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EFFECT OF REARING SEASONS ON THE ECONOMIC PARAMETERS OF CROSSBREED SILKWORM BETWEEN *SAMIA RICINI* AND *SAMIA CANNINGI*

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ABSTRACT

Samia ricini and *S. canningi* are non-mulberry silk worms with multivoltine and bivoltine nature reared indoor and outdoor, respectively. Both the varieties are found in the North-eastern states of India. *S. ricini* is susceptible to unhygienic and poor environmental conditions. The present study was designed to produce a crossbreed between *S. ricini* and *S. canningi* and to study the effect of seasonal variation on the rearing performance between the F1 hybrid and the parents. Experimental results have shown that the rearing performance of crossbreed showed superior quality compared to parental species. Temperature fluctuation was found to be the major factor in the rearing performance. The present study, therefore, suggest that the *S. ricini* x *S. canningi* crossbreed may be a good variety for silkworm industry whose productivity can be increased by taking good care of temperature fluctuation. However, further study regarding the productivity and temperature needs to done to establish the correlation.

KEY WORDS: Samia ricini, Samia canningi, crossbreed

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INTRODUCTION

Sericulture has been a part of life and culture of many Indians since time immemorial. Today sericulture industry earns about Rs.25 billion (2013-14) and provide employment opportunity to millions of people, especially in rural India (Central Silk Board, 2015). The productivity of sericulture mainly depends on high breeding stock of silkworm and the quality of food plants[1]. Moreover, by crossing genetically distinct populations and understanding the genetic mechanism of the silkworm, high yielding, disease tolerant races with distinct quantitative and qualitative traits can be achieved. The success in hybridization primarily depends on the selection of initial breeding materials followed by their effective utilization in different combinations to create genetic variability for selection[2]. In India, it is estimated that nearly 80% of the silk is produced by multivoltine × bivoltine hybrids where multivoltine races are used as female parent for commercial exploitation. The main reason attributed to this is that the contribution of bivoltine by virtue of its maternal inheritance may result in regular crop loss[3]. Suitable silkworm hybrids play a vital role in increasing the productivity and quality of silk which are important for sustainable sericulture industry[4]. Eri silkworm, *Samia ricini* is a domesticated multivoltine sericigenous insect largely reared by the farmers of North Eastern states of India, particularly Assam because of its easy rearing and availability of food plants[5]. *S. ricini* are susceptible to flacherie and different environmental conditions. The productivity and quality of cocoon, however, depends upon quality food supply, favorable environmental conditions and utmost hygienic condition[6]. Seasonal variation such as variation in temperature, humidity, sunshine, rainfall, etc. of a particular place, which is governed by different geographical parameters influences the rearing performance of silk worm[7-10]. Insect, being cold blooded organisms, the performance of all insect species solely depends on temperature changes[11,12]. The ideal range of temperature for the growth of eri silkworms ranges from 20°C to 40°C, however, increase in temperature beyond 35°C causes less spinning, mortality of larvae and pupae and poor moth emergence and sterility at adult stage [13,14]. Keeping in mind the importance of temperature and seasonal variations on the rearing performance of silkworms, the present study was designed to investigate the effect of rearing seasons on the economic parameters of crossbreed silkworm as compared to its parental stock, *Samia ricini* and *Samia canningi.*

MATERIALS AND METHODS

Study area and collection of seeds

The Kokrajhar district (area 3,169.22 Km^2) of the state of Assam has been selected as the study area. Healthy, disease free *S. ricini* were collected at the cocoon stage from the local rearer. *S. canningi* were collected at cocoon stage from different places of Assam. Identification of the sampled moth was done by the scientists of Central Silk Board, Guwahati. Locally available Castor (*Ricinus communis,* Family: Euphorbiaceae) were taken as the food plant during the experimental period (2009-2011).

Preparation and isolation of pure line

Parental seed cocoons of both *S. ricini* and *S. canningi* were collected and laying of the races was done by adopting the method described by Tazima[15] with little modification following Rao and Mariswamy[16]. Briefly, yellow plain colored larvae with brick red cocoon of multivoltine *S. ricini* were selected and maintained up to eight generations. Similarly, bivoltine *S. canningi* with greenish blue plain larval color and dull brown cocoon were selected for pure line maintenance.

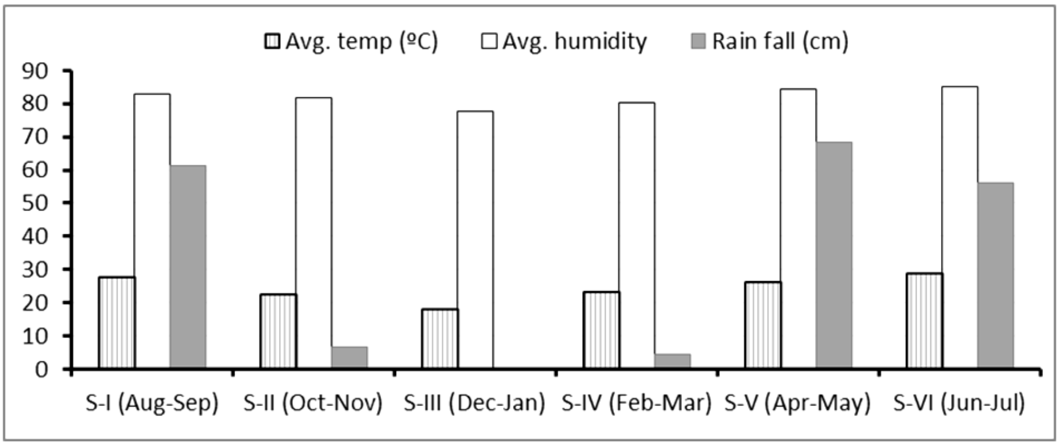
Rearing and life cycle study

Crossing has been done between multivoltine female *S. ricini* and male bivoltine wild race *S. canningi* under controlled conditions of temperature and humidity following Doddaswamy *et al*.[3]. Rearing of silkworm was done following standard protocol of Grekov and Tzenov with little modification[17].

RESULTS AND DISCUSSION

A thorough investigation was carried out in the Kokrajhar district to understand the popularity and richness of sericultural practices among the local people. Our studies have showed that out of 973 villages, 510 nos. of villages (16350 families) were found to practice sericulture. Among 16350 families 15336, 638 and 376 households were found to practice Eri, Muga and Mulberry rearing, respectively. During the maintenance of pure lines, the selected wild bivoltine blue plain *S. canningi* showed no morphological segregation during the experimental period while the domesticated Yellow plain multivoltine *S. ricini* showed segregation of spotted yellow larvae for two generations (F1 and F2) and afterwards no such segregation could be seen. *S. canningi* showed average fecundity of 201 nos., 72% hatching, 53% moth emergence, larval survivality of 53% along with 53% ERR. All the F1 generation of the cross between parental *S. ricini* (♀) with brick red cocoon color, yellow plain and multivoltine characters with *S. canningi* (♂) having dull brown cocoon, greenish blue larvae and bivoltine characters had resulted into light reddish brown colored cocoon, greenish blue plain larvae and multivoltine nature. The size of the egg, larva, cocoon, pupa and moth were all found larger in the C-breed in comparison to their parents.

Figure 1
Graphical representation of seasonal variation of temperature, humidity and rainfall



During the study period, the temperature fluctuation in Kokrajhar was found to range from 10 to 38°C. The relative humidity ranged from 70-92% with an average annual rainfall of 1964 mm in Kokrajhar (Figure 1). In accordance with the variation of temperature, humidity and rainfall, variations have been seen in the duration of the life cycle of *S. ricini*, *S. canningi* and Crossbreed (Table 1). Several studies have shown the variation of rearing performance with the variation of environmental conditions[9,18]. All the insect species has their own choice of temperatures for usual growth and very high temperature slows down the growth that may leads to developmental malfunction, such as larval ecdysis and adult emergence[19]. The life cycle duration is divided into incubation, larval stage, pupal stage and adult stage. *S. canningi* being bivoltine in nature were found to have only two crops i.e. Summer (May-July) and winter (Aug-May) in a year with diapausing character in the pupal stage during winter season for about 230 days while that of *S. ricini* and C-breed had six crops (Season-I to VI) in a year.

Table 1
Seasonal variation in the life cycle duration (in days) of S. ricini, S. canningi and C-breed

	Incubation period	Larval period	Pupal period	Adult - period	Total
S. ricini					
S-I: (*Aug-Sep*)	10±0.26	24±0.58	18±0.43	4±0.17	55±0.99
S-II: (*Oct-Nov*)	10±0.17	27±0.31	18±0.17	4±0.52	58 ±0.52
S-III: (*Dec-Jan*)	14±0.49	32±0.70	24±0.48	4±0.45	74±1.20
S-IV: (*Feb-Mar*)	10±0.31	28±0.56	22±0.42	4±0.21	64±0.91
S-V: (*Apr-May*)	10±0.48	22±0.65	18±0.48	4±0.26	54±1.42
S-VI: (*Jun-Jul*)	10±0.33	23±0.50	18±0.42	4±0.22	53±1.09
Mean (A)	10±0.28	26±0.62	19±0.47	4±0.12	60±1.28
Crossbreed					
S-I: (*Aug-Sep*)	9±0.43	25±0.49	21±1.02	5±0.42	59±1.09
S-II: (*Oct-Nov*)	14±0.40	22±0.73	20±0.43	4±0.26	60±0.76
S-III: (*Dec-Jan*)	17±0.37	29±1.09	25±1.20	4±0.17	74±2.37
S-IV: (*Feb-Mar*)	11±0.43	25±0.62	20±0.33	4±0.26	65±0.98
S-V: (*Apr-May*)	10±0.26	24±0.58	18±0.43	5±0.17	55±1.08
S-VI: (*Jun-Jul*)	10±0.31	23±0.68	16±0.54	4±0.21	52±1.26
Mean (B)	12±0.51	24±0.44	20±0.33	4±0.11	61±1.30
S. canningi					
(May-Jul) Summer	17±0.42	24±0.40	30±0.67	6±0.40	77±1.12
(Aug-May) Winter	18±0.42	31±0.40	229±0.79	5±0.22	283±1.30
Mean (C)	18±0.18	28±0.64	130±16.81	5±0.14	180±17.46
A×B (t-value)	-1.960**	1.892*	-0.234	-0.533	0.547
B×C (t-value)	-11.487**	-3.945**	-6.550**	-4.737**	-6.808**

Data are mean ± SE, NS=Non-Significant; * Significant at 5%; **Significant at 1% (highly significant).

The mean highest incubation period was found in *S. canningi* (18±0.18 days) followed by C-breed (12±0.51 days) and *S. ricini* (10±0.28 days). Season-wise, both *S. ricini* and C-breed showed longer incubation period Dec-Jan (Season-III) while the minimum incubation period was seen during Season-II (Oct-Nov) and during Season-I (Aug-Sep), respectively (Table 1). The average larval period for *S. ricini, S. canningi* and C-breed were found to be 26±0.62, 28±0.64 and 24±0.44, respectively. Similar to the incubation period, the larval periods showed longest days during S-III (Dec-Jan) for all the three groups of silk woms. However, C-breed showed shorter larval period (29±1.09 days) among the three groups (Table 1). The pupal period also showed a maximum of 24±0.48 and 25±1.20 days during S-III period for *S. ricini* and *S. canningi*, respectively. Maximum pupal period was noticed on *S. canningi* (130±16.81 days) with diapausing character during winter season (Table 1). Season-wise, *S. ricini* and the C-breed recorded minimum pupal period S-II (18±0.17 days) and S-VI (16±0.54 days), respectively (Table 1). With regards to the adult stage, till oviposition, no significant differences could be seen in the mean difference of *S. ricini* and Crossbreed. However, significant differences were recorded in the adult stage duration between *S. canningi* and Crossbreed. Season-wise also no differences were observed in duration of adult stage in *S. ricini* while it was maximum during Season-I and Season-V in Crossbreed (Table 1). The maximum life cycle duration was recorded to be 60±1.28, 180±17.46 and 61±1.30 days for *S. ricini*, *S. canningi* and C-breed, respectively (Table 1). The rearing performances such as hatching (%), larval survivality (%), pupation (%), emergence (%), fecundity (nos.) and ERR (%) showed slight variations with seasons. Table 2 showed the variation of rearing performance during the six seasons. The larval survivality % of *S. ricini* was found significantly high during S-VI and lowest during S-I while the C-breed showed high survivality during S-II and low at S-V (Table 2). However, no such significant season wise variations could be seen in the pupation % as well as emergence % in both *S. ricini* and C-breed (Table 2). In terms of fecundity (nos.) variation could be seen season wise in both the *S. ricini* and C-breed. Highest fecundity (nos.) was seen during S-I, (467.93±6.32 nos.) and (599.28±3.99 nos.) for *S. ricini* and C-breed, respectively. Similarly, lowest fecundity was found during S-IV for both the groups (Table 2). Similar to the findings of Debaraj et al.[20] the ERR% on the basis of season was found significantly high during S-VI followed by S-V in case of *S. ricini* whereas in Crossbreed it was found significantly high during S-II followed by S-IV (Table 2).

Table 2
Seasonal variation of rearing performance of S. ricini and Crossbreed

SEASONS	Hatching (%)		Larval Survivality (%)		Pupation (%)		Emergence (%)		Fecundity (Nos.)		ERR (%)	
	S. ricini	C-breed	*S. ricini*	C-breed	*S. ricini*	C-breed	*S. ricini*	C-breed	*S. ricini*	C-breed	*S. ricini*	C-breed
S-I: (*Aug-Sep*)	94.03±0.2	95.75±0.1	82.35±0.41	87.20±0.19	99.50±0.1	99.60±0.0	98.95±0.1	99.25±0.1	467.93±6.3	599.28±3.9	80.71±0.4	86.21±0.1
S-II: (*Oct-Nov*)	94.08±0.2	95.05±0.2	82.98±0.38	87.38±0.15	99.60±0.1	99.73±0.0	98.78±0.1	99.25±0.1	432.88±7.7	538.33±8.1	81.47±0.3	86.43±0.1
S-III: (*Dec-Jan*	93.25±0.1	95.33±0.2	83.60±0.27	87.08±0.13	99.53±0.1	99.70±0.1	98.85±0.1	99.40±0.0	402.65±8.0	507.73±8.7	81.91±0.2	86.13±0.1
S-IV: (*Feb-Mar*	94.35±0.2	95.95±0.2	83.23±0.28	87.28±0.14	99.55±0.1	99.68±0.1	98.80±0.1	99.40±0.1	419.08±8.2	527.38±6.5	81.73±0.2	86.41±0.1
S-V: (*Apr-May*)	93.50±0.2	94.30±0.2	83.88±0.36	86.78±0.19	99.40±0.1	99.58±0.1	98.78±0.1	99.40±0.0	440.53±6.7	519.50±7.8	82.12±0.2	85.91±0.1
S-VI: (*Jun-Jul*)	93.38±0.3	94.35±0.2	84.30±0.35	86.90±0.21	99.35±0.1	99.55±0.1	99.05±0.1	99.25±0.1	391.18±7.0	506.15±9.5	82.50±0.2	85.79±0.1
Total	93.76±0.1	95.12±0.1	83.39±0.15	87.10±0.07	99.49±0.0	99.64±0.0	98.87±0.0	99.33±0.0	425.70±3.4	533.06±3.7	81.74±0.1	86.15±0.0
Seasonal Interactions *(Mean differences values)*												
(I×II)	ns	0.70*	Ns	ns	ns	Ns	ns	ns	35.05*	60.95*	ns	ns
(I×III)	0.78*	ns	-1.25*	ns	ns	Ns	ns	ns	65.28*	91.55*	-1.20*	ns
(I×IV)	ns	ns	Ns	ns	ns	Ns	ns	ns	48.85*	71.90*	-1.02*	ns
(I×V)	ns	1.45*	-1.53*	ns	ns	Ns	ns	ns	27.40*	79.78*	-1.41*	ns
(I×VI)	ns	1.40*	-1.95*	ns	ns	Ns	ns	ns	76.75*	93.13*	-1.79*	0.42*
(II×III)	0.83*	ns	Ns	ns	ns	Ns	ns	ns	30.23*	30.60*	ns	ns
(II×IV)	ns	-0.90*	Ns	ns	ns	Ns	ns	ns	ns	Ns	ns	ns
(II×V)	ns	0.75*	Ns	0.60*	ns	Ns	ns	ns	ns	Ns	ns	0.52*
(II×VI)	0.70*	0.70*	-1.33*	0.48*	ns	Ns	ns	ns	41.70*	32.18*	-1.03*	0.64*
(III×IV)	-1.10*	-0.63*	Ns	ns	ns	Ns	ns	ns	30.23*	Ns	ns	ns
(III×V)	ns	1.03*	Ns	ns	ns	Ns	ns	ns	ns	Ns	ns	ns
(III×VI)	ns	0.98*	Ns	ns	ns	Ns	ns	ns	ns	Ns	ns	ns
(IV×V)	0.85*	1.65*	Ns	0.50*	ns	Ns	ns	ns	-21.45*	Ns	ns	0.50*
(IV×VI)	0.98*	1.60*	-1.08*	ns	ns	Ns	ns	ns	27.90*	Ns	ns	0.62*
(V×VI)	ns	ns	Ns	ns	ns	Ns	ns	ns	49.35*	Ns	ns	ns

Data are mean ± SE (standard error), ns = non-significant; *significant level at p<0.05; **significant level at p<0.01 (highly significant).

Similar to the present study, experimental observations on the different eco-races of eri silkworm *Philosamia ricini* showed 93 to 94 hatching percentage[21]. However, the larval stage took shorter time period 19-20 days compared to our study. Studies have also shown that the larval duration was relatively short during July - August (Monsoon) rearing than winter season and also recorded minimum pupal period, less cocoon weight and shell weight[22]. Similarly, found highest hatching percentage, larval weight, cocoon weight, shell weight, silk ratio and minimum larval period during August-September rearing season[23]. Other researchers have also recorded maximum hatching percentage (98.40%) during September-October, maximum moth emergence% (98.70%) during November-December[24]. Similar to our study, better hatching % when different races of *Bombyx mori* with multivoltine and bivoltine nature was crossed[3]. However, it was different from the findings of Naik[25] who reported shortest life cycle (51 days) during November-December.

CONCLUSION

It is revealed from the present study that the F1-hybrid of *S. ricini* x *S. canningi* showed better rearing performance in terms of precocoon characters i.e. hatching%, larval survivality%, emergence%, fecundity nos., ERR% compared to their parental groups. Seasonal variations could also be seen in rearing performance. The difference might be due to agro-climatic condition as well as quantity and quality of the food plants provided. The effects of temperature on the life span of silk worm and its rearing performance may be established from the present findings. However, there were few variations in number of days which may be due to rearing procedure and area of rearing. Therefore, the productivity of a sericulture industry may be increased by taking care of environmental fluctuations and by introducing newer hybrids with higher adaptability.

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