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Original Research

Studies on the 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

The 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. 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. The young age (1st and 2nd instars) silkworms were fed with daily once (8 am), twice (8 am and 8 pm) and thrice (8 am, 2 pm and 9 pm).While late age (3rd, 4th and 5th instars) 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). 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.

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INTRODUCTION

Silkworms, lepidopteran insects have a great economic importance for its natural protein fibers. One among the domesticated commercialized silkworms is the er-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). Castor (Ricinus communis) is the principal host plant of erisilkworm (*Samia Cynthia ricini*) (Chowdhury, 1982). The rearers of erisilkworm largely depends upon the use of castor leaves in conducting rearing as it produces the best result in respect 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 in turn influence the cocoon productivity and the economic traits of the cocoon. Good quality and sufficient quantity castor leaves feeding to the developing worms leads to an increase in body size and dry weight of cellular mass which are dependent 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). The quality and quantity of the leaves has a profound effect on the superiority of silk produced by S. c *recini.* 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 production in eri-silkworm (*S.c.recini*) (Murugan *et al*., 1998).

Castor feeding silkworm is a voracious feeder during the last two instars and requires to be fed many times for better and uniform larval growth and development. Castor leaf quality, time of harvesting, method and duration of storage of castor, feeding method, way of chopping, appetite of silkworms, silkworm breeds / hybrids, larval instar and temperature and relative humidity existing in the rearing room are known to decide the feeding frequency in silkworm rearing so as to harvest better cocoon crops. Quantitative differences in feed influence both the larval growth and cocoon character in eri-silkworm (*S.c.recini*). It was known that silkworm consumes 14% and 80% of the total quantity of leaf

required in IV and V instars, respectively. As per the environmental conditions of different seasons, feeding is given two times per day in rainy season, while three times per day in rainy season, while three times during winter season and summer seasons (Krishnaswam *et al.*, 1980).

Matsumara *et al.* (1958) and Joshi (1992) opined that quality of castor leaves contributes 38.20 per cent for quality cocoon production. Quality of castor leave is determined by its moisture retention capacity and nearly 75 per cent of water content in castor leaf was found to influence the dietary efficiency of silkworm (Rajendran *et al.*, 1993). In tropical climate, castor leaves loss considerable amount of moisture 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 leaf moisture and to maintain the freshness of the leaves, the sericulture farmers of most Indian and Chinese used to dip both castor and mulberry leaf in the 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-transformation is very high and changes the leaf to unpalatable form for the silkworms. The literature and scientific data pertaining to the effect of wet castor leaf feeding and feeding frequencies on the rearing performance of eri-silkworm are scanty and hence the present study.

MATERIAL AND METHODS

The experiment was conducted at Melkassa Agricultural Research Center in the sericulture and apiculture research laboratory during 2012 and 2013 cropping seasons. The objective of the experiment was to investigate the effect of tender and matured wet castor leaf feeding and feeding frequencies on eri-silkworms larvae, cocoon and post cocoon traits. Castor cultivation and eri-silkworm rearing was carried out as per the recommended agronomic practices and standard rereading procedures (Krishnaswami *et al.*, 1978a; 1978b). The experiment was laid out in a randomized block design in three replications with a disease free laying per replication. The eri-silkworm rearing was carried out both during 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 (-at 8 am-), twice (-at 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 & 8pm), thrice (-8am, 2pm and 8 pm-) and four times (8am, 12 noon, 4 pm and 9 pm). The control batches, eri-silkworms 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 rearing. Data were pooled and analyzed as suggested by Gomez and Gomez (1984).

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

Larval Duration: - The period covered from hatching of an egg to 5th instar larval spinning refer to larval duration.

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

Effective Rate of Rearing

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.

Filament Length

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

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 coccon shell weight)(g)/ (single coccon weight (g)) x100

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, coverted 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 weight in grams for 10 cocoons 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 collected from all experiment with three replications were subjected to statistical analysis. Two way analysis of variance (ANOVA) was carried out to find out the significant differences between the feeding. Multiple comparison of means were made depending on F ratio and critical differences values based on student t critical at 5% level of significances.

RESULTS

Larval Duration

Young age larval duration (251.96h) and total larval duration (611.83 h) was significantly shorter in two times wet castor leaves feeding at young age plus three times matured wet castor leaves feeding/day at late age as compared to 262.95 and 654.63 h in three times tender

leaf feeding at young age plus three times normal matured castor leaves feeding/day at late age, respectively. 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 on par with two times tender wet leaf feeding at young age + three times matured wet leaf feeding/day at late age.

Larval Weight, ERR, Pupal Weight

The young age larval weight (1.527 g/10 larvae), mature larval weight (46.300 g/10 larvae) and effective rate of rearing (83.66%) were significantly highest in two times tender wet leaf feeding at young age + three times matured wet castor leaf feeding/day at late age as compared to 1.157 g, 33.303 g and 70.66 per cent, respectively, in three times normal leaf feeding at young age + three times normal matured leaf feeding/day at late age. 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 (Table1).

Table 1: 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

Disease Incidence and Severity

Per-centage defective cocoons (5.20%), grasserie (3.75 %) and flacherie (4.08%) disease infection were significantly lower in two times wet tender leaf feeding at young age + three times wet matured castor leaf feeding/day at late age as compared to 9.32, 6.25 and 6.83 per cent, respectively, in three times normal leaf feeding/day both at young and late age (Table 3).

Cocoon and Post Cocoon Traits

The 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).

The highest silk productivity (6.25 cg/day), single cocoon filament length (959.66m) and finer denier (2.58) was recorded in two times tender wet leaf feeding at young age + three times wet matured mulberry leaf feeding/day at late age as 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 reveals 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.

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

Treatments	Cocoon yield/ 10000 larvae's (kg)	Cocoon yield (cocoons/ 1000 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**

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

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

DISCUSSION

Rearing of silkworms with different feeding regimes caused marked influence on late age larval duration and total larval duration but had no effect on young-age worms. These results are supported by Haniffa *et al.* (1988) who reported that when the numbers of feeds were restricted from 8 to 1/day, the larval period was extended. Krishnaswami *et al*. (1980) also observed prolongation of larval period as a result of under feeding. The larval duration in the present study has almost followed the trend observed by the previous workers (Das *et al*., 1994; Chandrashekar, 1996).

The current study indicated the superiority of wet leaf feeding over the others treaments and this may due 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 is known to increase 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 both during winter and summer has increased the cocoon and shell weight in bivoltine and multivoltine silkworms (Anon, 1993). Similarly, Rayar (2001) reported that, the reduction in larval duration and improvement in cocoon and silk traits by feeding wet matured leaf daily thrice to late age (3rd, 4th and 5th instars) silkworms during winter season and confirm the present observation. Dipping the leaf in water also removes the dust and dirt present on the leaves and making it more hygienic to silkworms for feeding. The current observations are also supported by the previous findings 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).

CONCLUSIONS

Rearing of castor silkworm by feeding tender wet castor plant leaf daily twice at 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. Our 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 the silk worms.

Conflict of Interest

Conflict of interest non declared.

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