ACCEPTANCE OF TERTIARY AND NON-FOOD PLANTS BY ERI SILKWORM, *SAMIA CYNTHIA RICINI* BOISDUVAL (LEPIDOPTERA: SATURNIIDAE)

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ABSTRACT: Performance of fourth and fifth instar larvae of eri silkworm, *Samia cynthia ricini* Boisduval (Lepidoptera: Saturniidae) on tertiary, papaya (*Carica papaya* L) (Caricaceae), and non-food plants, Indian acalypha, *Acalypha indica* L. (Euphorbiaceae), mulberry *Morus alba* L. (Moraceae), great morinda, *Morinda citrifolia* (Rubiaceae), white lead tree *Leucaena leucocephala* (Lam.) de Wit (Fabaceae) compared to its primary food plant, castor (*Ricinus communis* L) (Euphorbiaceae) was observed under laboratory conditions. Both fourth and fifth stadium larvae preferred castor followed by papaya. The fifth stadium larvae gained their weight both in non-starved and starved conditions whereas, fourth instar larvae losses the weight. Under Palayamkottai condition, first time, the biological traits like developmental times, reproduction and cocoon shell ratio was recorded. Results revealed that the tertiary food plant C. papaya can also be fed to eri silkworm on scarcity of castor leaves for successful production of eri silk.

KEY WORDS: Eri silkworm, biology, tertiary food plant, non-food plants, preference, weight gain or loss, economic traits

Eri silkworm, *Samia cynthia ricini* (Boisd.) (Lepidoptera: Saturniidae) is polyphagous in nature feeds on wide range of plants over 30 species (Choudhury, 1982; Reddy et al., 1989). The host plants are categorized as primary, secondary and tertiary based upon the degree of acceptance by the larvae, their growth, development and cocoon yield (Bindroo et al., 2007). Castor (*Ricinus communis*) and kesseru (*Heteropanax fragrans*) are considered to be the primary hosts while tapioca (*Manihot esculenta*) and payam (*Evodia flaxinifolia*) are secondary and these plants can be used for commercial production of eri silk (Sakthivel, 2012). Rest of the plant species like barkesseru (*Ailanthus excelsa*), papaya (*Carica papaya*), Jatropha (*Jatropha curcas*), barpat (*A. grandis*), gulancha (*Plumeria acutifolia*), gamari (*Gmelina arborea*) *etc* are tertiary on which the silkworm could complete its lifecycle. Eri silkworm could also survive on certain non host plants species if meet with starvation due to non availability of its food plants.

Therefore, the present study was carried out to find out the acceptance of commonly available tertiary, papaya (*Carica papaya* L) (Caricaceae), and some non-food plants, Indian acalypha, *Acalypha indica* L. (Euphorbiaceae), mulberry, *Morus alba* L. (Moraceae), great morinda, *Morinda citrifolia* (Rubiaceae), white lead tree, *Leucaena leucocephala* (Lam.) de Wit (Fabaceae) at Palayamkottai zone of Tamil Nadu, India by eri silkworm and feasibility if eri silk production compared to its primary food plant, castor (*Ricinus communis* L) (Euphorbiaceae).

MATERIAL AND METHODS

Source of eri silkworm and its maintenance

Disease fee laying (eggs) of *S. cynthia ricini* were obtained from the Eri Silkworm Seed Production Center, Central Silk Board, Hosur - 635109, Tamil Nadu, India were surface sterilized with 0.05% sodium hypochloride and incubated in petriplates (9.8 x 2cm). A small wet cotton swab was placed inside the petriplate to maintain the optimum temperature (25 ± 1^{o}C) and relative humidity (80–85 %).After hatching, a tender leaf of castor was placed over the neonate larvae and allowed for 15 minutes. The worms crawled on the leaf were then transferred into plastic troughs (16 x 7cm) and the stock culture were maintained as per the standard procedure (Sakthivel, 2012) on castor leaves under laboratory condition (29±1^{o}C temperature; 65 – 75 % RH).

Biological traits: For biological traits experiment, local castor variety was used. Tender leaves were fed four times a day up to third instar larvae and semi-tender and mature leaves were fed five times a day to the fourth and fifth instars, respectively. A total of 300 first stadium larvae were randomly selected from the stock culture and divided into six groups. Each group (50 larvae) is considering as a replicate and maintained them till their pupation in a paper box (37 x 6.4 cm and 3 mm thickness). Rearing arena was checked daily and dead larvae and unfed food was removed. Egg period, larval period and weight, pupal period and weight and adult period were recorded. Survival rate of each stadium was also recorded. Ten cocoons were randomly selected and the mean cocoon weight was computed in grams using monopan balance up to two decimals accuracy. After removing the pupa and exuvium from the 10 randomly selected cocoons, the shell weight was recorded in grams using the same balance. Ten fertilized gravid female moths were selected randomly replication and were allowed to lay eggs on plastic tray of uniform size in a dark room for 48 hours. The eggs laid were collected and counted to record the average fecundity per female.

Food Acceptance bioassay: On a plastic tray (18.5 length and 10.2cm width) mature leaves of leaves of *C. papaya, A. indica, M. Alba, M. citrifolia, L. leucocephala* along with the primary food plant castor, *R. communis* (approximately one gram each) was placed. Equal distance (3 cm) was maintained between each plant leaves. Then three uniform sized newly moulted fourth instar larvae were introduced at the centre of the feeding arena and record the food acceptance of the larvae in minutes by visual method. Six replications were maintained. In another set of experiment, newly moulted larvae were starved for 24 hours and then the acceptance of tested plants was recorded as mentioned above. In the third set of experiment, newly moulted larvae were starved for 48 hours and then the experiment was carried out. Similar experiments were also conducted for fifth instar larvae (0 day, 1-day starved and 2-days starved). Acceptance was calculated by using the following formula: Acceptance (%) = Number of larvae accepted a particular leaf/Total number of larvae used x 100.

Weight gain/loss: The mean preference results showed that eri silkworm larvae accepted castor followed by *C. papaya*. Hence, secondary food plant papaya was provided to the larvae and allowed to feed continuously for 24 hours. Initial and final weight of the larvae was recorded. From the data, the weight gain and/or loss was calculated by using the following formula.

Weight gain and / or loss per day (weight/ day / animal) = Initial weight - final weight/ Experimental days.

The experiment was conducted for both fourth and fifth instar larvae. Ten replications were maintained for each stadium.

Statistical analysis: The larval weight (mg), larval period, pupal period, adult period, fecundity and hatchability and economic parameters were analyzed by students 't' test whereas acceptance behavior was analysis by ANOVA using SPSS software (20 version). The interpretation of the data was done using critical difference values calculated at 5%.

RESULTS AND DISCUSSIONS

The potentiality of ericulture as a viable subsidiary occupation has been highlighted by several workers (Prakash et al., 2003; Saratchandra, 2003). It is evident that there will be a substantial increase in annual income of the farmers by practicing ericulture which brings socioeconomic change at the rural level. Since, Vellore (12.9202° N, 79.1333° E) and Palayamkottai (8°43' N, 77°48' E) are the hottest cities in Tamil Nadu, no farmer has been undertaken this practice here. Hence it is worthwhile to record the biological traits of eri silkworm under Palayamkottai condition. Incubation period was 9.5 days as observed by (Basaiah, 1988) on local castor variety.

Total larval period, pupal period and adult period were 19.9, 10.3 and 8.3 days respectively. Previously it was reported that the larval period varied at various locations, for instance, 20.0 and 45.0 days under Mysore (Anonymous, 1979), 21.0-28.0 and 16.0-19.0 days under Dharwad and Raichur conditions respectively (Devaiah et al., 1978; Patil et al., 1986). Further, significantly longer total larval period (25.7±1.6-days) as observed by Kavane (2014) and more larval survival (29%) ($t=2.000$; $P<0.05$) were recorded while SCR fed with papaya during fourth and fifth stadium. In Tamil Nadu, during winter the larval duration was 29.0 days where as it was 23.16-21.13 days during rainy and summer seasons respectively (Sakthivel, 2012). He further reported that the moderate average temperature (20-27°C) and relative humidity (RH-63-71%) in Tamil Nadu which are ideal for growth and development of silkworm and cocoon formation whereas high temperature (35.54°C) and low relative humidity (48.15%) summer prevalent are known to have negative impact of silkworm rearing and hence lower cocoon yield indicating spatial influence too. However, Rajadurai et al. (2010) did not find much difference in larval periods in different seasons.

The results indicate that Palayamkottai is a suitable place for rearing eri silk worm. This was also supported by normal body size observed in adults. For instance, the length of the head, thorax and abdomen is about 1.96, 7.3 and 14.4 mm respectively and mean total length is 2.36 cm. The average for, mid and hind leg length is 1.0, 1.1, and 1.3 cm respectively. Though only 28% of larvae attained into fifth stadium, 95.24% pupation having 1.1 ± 0.1g pupal weight and 100% adult emergence recorded when the larvae were fed with castor leaves. However, when larvae were provided with papaya leaves in fourth and fifth stadium, 87% of the larvae attained in to pupae and 92% pupae emerged as adults.

The sex ratio of the emerged adult was 1: 0.57 both in castor and papaya fed eri silkworm. In an average a female lay 138.66 ± 12.26 eggs with the hatching per cent of 60.78 ± 5.6 in papaya leaves fed SCR. It was significantly increased when the larvae were fed with castor leaves (189.38 ± 2.95 eggs with the hatching per cent of 71.87 ± 2.5) ($t=2.021$; $P<0.05$).

The cocoon and shell weight was 1.375 ± 0.2 mg and 0.175 ± 0.03 mg respectively with the cocoon shell ratio of 13.53% as observed by Ibrahim et al. (2015). However, the cocoon shell ratio was ranged from 9.65% to 11.87% even after the application of Juvenile Hormone analogue (JHA) methoprene (Magadumn & Magadum, 1991). Biochemical analysis of shell fiber consists of more proportion of fibroin (75.06 ± 1.125%) and less proportion of sericin (24.71 ± 0.85%). An opposite trend was recorded while the eri silkworm fed with papaya leaves (Table 3).

Fourth stadium larvae lasts its weight when *C. papaya* (P < 0.05) provided at 1 and 2-days starved *S. cynthia ricinii,* however fifth stadium larvae accepts papaya leaves and gained weight whether it was starved (df1,18; F=4.41; P < 0.005) or not (df1,19; F=4.38; P < 0.005) (Figure 1). *Carica papaya* was reported as preferred secondary food plant (Nangia et al. (2000). Further, Subramanian et al. (2013) recorded low mortality and moderate feeding was observed in the case of *Carica papaya*. No significant difference was observed between castor and papaya fed larvae considering cocoon and pupal weights (t=2.57; P>0.05). However, significantly heavier shell weight and cocoon shell ratio was observed in castor fed eri silkworm (t=1.943; P>0.05) (Table 3). Castor is considered as the primary food plant of eri silkworm. However, during the scarcity of castor leaves especially at fifth instar when the larvae consume more quantity of leaves, secondary food plants like papaya can be used for successfully rearing purpose as proposed other plants by Reddy et al. (1989) and Rajesh Kumar & Gangwar (2010).

Invariable of starvation, *Samia cynthia ricinii* fourth (mean value = 56.1±3.3%) (df1,19; F=3.52; P < 0.005) and fifth (mean value = 61.1±2.3 %) (df1,18; F=3.55; P < 0.005) stadium larvae highly accepted its primary host plant. Mean value indicates that fifth stadium highly accepts the castor to perform its normal physiological and biological activities than fourth stadium. Considering the tertiary and non food plants, during non-starved fourth stadium larvae accepted both *M. alba* and *A. indica* (df1,17; F=3.59; P < 0.05) (Table 1). However, during starvation the larvae preferred *C. papaya* leaves (df1,16; F=3.635; P < 0.005). Fifth stadium larvae accepted *M. citrifolia* (df1,19; F=3.5231; P < 0.05) during non-starvation period and papaya (df1,18; F=3.552; P < 0.005) at starvation periods as observed for fourth stadium (Table 2). The indigenous population of eri silkworm in Tamil Nadu, India uses a variety of plants as food. Our study reveals that, we can utilize papaya leaves along with castor for rearing the larvae at Palayamkottai climatic conditions. Present results indicates that the eri silkworm can be reared with local variety of castor leaves the food plant to the growing larvae instead of depending much on the secondary or tertiary food plants. All life trait parameters were in favor of economical values of sericulture. Since, both castor and papaya leaves were accepted by the eri silkworm among all six plants tested here, these plants can be used for the successful production of eri silk at Palayamkottai condition.

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Table 1. Larval developmental period (days), survival (%) and weight (g) of eri silkworm reared at Palayamkottai under laboratory condition with castor leaves.

Parameters	Larval stadium					Total
	First	Second	Third	Fourth	Fifth	
Developmental period (Days)	6.5±0.6	3.7±0.2	3.2±0.01	3.3±0.2	3.0±0.2	19.9±0.7
Larval survival (%)	66.7	61.7	84.5	85.0	87.5	23.3
Larval weight (g)	0.02±0.01	0.31±0.02	1.28±0.2	2.35±0.45	5.31±0.3	-

\- Indicates not applicable

Table 2. Tertiary and non-food-plant acceptance (%) behavioral response of *Samia cynthiaricini* fourth and fifth stadium larvae in relation to starvation (0, 1 and 2 days) under laboratory conditions.

Starvation period (days)	Food Plants provided					
	Morus alba	*Carica papaya*	*Morindacitr ifolia*	*Acalyphaindica*	*Leucaenaleucocephala*	*Ricinuscommunis*
Fourth stadium larvae						
0	15.0±2.3a	8.0±2.2b	10.0±0.0c	15.9±2.2ad	3.3±1.2e	46.7±2.1 f
1	10.0±1.3a	26.3±1.5b	13.3±1.5c	13.3±1.2cd	0	55.0±2.2f
2	6.7±1.2a	23.3±1.2b	0.0±0.0c	3.0±1.2ad	0	66.7±1.2f
Mean	10.5±0.3a	19.2±0.7b	7.8±0.8c	10.4±0.8ad	1.1±0.3e	56.1±3.3f
Fifth stadium larvae						
0	3.3±1.2a	13.7±1.2b	21.7±1.5 c	15.3±1.2d	3.3±1.2e	43.2±1.0 f
1	6.0±1.2 a	16.0±1.4 b	10.0±0.0c	3.3±1.2 d	0	66.0±1.2 f
2	10.3±1.3 a	17.5±1.0 b	0.0±0.0 c	1.6±1.0 d	0	73.0±1.2 f
Mean	7.0±0.8a	15.4±0.3b	10.6±0.7c	6.5±0.3ad	1.1±0.3e	61.1±2.3f

Mean followed by same alphabets in the row is not significant by Turkey test at 5% level.

Table 3. Comparative performance and economic traits of *Samia cynthiaricini* fed with papaya (only forth and fifth stadium) and castor leaves (in all stadium).

Parameters	Papaya	Castor
Effective rate of rearing (ERR)	74.13±10.2NS	92.38±7.2
Cocoon weight (g)	1.21±0.7NS	1.37±0.2
Pupal weight (g)	1.0±0.1NS	1.1±0.1
Shell weight (g)	0.215±0.1*	0.275±0.03
Cocoon shell ratio (%)	17.57*	20.01
Fibroin content (%)	70.01±0.78*	75.06±1.12
Sericin content (%)	29.69±0.19*	24.4±0.85

Statistical analysis was made between Papaya and castor fed group by students't' test and significance expressed at 5% level, NS- indicates not significant

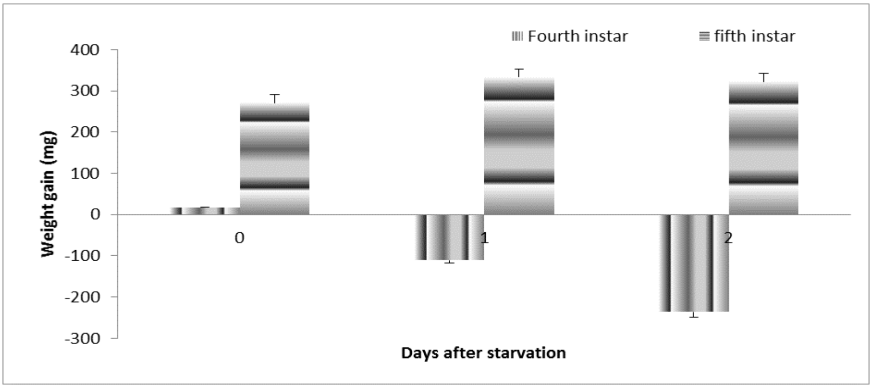

Figure 1. Weight gain or weight loss (mg) of *Samia cynthia ricinii* fourth and fifth nymphal instars fed with papaya plant leaves when compared with castor leaves.