Journal of Science and Sustainable Development (JSSD), 2015, 3(2), 45-56

ISSN: 2304-2702 (print); 2414-4479 (online)
DOI: https://doi.org/10.20372/au.jssd.3.2.2015.047

Effect of Wet Castor Leaf Feeding and Feeding Frequencies on Economic Traits of Eri-Silkworm, *Samia cynthia ricini* Boisduval (Saturnidae: Lepidoptera)

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Abstract

This study was carried out at Melkassa Agricultural Research Center in the sericulture and apiculture research laboratory during 2012 and 2013G.C. cropping seasons. Both tender and matured castor leafs were obtained from Melkassa Agricultural Research Center, sericulture research field to investigate the effects on castor feeding silkworms. The treatments consist of young and late age rearing of silkworm. During young age (1st and 2nd instars) rearing, the tender leaf and late age (3rd, 4th and 5th instars) rearing, matured castor leaf were dipped in the water and excess water was drained out by shaking and fed to the silkworms as per the treatments. Feeding the 1st and 2nd instars silkworms (young age) with daily once (8 am), twice (8 am and 8 pm) and thrice (8 am, 2 pm and 9 pm) with tender wet leaf. While at late age (3rd, 4th and 5th instars) the silkworms were fed with daily twice (8 am & 8pm), thrice (8am, 2pm and 8 pm) and four times (8am, 12 noon 4 pm and 9 pm) with matured castor leaf. The control batch silkworms were reared as per the standard rearing practices. The experiment was laid out in a randomized block design in three replications with a disease free laying per replication. Rearing of castor feeding silkworm by giving tender wet leaf daily twice at young age (1st and 2nd instars)) and matured wet castor plant leaf daily thrice for late age (3rd, 4th and 5th instars) silkworm significantly reduced the larval duration and diseases incidences and improved all the larval, cocoon and silk traits as compared to other feeding frequencies. While, the recommended normal three times/day castor leaf feeding at young age (1st and 2nd instars) and normal three times/day castor leaf feeding at late age was inferior in larval, cocoon and silk traits.

Keywords: *Samia cynthia ricini*, cocoon traits, feeding frequencies, Wet leaf

Introduction

Lepidopteran insects like silkworms have a great economic importance for its natural protein fibers. Among the domesticated commercialized silkworms is the eri-silkwom {*Samia Cynthia ricini* Boisduval (Saturnidae: Lepidoptera)}. Though the insect is a polyphagous insect, the primary food plant of the insect from which it drives its nutrition is castor plant, *Recinus communis* (Nagaraju, 2002), which has also been identified as the principal host plant (Chowdhury, 1982). The rearing of eri silkworm largely depends upon the use of castor leaves as it produces the best result in terms of qualitative and quantitative characters of the erisilk.

The quality and quantity of castor leaves, therefore, play an important role in growth and development of eri-silkworm, particularly during adult and larval stages, which influence cocoon productivity and the economic traits. Good quality and sufficient quantity of castor leaves feeding to the developing worms leads to an increased body size and dry weight of cellular mass which all depend on the rate of metabolism, absorption of nutrients, and stage of development (Rajanna, 1991).

The nutritional elements of castor leaves determine the growth and development of the larvae and cocoon production (Seidavi *et al*., 2005). Leaves of superior quality, free from diseases and dust, enhance the chances of good cocoon crop (Ravikumar, 1988). It has also been demonstrated that the dietary nutritional management has a direct influence on quality and quantity of silk produced *(*Murugan *et al*., 1998).
The castor feeding silkworm is a voracious feeder during the last two instars and needs to be fed many times for better and uniform larval growth and development. Castor leaf quality, time of harvesting, method and duration of storage, feeding method, way of chopping, appetite of the silkworms, silkworm breeds, larval instar, the temperature and relative humidity existing in the rearing room are known to decide the feeding frequency in silkworm rearing in order to harvest better cocoon crops. Quantitative differences in feed had been reported to influence both the larval growth and cocoon character in eri-silkworm (*S.c.ricini*). Krishnaswam *et.al*, (1980) reported that silkworm consumes between 14% and 80% of the total quantity of leaf required in the 4th and 5th instars, respectively based on the environmental conditions (season), when feeding was carried out two times per day in the rainy season, and three times during the winter and summer seasons.

Matsumara *et al.,* (1958) and Joshi (1992) both reported that quality castor leaves contributes 38.2 per cent to good quality cocoon production. The quality of castor leave is determined by its moisture retention capacity, and nearly 75 per cent of the water content in castor leaf has been found to influence the dietary efficiency of silkworm (Rajendran *et al*., 1993). In tropical climate, castor leaves loss considerable amount of its moisture content during storage and on the rearing bed before they are actually fed by silkworms due to high rate of transpiration. In order to conserve the moisture and maintain its freshness, sericulture farmers in India and China used to dip both castor and mulberry leaf in water before feeding to silkworms (Rayar, 2001). Ethiopia in general and Malkassa Agricultural Research Center in particular are parts of tropical climate and castor leaf moisture evapo-transpiration is very

high and this makes the leaf unpalatable for silkworms. There are very few literature and scientific data pertaining to the effect of wet castor leaf feeding and feeding frequency on the performance of eri-silkworm. Hence, this study was undertaken to investigate the effect of tender and matured wet castor leaf feeding and feeding frequencies on eri-silkworms larvae, cocoon and post cocoon traits.

Materials and Method

The experiment was carried out at the Melkassa Agricultural Research Center (MARC), in the sericulture and apiculture research laboratory during the 2012 and 2013 cropping seasons. MARC lies at 8° 24′ N latitude and 39° 21′ E longitude, 17 km South of Adama, at an altitude of 1550 m.a.s.l. The area is characterized by warm and semi-humid climate. The annual average rainfall, relative humidity, minimum and maximum atmospheric temperatures during 2012 and 2013 cropping seasons are 810.1mm, 924.7mm, 65%, 71%, 14.5^{0}C, 13.2^{0}C and 28.9^{0}C, 29.1^{0}C, respectively.

Castor cultivation and eri-silkworm rearing was carried out as per the recommended agronomic practices and standard rearing procedures (Krishnaswami *et al*., 1978a; 1978b). The experiment was laid out in a randomized block design with three replications and ensuring a total disease free laying condition for each replication. The eri-silkworm rearing was carried out during the winter and summer season. For young age (1st and 2nd instars) rearing, tender leaves and for the late age (3rd, 4th and 5th instars) rearing matured castor leaves were dipped in the water and excess water was drained out by shaking and then fed to the eri-silkworms as per the treatment details (Table 1). The young age eri-silkworms were fed with wet castor leaves daily once (8 am), twice (8 am and 8 pm) and thrice at (8 am, 2 pm and 9 pm). While late age eri-silkworms were fed with wet castor leaves daily twice (8 am and 8pm), thrice (8am, 2pm and 8 pm) and four times (8am, 12 noon, 4 pm and 9 pm). The control batches of the eri-silkworms were reared as per the standard rearing practices, were maintained for comparison. The data on growth and development of larvae, cocoon traits, post cocoon traits and disease incidence and severity were collected for each treatment () following the procedure. Data were pooled and analyzed as suggested by Gomez and Gomez (1984).

Larval weight: The mean larval weight (g) was recorded from 10 randomly selected larvae (fifth instars) at peak of growth from each replication. This will indicate the general health of the larvae.

Larval duration: The period covered from hatching of an egg to 5th

instar larval spinning is recorded as larval duration.

Effective rate of rearing

$$ERR\ (\%) = \frac{Number\ of\ cocoon\ harvested}{Total\ number\ of\ larvae\ brushed} x100$$

Filament length: This the most important parameters used by industry. Silk filament length indicates the reelable length of the silk filament from a cocoon. It was calculated using the average length of unwound silk filament from 10 cocoons (obtained using a mono cocoon reeling unit) and expressed in meters according to the following formula.

$$Filamentlength = \frac{length\ \ raw\ silk(m) x 1.25\ (circumferance)}{No\ of\ reeling\ cocoon}$$

Rendita:

Cocoon Quality Index (CQI) defined as numerical measure or an expression of the totality of its quality feature.

$$CQI = -8.5 + 0.682(SR\%) - 0.414(defective\ cocoon)$$

Rendita= $Filment\ length = 8.5 - 0.6 * CQI\ if\ CQI > -1.0$

Rendita= $Filment\ length = 9.5 - 0.6 * CQI\ if\ CQI < -1.0$

Cocoon shell ratio: The total quantity of silk available from a single cocoon was expressed as a percentage of using the following equation: - Single cocoon shell weight (g)/ (single coccon weight (g) x 100

Cocoon weight (g): The average single cocoon weight in grams chose randomly on the 6th or 7th day of spinning.

Cocoon yield for 10,000 larvae: The mean number of cocoons harvested relative to the number of larvae at the beginning of the experiment, converted to 10, 000 larvae.

Cocoon yield by weight (kg) for 10,000 larvae: The mean weight of the cocoons harvested in kilograms (kg) for every 10,000 larvae by weight.

Pupal weight (g): The average single pupal weight come out from cocoon in grams chosen randomly on the 6th or 7th of spinning.

Shell weight (g): The average single cocoon shell weights in grams for 10 cocoons were chosen randomly. The shells used were the same cocoon used for cocoon weight determination.

Dinier (d): The thickness of the silk filament measured by following formula.

$$Dinier = \frac{weight\ of\ total\ filament(g) * 9000}{Total\ total\ filamentlength}$$

Data analysis

All data collected were subjected to a two way statistical analysis of variance (ANOVA) to determine treatments effect. Where significance differences exist, the multiple comparisons of means was made using student t critical difference values at 5% level of significance.

Results

Larval duration

Young age larval duration (251.96h) and total larval duration (611.83 h) were significantly shorter with two times wet castor leaves feeding at young age and three times matured wet castor leaves feeding/day at late age when compared to 262.95h and 654.63 h recorded for the three times tender leaf feeding at young age plus three times normal matured castor leaves feeding/day at late age, respectively (Table 1). Furthermore, the young age larval duration with two times tender wet castor leaf feeding at young age + two times matured castor leaves feeding/day at late age (252.35 h) and two times tender wet castor leaf feeding at young age + four times matured wet castor leaf feeding at late age (252.55 h) were at par with two times tender wet leaf feeding at young age + three times matured wet leaf feeding/day at late age (Table 1).

Larval weight, Effective rate of rearing, and pupal weight

The larval weight for young age (1.527 g/10 larvae), mature age (46.300 g/10 larvae) and effective rate of rearing (83.66%) were significantly higher in two times tender wet leaf feeding at young age + three times matured wet castor leaf feeding/day at late age when compared to 1.157 g, 33.303 g and 70.66 per cent, obtained for LW, mLW and ERR respectively, in three times normal leaf feeding at young age + three times normal matured leaf feeding/day at late age (Table 1). The highest pupal weight (18.720 g/10 pupae) was recorded in two times wet tender leaf feeding at young age + three times wet matured leaf feeding/day at late age, as compared to 13.463 g/10 pupae in three times normal tender leaf feeding at young age + three times normal matured leaf feeding/day at late age (Table 1).

Cocoon and post cocoon traits

The data analysis showed that eri-silkworms reared by feeding wet castor leaves two times and three times per day at young age produced the highest cocoon yield/10,000 worms (20.58 kg), cocoon yield by number per 1000 worms (837), cocoon

weight (23.020 g/10 cocoons), cocoon shell weight (4.317 g/10 shells) and cocoon shell ratio (18.83%) as compared to other treatments. While it was 15.47 kg, 707, 16.083 g, 2.603 g and 16.11 per cent, respectively, in three times tender normal leaf feeding at young age + three times normal castor leafs feeding/day at late age (Table 2).

Disease incidence and severity

Percentage defective cocoons (5.20%), grasserie (3.75 %) and flacherie (4.08%) disease infection were observed to be significantly lower in two times wet tender leaf feeding at young age + three times wet matured castor leaf feeding/day at late age when compared to the values recorded for defective cocoons (9.32%), grasserie (6.25%) and flacherie (6.83%) in three times normal leaf feeding/day both at young and late age (Table 3).

Moreover, the highest silk productivity (6.25 cg/day), single cocoon filament length (959.66m) and finer denier (2.58) was recorded with two times tender wet leaf feeding at young age + three times wet matured castor leaf feeding/day at late age compared to other treatments. While, three times normal castor leaf feeding at young age + three times normal matured castor leaf feeding/day at late age recorded lowest silk productivity (3.14 cg/day), shorter silk filament (688.10 m) and coarser denier (2.89). Similarly, the rendita was superior in two times tender wet mulberry leaf feeding at young age + three times wet matured mulberry leaf feeding/day at late age (7.23) and two times wet castor leaf feeding at young age + four times wet matured castor leaf feeding/day at late age (3^{rd}, 4^{th} and 5^{th} instars) (7.25) and were on par with each other. While, the rendita was inferior in three times tender leaf feeding at young age + three times normal matured leaf feeding/day at late age (7.90) (Table 3). The results clearly revealed the superiority of tender wet leaf feeding to the young age and wet matured castor leaf feeding to late age silkworms over normal leaf feeding. Among the different tender and matured wet leaf feeding frequencies, two times tender wet leaf feeding at young age + three times wet matured leaf feeding/day at late age was found to be significantly superior.

Table1. Effects of wet castor leaf feeding and frequencies on growth and development of eri-silkworms, *Philosamia recini*

Treatments	Young age Larval duration (h)	Young age larval weight (g/10 larvae)	Matured larval weight (g/10 larvae)	Total larval duration (h)	Effective rate of rearing (%)	Pupal weight (g/10 pupae)
1 time/day tender wet leaf at young age + 2 times matured wet leaf feeding/day at late age (T_1)	257.33bcd (10.72)	1.193ef	39.247f	631.79e (26.32)	75.75 (60.87)c	14.017g
1 time/day tender wet leaf at young age + 3 times matured wet leaf feeding/day at late age (T_2)	258.50d (10.77)	1.210ef	41.033c	626.25c (26.09)	76.00 (61.04)c	14.357fg
1 time/day tender wet leaf at young age + 4 times matured wet leaf feeding/day at late age(T_3)	258..03cd (10.75)	1.243e	41.450c	626.32c (26.09)	75.83 (60.91)c	14.883e
2 time/day tender wet leaf at young age + 2 times matured wet leaf feeding/day at late age(T_4)	252.35a 10.51	1.417b	39.543ef	629.40c (26.22)	75.75 (60.86)c	14.653ef
2 time/day tender wet leaf at young age + 3 times matured wet leaf feeding/day at late age(T_5)	251.96a 10.49	1.527a	46.300a	611.83a (25.49)	83.66 (66.91)a	18.720a
2 time/day tender wet leaf at young age + 4 times matured wet leaf feeding/day at late age(T_6)	252.55a 10.52	1.407bc	44.380b	617.92b (25.74)	78.00 (62.76)b	17.970b
3 time/day tender wet leaf at young age + 2 times matured wet leaf feeding/day at late age(T_7)	256.12b 10.67	1.350d	39.803def	629.01d (26.20)	76.00 (60.99)c	15.397d
3 time/day tender wet leaf at young age + 3 times matured wet leaf feeding/day at late age(T_8)	255.99b 10.66	1.360cd	39.950de	627.00c (26.12)	76.16 (61.06)c	16.270c
3 time/day tender wet leaf at young age + 4 times matured wet leaf feeding/day at late age(T_9)	256.62bc 10.69	1.337d	40.347d	627.17c (26.13)	74.75 (60.11)d	15.163e
3 time/day normal leaf at young age + 3 times normal leafs feeding/day at late age(T_{10})	262.95e 10.95	1.157fg	33.303g	654.63f (27.27)	70.66 (57.63)e	13.463h
S.E+	**0.939**	**0.037**	**0.440**	**0.674**	**0.394**	**0.332**

Within column, means followed by similar letter are not significantly different (CD=0.05) by DMRT, T= treatment

Table 2. Effects of wet castor leaf feeding and feeding frequencies on **cocoon traits** of eri-silkworms, *Philosamia recini*

Treatments	Cocoon yield/10000 larvae's(kg)	Cocoon yield (cocoons/100 0 larvae)	Cocoon weight (g/10 cocoons)	Cocoon shell weight(g/10 sheels)	Cocoon shell ration (%)	Rendita
1 time/day tender wet leaf at young age + 2 times matured wet leaf feeding/day at late age (T_1)	16.56d	753de	17.021f	2.837f	17.07f (24.36)	7.35c
1 time/day tender wet leaf at young age + 3 times matured wet leaf feeding/day at late age (T_2)	17.33c	760c	17.543ef	3.190c	18.09b (25.25)	7.32b
1 time/day tender wet leaf at young age + 4 times matured wet leaf feeding/day at late age(T_3)	17.29c	758c	17.993de	3.080cd	17.20cd (24.44)	7.30b
2 times/day tender wet leaf at young age + 2 times matured wet leaf feeding/day at late age(T_4)	17.26c	757cd	17.140f	2.900ef	16.81cd (24.17)	7.31b
2 times/day tender wet leaf at young age + 3 times matured wet leaf feeding/day at late age(T_5)	20.58a	837a	23.020a	4.317a	18.83a (25.67)	7.23a
2 times/day tender wet leaf at young age + 4 times matured wet leaf feeding/day at late age(T_6)	18.02b	780b	21.753b	3.847b	17.87b (24.96)	7.25ab
3 times/day tender wet leaf at young age + 2 times matured wet leaf feeding/day at late age(T_7)	17.07cd	760c	18.490d	2.983de	16.06e (23.57)	7.27b
3 times/day tender wet leaf at young age + 3 times matured wet leaf feeding/day at late age(T_8)	17.38c	762c	19.397c	3.107cd	16.29de (23.75)	7.29b
3 time/day tender wet leaf at young age + 4 times matured wet leaf feeding/day at late age(T_9)	16.87cd	748e	18.051de	3.013de	16.55cd (24.00)	7.31c
3 times/day normal leaf at young age + 3 times normal leaf feeding/day at late age(T_{10})	15.47e	707f	16.083g	2.603g	16.11e (23.55)	7.90d
S.Em±	0.164	3.631	0.373	0.089	0.278	0.013

Means followed by the same letter within column are not significantly different according to DMRT, T= treatment

Table 3. Effects of wet castor leaf feeding and frequencies on **silk traits and disease incidence** of eri-silkworms, *Philosamia recini*

Treatments	Silk traits			Disease incidence (%)		
	Silk productivity Cg/day	Single cocoon filament length (m)	Denier	Defective cocoon	Grasserie	Filacheries
1 time/day tender wet leaf at young age + 2 times matured wet leafs feeding/day at late age (T_1)	3.73d	770.23e	2.73c	8.81bc (17.20)	5.91cd (13.74)	5.59bcd (13.05)
1 time/day tender wet leaf at young age + 3 times matured wet leaf feeding/day at late age (T_2)	3.98c	784.76cd	2.71c	8.97bc (17.07)	6.50def (14.43)	8.17cde (13.53)
1 time/day tender wet leaf at young age + 4 times matured wet leafs feeding/day at late age(T_3)	4.12c	780.71cde	2.72c	8.52b (16.48)	5.91cd (13.61)	5.50bcd (12.73)
2 times/day tender wet leaf at young age + 2 times matured wet leafs feeding/day at late age(T_4)	3.75d	756.72f	2.71c	9.76cd 17.97	5.58bcd (13.39)	5.25bc (13.11)
2 times/day tender wet leaf at young age + 3 times matured wet leafs feeding/day at late age(T_5)	6.25a	959.66a	2.58a	5.20a (12.93)	3.75a (10.55)	4.08a 10.91
2 times/day tender wet leaf at young age + 4 times matured wet leafs feeding/day at late age(T_6)	5.37b	895.24b	2.62b	7.69b (16.32)	5.75bc (13.23)	4.91b (12.79)
3 times/day tender wet leaf at young age + 2 times matured wet leafs feeding/day at late age(T_7)	3.83d	778.32de	2.70c	8.45bc (16.63)	4.83b (12.38)	6.16def 13.82
3 times/day tender wet leaf at young age + 3 times matured wet leafs feeding/day at late age(T_8)	4.04c	791.35c	2.71c	8.52b (16.61)	5.91bcd (13.38)	5.75cde (13.58)
3 time/day tender wet leaf at young age + 4 times matured wet leafs feeding/day at late age(T_9)	4.08c	790.55cd	2.71c	8.51bc (16.56	6.91ef (14.93)	6.66efg (14.26)
3 times/day normal leaf at young age + 3 times normal leafs feeding/day at late age(T_{10})	3.14e	688.10g	2.89d	9.32bcd 17.52)	6.25def (13.94)	6.83fg (14.77)
S.Em+	**0.093**	**7.826**	**0.017**	**0.858**		

Means followed by same letter within column are not significantly different according to DMRT, T= treatment

Discussion

Rearing of silkworms with different feeding regimes reportedly caused marked influence on late age and total larval duration, but had no effect on young-age worms. These result agrees with Haniffa *et al.* (1988) who reported an extended larval period when feeding frequency was reduced from 8 to once per day. Krishnaswami *et al*. (1980) had also observed the prolongation of larval period as a result of under feeding. The larval duration recorded in this study agrees with these findings as well as that of Das *et al*., (1994) and Chandrashekar (1996).

The current study showed the superiority of wet leaf feeding over other treatments. This could be attributed to the maintenance of leaf moisture at optimum level for longer time on the rearing bed, thus making the leaves more palatable for silkworms. Ito (1963) and Yokoyama (1974) indicated that higher leaf moisture increased the amount of leaf ingestion and digestion capacity of silkworm. Parpiev (1968) reported the increase in palatability and assimilation of nutrients due to high leaf water content. Soaking and spraying of leaves with water during winter and summer seasons had been reported to increase the cocoon and shell weight in bivoltine and multivoltine silkworms (Anon., 1993). Similarly, Rayar (2001) had reported a reduction in larval duration and an improvement in cocoon and silk traits by feeding wet matured leaf daily thrice at the late age (3rd,4th and 5th instars) silkworms during winter season and this agrees with the observation in the present study. Dipping the leaf in water also removes the dust and dirt present on the leaves thus making it more hygienic to silkworms for feeding. The results of the current study are supported by the previous findings (Matsumara *et al.,* 1958; Joshi, 1992 and Rajendran *et al*., 1993) wherein, wet feeding 3 times/day from third instar onwards resulted in higher silk ratios, dinier and lower diseases incidence compared to lower feeding per day. Similar results as at present were observed in the past (Das *et al*., 1994). Even in silkworm hybrids, NB18 x NB7 and PM x NB18 the schedule of 2feeds/day in young age followed by 3 and above feeds/day in late-age silkworm rearing resulted in higher cocoon yield (Anon., 1987).

Conclusion

This study concludes that the rearing of castor silkworm by feeding tender wet castor plant leaf young age and matured wet castor plant leaf daily thrice to late age has significantly reduced the larval duration and diseases incidence and improved all the larval, cocoon and silk traits as compared to other feeding frequencies. This study confirmed that two times feeding/day tender castor leaf for young age silkworms and three times feeding/day wet matured castor leaf for late age silkworms can be effective rearing practice for silk worms.

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