bombyx mori* (Lepidoptera: Bombycidae) silkworm strains in Kenya. The Open Entomol. J. 3,1-6
- Petkov N, Nguyenvan L (1987). Breeding genetic studies on some lines of silkworm, *Bombyx mori* L. *Genetika-i-seleksiya* 20:344 – 354.
- Rangaiah S, Devaiah MC, Govindan R, Kulkarni S, Narayanaswamy TK (1995). Interrelationship among some quantitative traits in multivoltine races of silkworm *Bombyx mori* (L). *Current Res. Univ. Agric. Sci Bangalore*, 24(5): 87-88.
- Rao CGP, Seshagiri SV, Ramesh C, Basha A, Ibrahim K, Nagaraju H, Chandrashekaraiiah C (2006). Evaluation of genetic potential of the polyvoltine silkworm (*Bombyx mori*) germplasm and identification of parents for breeding programme. *J Zhejiang Univ. Sci B* 7(3): 215-220.
- Rao PRM, Permalatha V, Ravindra S, Vijayaraghavan K, Singh R (1997). Variability studies in some pure races and F1 hybrids of the silkworm *Bombyx mori* (L). *Environ. Ecol.*, 15(3): 683 – 687.
- Seidavi A (2011). Evaluation of the genetic potential of six native strains of silkworm, *Bombyx mori* *African Journal of Agricultural Research* Vol. 6 (20) pp 4816 – 4823.
- Sericultum, (2000). The remarkable silkworm. The science of silkworms for the course of nature.
- Tsukada M, Islam S, Arai T, Bosch A, Fred G (2005). Microwave irradiation technique to enhance protein fibre properties. *Autex Research Journal* Vol 5 no 1
- Ulla ISR, Narasimhanna MN (1987). Handbook of practical sericulture. rd

Venkatesh KR, Seema C (2011). Biochemical constituents of different parts of mulberry genotypes. *Inter. J. Agric. Sci.* 3 (2) 90-96.
Ventaka Narsaiah P (1992). *Sericulture in India*, Ashis Publishing House, New Delhi spp. 142.
Zanatta DB, Bravo JP, Arbosa B, Mumhoz P, Ferandez MA (2009).

Ecology, behaviour and bionomics evaluation of economically important traits from sixteen potential strains of the silkworm *Bombyx mori* (L). (Lepidoptera: Bombycidae) *Neotropical Entomology*, 38:327 – 331.