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# Rearing Performance and Quantitative Assessment of F1 and F2 hybrids of Tasar Silkworm, *Antheraea mylitta* Drury

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**ABSTRACT:** In Tasar culture, *Antheraea mylitta* Drury is exploited in country mainly for commercial silk production. It is a wild sericigenous insect species found in diverse geographic areas of varied eco-climatic conditions like temperature, humidity, photoperiod, rainfall; edaphic factors like soil texture, geographic coordinates, and forest resources - food plants which they feed on viz., *Terminalia arjuna* (arjun) and *T. tomentosa*. The improved varieties of these silkworms can be evolved by employing various breeding techniques. Breeding is a method to improve the traits in the upcoming generation by selective parental selection. The present study is based on hybridization between Andhra local and Daba TV ecoraces by backcross method. The rearing performance of F1 and F2 generations and other characteristics like feeding duration, thermal tolerance and disease resistance were also analyzed. An increase in quantitative traits such as larval and cocoon weight was observed. The important economic traits such as fecundity, as hatching (%), cocoon yield/df, cocoon weight, shell weight, shell ratio and filament length have also found to be improved in the hybrid generations.

**KEYWORDS:** *Antheraea mylitta*, ecoraces, breeding, backcross, economic traits.

### I. INTRODUCTION

Tasar silkworm, *Antheraea mylitta* is exploited for commercial vanya silk production in the country and presently, about 2.82 lakh families are directly or indirectly associated with tasar culture. There is need for improved races, breeds in order to enhance tasar silk production and bring improvement in its quality. Therefore, genetic resources of Tasar silkworm are in dire need to be explored, catalogued, conserved and characterized for its commercial utilization by breeders and geneticists (Ravindranath Singh *et al.*, 2014). The Tasar silkworm, *A. mylitta* has rich genetic resource as 44 ecoraces, however, the Tasar culture, an important co-discipline of applied forest biology, needs special understanding and addressing towards breeding perspective to promote the sustainable utilization of this precious natural resource (R. Manohar Reddy *et al.*, 2010).

Backcrossing is a well known and long established breeding plan where a character is introgressed from a domesticated or wild relative donor parent into the genomic background of a recurrent parent, which progress better with selection of genetically diverged parental breeds. The backcross breeding of silkworm using parents with preferred traits and selection in subsequent generations offer superior varieties (R. Manohar Reddy *et al.*, 2009).

A recent study, flimsy cocoons were formed in F1 hybrid population and the larvae survived only till fifth instar in some of the crops, a few stray or no emergence of moths was observed. The failure or delay in emergency may be due to hormonal imbalance, as in the silkworm pupae, the brain secretes a hormone which activates the prothoracic glands which in turn secretes a hormone inducing the metamorphosis into the moth (Renuka, 2014).

The present investigation is an attempt to study the genetic proximity of the ecoraces of *Antheraea mylitta*, bring about an idea of breeding of Andhra local ecorace with other ecoraces, without losing its beneficial commercial characters and suggest methods to overcome its weaknesses.

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## II. MATERIAL AND METHODS

### Collection of seed cocoons of Tasar Silkworm *Antheraea mylitta* D (Andhra Local and Daba-TV)

The parental stocks of ecoraces viz., Andhra Local and Daba-TV of Tasar Silkworm *Antheraea mylitta* were raised during the seed crop rearing season, July-August, 2015. The Andhra local and Daba TV seed cocoons were collected from RTRS (Warangal district) and Telangana State Silk Board (Chennur Mandal, Adilabad district) respectively (Fig. 1.a, b). They were arranged in the form of garlands in grainage chambers. A garland can consist of 100 cocoons in bunches containing both male and female pupae. Each bunch consists of five cocoons tied together with the thread at the peduncle end. The disinfection of room was done using with 2% formaldehyde, prevented by arranging suitable nylon net, well ventilated grainage chambers in the laboratory (Fig.1. c). The date of emergence of each of the ecorace (male/female) was noted. The male and female moths emerged out of non-diapausing cocoon stocks of the above divergent geographic ecoraces were used for the study.

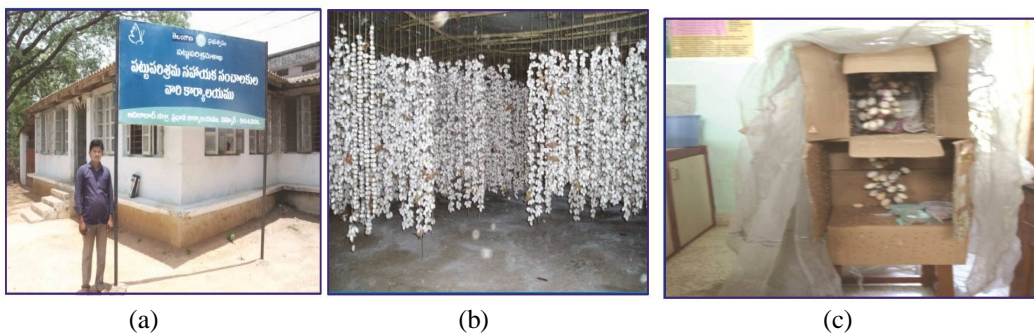


Fig.1 (a) Collection of seed cocoons Telangana State Silk Board Chennur Mandal, Adilabad district (b) Daba- TV Seed cocoons (c) Grainage activity of Tasar Silkworm, *Antheraea mylitta* D, Andhra local and Daba- TV ecoraces (Seri-biotech lab, KU).

### Emergence pattern

Moth emergence was studied during first grainage season (June-July 2015). The emergence of moths start late in the evening mostly, between 18.00 to 22.00 hr. Coupling of moths just after emergence is not allowed. By keeping male and female moths separately in the cages for about 2-3 hr so as to from 19.00 hr and continued u to 23.00 hr. The number of moths emerged and male - female synchronization was recorded in Andhra local and Daba-TV parental ecoraces. The male moths start emerging 1- 2 days earlier than female moths. Immediately after emergence male-female moths were selected from different batches as per the requirement, to prepare back crosses among Andhra local and Daba-TV ecoraces (Fig. 2.a, b).

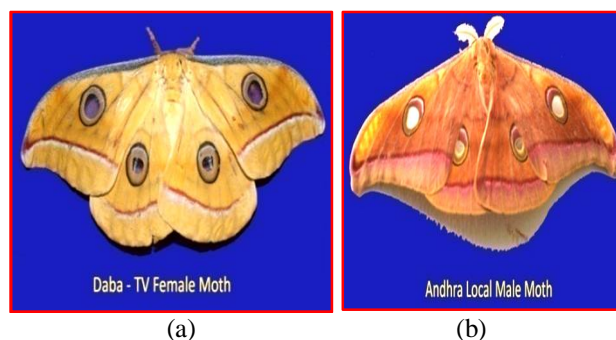


Fig.2. (a) Andhra local (b) Daba TV Moths of Tasar Silkworm, *Antheraea mylitta* D

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### Backcross Methodology

Breeding of silkworm means improvement of silkworm strains, which is an extremely important issue for silk industry. Methods adopted for the improvement of silkworm strains are more or less the same as those in other animals and plants. Three methods are followed viz., (1) selection of pure lines, (2) cross breeding, and (3) induction of mutations. At present, out of the three methods, cross breeding is the most popular and widely applied to develop a large number of strains. In cross breeding, in most cases, an objective is set and decided upon and strains suitable for the purpose are carefully selected. By producing hybrids of the two parent strains, various combinations of characters manifested in the filial generations are observed and the excellent ones are selected and fixed (Hisao Aruga, 2001).

### Production of F1 and F2 Hybrids

During hybridization, Daba TV (female) was crossed with Andhra local (male) to produce F1 hybrids, in which Daba TV (female) will be donor parent whereas male counterpart of Andhra local acts as recipient parent. F1 (male) was crossed with Andhra local (female) to produce F2 hybrids. Rearing performance of different back crosses was observed for different parameters and recorded as follows. During hybridization, in the next crop, i.e., during September 2015, F1 (male) was crossed with Andhra local (female) to produce F2 hybrids, in which F1 (male) will be donor parent whereas male counterpart of Andhra local acts as recipient parent. This method is aimed at introgression of survivability traits of Andhra local ecorace.

### Coupling

On reaching the female moth, the male moth starts courtship behavior with raised antennae, fluttering wings around the female followed by mating. Mating lasts for 10-12 hr but it continues up to 24 hr of the next day if not disturbed. In copulation one male moth is enough for complete fertility of the female moth. Male moths were utilized for second time mating when there is shortage of female moths. The optimum temperature and relative humidity for moth emergence and coupling were recorded (Table.1)

### Egg laying Oviposition of hybridized female moth

Female moths were decoupled and kept in mud cups or nylon net bags (15 × 20 cm) and kept in dark condition at 22±2°C and 75±5 % R.H, (Ovi-position/egg laying device) for ovi-position upto 72 hrs. The number of eggs laid by individual mother moth in three days (72 hrs.) was counted and recorded as fecundity. The average fecundity ranges from 185-230 eggs in both the crop seasons. The coupled moths detached at a slight mechanical disturbance (Fig.3.a, b).



Fig.3. (a) Moths Coupling (b) Egg laying Oviposition of hybridized female moths of Tasar Silkworm, *Antheraea mylitta* D

### Egg washing

The eggs were washed to ensure removal of outer meconium (gummy coated) layer the egg surface was sterilized to prevent disease contamination as eggs are one of the vital pre-requisites for successful rearing. The occurrence of disease is prevented by using formalin (5%) and surface sterilized to prepare disease free layings- DFLs.

### Hatching

Larval hatching was recorded on the 7<sup>th</sup> or 8<sup>th</sup> day of incubation after date of coupling. Comparative hatching performance was calculated in percentage. Hatching percentage (brushing calculation) was calculated by using the formula-

$$\text{Total number of larvae hatched} / \text{total no. of eggs} \times 100.$$

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### Supervision and maintenance of rearing breeding larvae of Tasar silkworm *Antheraea mylitta* (Daba- TV, Andhra local Ecoraces)

#### Influence of Temperature

Larvae survive over wide range of temperature *i.e.*, from a of maximum 34° - 35°C and a minimum of 9- 10°C in rearing site. Larvae react to temperature, *i.e.*, above 30°C they become restless while when the temperature is below 20°C they become inactive. The temperature also determines larval life span. In the present study, the temperature was recorded with the help of laboratory thermometer. The average of lowest and highest values were taken and recorded instar-wise.

The present investigation is taken up to study the influence of environmental conditions like optimum temperature during the rearing period were F1 and F2 populations Instars wise are 29-32°C and 28-29°C respectively (Table. 1). During rearing, environmental fluctuations were seen, which sometimes involved unfavorable conditions like rain, storm or hail.

#### Influence of Humidity

Larvae survive over wide range of humidity *i.e.*, a maximum of 90- 100% and a minimum of 30-40% in rearing site. Relative humidity also determines larval life span, *e.g.*, early instars need higher humidity of 75-85% while late instars require a lesser humidity of 60-70%. In the present study, the humidity was recorded with the help of lab hygrometer. During the rearing period were F1 and F2 populations instars wise are 86-90% and 87-94 respectively (Table. 1).

#### Larval parameters: (length, weight, colour, size and shape of larvae)

At the beginning of each instar, 5-10 healthy worms were selected at random from the rearing lot of Tasar Silkworm, *Antheraea mylitta* (F1 and F2 Hybrid populations) rearing on *Terminalia arjuna* plantation at Kakatiya University, Warangal, Telangana, India for measurement of length and weight. These parameters are taken just after hatching for the first instar and just before moulting for second instar and daily for fourth and fifth instar. Larval weights were measured in an electronic balance of Citizen (Model: CG 203).

The weights were measured for first instar to fifth instar, the length of the larvae were measured in cm by using a graph paper. The larval lifespan was also recorded. The larval mortality was calculated by counting the number of worms lost due to various reasons during each instar (Table. 4).

Plantation uniformly after one day of completion of 2nd moult, by cutting off branches with young worms with a help of secateurs, putting gently on sheet of polythene spread in a basket. Transfer the worms in basket to another plantation in rearing garden, one by one with the branch of the plants during early morning or evening cooler hours. Larvae should not be disturbed during moult/ spinning.

#### Early age rearing (I to III instars) of F1 and F2 hybrid populations of Tasar Silkworm, *Antheraea mylitta*

Two DFLs (F1) and One DFL (F2) of the young age larvae (I to III instars) of F1 and F2 population were reared on *T. arjuna* plants maintained separately to avoid mixing of parental stocks. The young age larvae prefer tender leaves. It was observed that the young age worms crawl up to the tip of the branches and start eating tender leaves. The young age rearing was conducted in rearing garden under cover of nylon net to provide protection to the young larvae from heavy rain, hail storm, pest and predators *etc.*, to minimize larval loss during early instars. (Table.1 & Fig.4. a, b, c, d).



Fig.4. (a) Early age rearing newly hatched larvae (b) I instar larvae (c) II instar larvae (d) III instar larvae of F1 and F2 hybrid populations of Tasar Silkworm, *Antheraea mylitta* D

#### Late age rearing (IV and V instars) of F1 and F2 hybrid populations of Tasar Silkworm, *Antheraea mylitta* D.

For the healthy growth of the larvae, semi-mature and mature leaves were provided to the 4<sup>th</sup> and 5<sup>th</sup> instars respectively. The mature larvae 1-2 days stop feeding and either rest on the food plant or come down to the tree trunk near the strips of plastic sheet tied around the tree trunk. The larvae remained there by raising their head upwards till



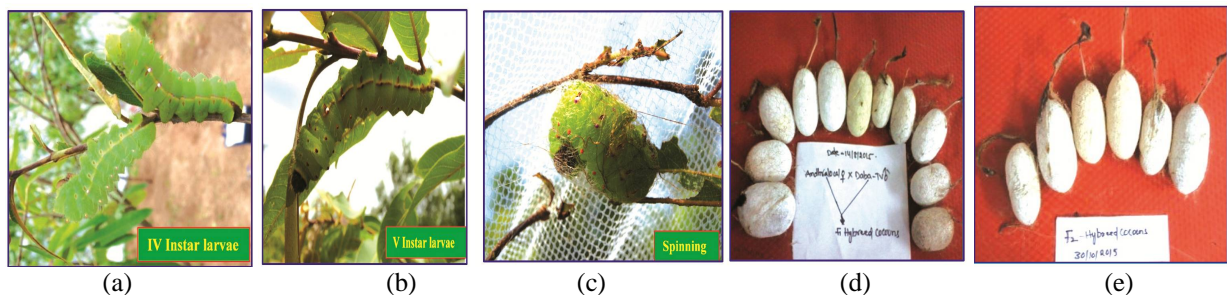
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evening and released their last excreta. Afterwards the larvae started searching suitable location for cocooning and pupation. At this stage, the mature larvae were picked up and kept in the bundle of dry twigs or in the bamboo made moutage for cocooning. The pupation was completed inside the (F1) cocoon within 9-10 days, (F2) cocoon within 10-15 days and cocoon formation was completed (Fig.5. a, b, c, d, e).



(a) (b) (c) (d) (e)  
Late age rearing (a)IV instar (b) V instars (c) spinning larvae (d) F1 cocoons (e) F2 cocoons of hybrid populations of Tasar Silkworm, *Antheraea mylitta* D.

### Cocoon and Post-cocoon characteristics of Tasar silkworm, *Antheraea mylitta* (Daba-TV and Andhra local Hybrid Population)

The weights of the cocoon, pupa and shell of Tasar silkworm, *Antheraea mylitta*, Daba-TV, Andhra local Ecoraces, were measured using standard Electronic Balance of Citizen-make in terms of grams.

The length of cocoon and peduncle; width of the cocoon were measured by using *Vernier Calipers* and the Shell Thickness was measured by using Screw Gauge.

The post cocoon parameters *viz.*, Shell Ratio was measured according to standard procedures and recorded.

#### Shell Ratio

The Shell Ratio is calculated by the following formula:

$$\text{Shell Ratio} = \frac{\text{Shell Weight}}{\text{Cocoon Weight}} \times 100$$

#### Length and Width of cocoon

The length and width of the cocoon shell and peduncle was measured with vernier calipers.

$$\text{Total Length} = \text{Main Scale Reading} + \text{Vernier Coincidence} \times \text{Least count.}$$

#### Thickness of cocoon shell

Thickness of the cocoon shell and peduncle was done by using the Screw Gauge.

$$\text{Least count} = \frac{\text{Pitch of the screw}}{\text{No. of divisions on the head scale}}$$

#### Reelability

The reelability of cocoons for economic reeling is the ease with which the cocoons yield the bave in reeling, which is called the reelability of cocoons. This is calculated by the following formula:

$$\text{Reelability} = \frac{\text{Weight of the silk reeled}}{\text{Weight of the cocoon}} \times 100$$

#### Denier

The difference in thickness of the size of the bave from beginning to the end is so gradual and minute in tasar cocoon that it does not interfere with the quality of the size of ultimate raw silk reeled. Denier is obtained by the following formula:

$$\text{Denier} = \frac{\text{Weight of the silk reeled}}{\text{Length of the silk reeled}} \times 9000$$

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### III. RESULTS

**Table.1 Date of emergence of parental and hybrid populations of tasar silkworm, *Antheraea mylitta* D**

S.No.	Ecorace	Dates of Emergence	Dates of Coupling	Dates of egg-laying	No of eggs	Date of hatching
1	AL♂	27-06-2015	27-06-2015	28-06-2015	325	05-7-2015
2	DTV♀	27-06-2015	27-06-2015			
3	F1♂	03-09-2015	03-09-2015	05-09-2015	170	10-09-2015
4	AL♀	03-09-2015	03-09-2015			
5	F2♀	10-11-2015	-	-	-	-

The Instar wise average Temperature (°C) and its standard deviation of Tasar silkworm *Antheraea mylitta* (F1 and F2 Hybrid) were as follows. F1 Hybrid: 32.21±0.966 (S.D), 32.22±2.108 (S.D), 30.14±1.463 (S.D), 31.16±1.834 (S.D), 29.20±2.592 (S.D), and F2 Hybrid: 28.50±1.322 (S.D), 28.91±0.948 (S.D), 28.35±0.748 (S.D), 28.78±0.9063 (S.D), 29.37±0.882 (S.D), for I, II, III, IV and V instars respectively. The instar-wise average Relative Humidity (%) and its standard deviation for F1 Hybrid were 86.78±6.619 (S.D), 86.11±6.050 (S.D), 88.42±7.390 (S.D), 90.16±3.544 (S.D) and 90.50±4.377 (S.D) and F2 Hybrid were 93.14±2.672 (S.D), 91.50±4.764 (S.D), 94.00±2.516 (S.D), 92.28±4.644 (S.D) and 87.58±3.648 (S.D) in I, II, III, IV and V instars respectively (Table.2).

**Table.2 Instar-wise Temperature (°C), Relative Humidity (%) of F1 and F2 hybrids of Tasar Silkworm *Antheraea mylitta* D.**

\*The values are expressed in terms of Standard Error of the mean

Instar	Temperature (°C)		Relative Humidity (%)	
	F1	F2	F1	F2
I	32.21±0.966	28.50±1.322	86.78±6.619	93.14±2.672
II	32.22±2.108	28.91±0.948	86.11±6.050	91.50±4.764
III	30.14±1.463	28.35±0.748	88.42±7.390	94.00±2.516
IV	31.16±1.834	28.78±0.9063	90.16±3.544	92.28±4.644
V	29.20±2.592	29.37±0.882	90.50±4.377	87.58±3.648

The no of df's of Tasar silkworm *Antheraea mylitta* (F1 and F2 Hybrid) were 02 and 01; the mortality was 109 and 54 *i.e.*, 33.5% and 41% respectively, and cocoon yield was 80 and 26 *i.e.*, 26% and 17.3% respectively in F1, F2 hybrids (Table.3).

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**Table.3 Rearing performance of F1 and F2 hybrids of Tasar silkworm, *Antheraea mylitta* D in 2015 (for 1 DFL = 150 eggs).**

S.No	Hybrid	No of dfls	Mortality	Percent Mortality	Cocoon yield	% cocoon yield
1	F1	2	109	33.5%	80	26
2	F2	1	54	41%	26	17.3

The instar wise mortality of F1 and F2 were 32, 39 18, 13, 7 and 15, 14, 14, 9, and 2 respectively, and the instar-wise larval life span/days was 7, 9, 7, 6, 10 and 7, 6, 7, 7 and 12 in I, II, III, IV and V instars respectively.

The instar wise average larval weight (g) and its standard deviation of F1 Hybrid 2.59±0.76 (S.D), 10.58±2.29 (S. D), 13.83±5.13 (S.D), and 23.66±3.72 (S.D) and F2 Hybrid 2.45±0.65 (S.D), 11.88±3.88(S.D), 17.95±2.32(S.D), and 20.32±2.66 (S.D), in I, II, III, IV and V instars respectively.

The instar wise average larval length (cm) and its standard deviation of Tasar silkworm *Antheraea mylitta* (F1and F2 Hybrid) were F1 Hybrid: 4.61±1.17 (S.D), 5.38±2.58 (S.D), 9.57±1.21 (S.D), 12.11±0.92 (S.D) and F2 Hybrid: 2.22±0.41 (S.D), 9.68±0.58 (S.D), 10.72±0.40 (S.D), 13.85±0.94 (S.D), in I, II, III, IV and V instars respectively (Table. 4).

**Table.4 Instar-wise Larval Period of F1 and F2 hybrids of Tasar Silkworm *Antheraea mylitta* D.**

\*The values are expressed in terms of Standard Error of the mean.

Instar	Larval life span		Mortality		Larval weight (grms)		Larval Length (cm)	
	F1	F2	F1	F2	F1	F2	F1	F2
I	7	7	32	15	-	-	-	-
II	9	6	39	14	2.59±0.76	2.45±0.65	4.61±1.17	2.22±0.41
III	7	7	18	14	10.58±2.29	11.88±3.88	5.38±2.58	9.68±0.58
IV	6	7	13	9	13.83±5.13	17.95±2.32	9.57±1.21	10.72±0.40
V	10	12	7	2	23.66±3.72	20.32±2.66	12.11±0.92	13.85±0.94
<b>Total</b>	<b>39</b>	<b>39</b>	<b>109</b>	<b>54</b>	-	-	-	-

Cocooning and pupal duration in F1 was 7-9 days time while it has prolonged in F2 to 9-10 days. Cocoons were harvested after full pupation. The pupal formation in F1 Hybrids was 14-15 days while it prolonged in F2 Hybrids to 15-17 days, which was higher when compared to that of parental ecoraces {(6-7 days) (Table. 5)}.

**Table.5 Cocoons harvested and Pupal duration of F1 and F2 hybrids of Tasar silkworm, *Antheraea mylitta* D.**

Cocoon formation in Days		Pupal duration in days	
F1	F2	F1	F2
7-9	9-10	14-15	15-17

The average cocoon weight, Pupal weight, Shell weight (gm), of Tasar silkworm *Antheraea mylitta* (Andhra local Parental, Daba-TV Parental, F1and F2 Hybrid) standard deviation of Cocoon weight were 6.2218±1.459 (S.D), 8.962±0.973 (S.D), 7.746±1.808(S.D), and 5.6033±1.157 (S.D)) and Pupal weight 4.8277±1.573 (S.D), 7.3435±1.032 (S.D), 6.704±1.574 (S.D), and 4.861±1.016 (S.D), while Shell weight (gm), 1.3941±0.114 (S.D), 1.1618±0.059 (S. D), 1.0420±0.234 (S.D), and 0.7423±0.141(S.D).

The average Shell ratio (%), Cocoon length (cm), Cocoon width (cm), Reelability (%), Denier, Shell thickness and Filament length (cm) of Tasar silkworm *Antheraea mylitta* (Andhra local Parental, Daba-TV Parental, F1and F2 Hybrid) were 22.40, 12.95, 13.45 and 13.24, Cocoon length (cm) 4.0, 4.22, 3.75, and 3.60 while Cocoon width (cm) 2.28, 2.61, 2.40, 2.33 respectively and reelability (%) of (Andhra local Parental, Daba-TV Parental, F1and F2 Hybrid)

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13.37, 7.76, 8.06, 7.92 while denier 7.75, 9.07, 9.07, 9.08 and shell thickness (mm) 0.278, 0.192, 0.160, 0.20 Filament length (m) 829, 690, 620 and 441 respectively (Table. 6).

**Table.6 Cocoon Characteristics of F1 and F2 Hybrids of Tasar Silkworm, *Antheraea mylitta* D.**

No	Type	Cocoon weight (gms)	Pupal Weight (gms)	Shell weight (gms)	Shell ratio (%)	Cocoon length (cm)	Cocoon width (cm)	Reelability (%)	Denier	Shell thickness (mm)	Filament length (meters)
1	P1 Andhra local	6.221±1.459	4.8277±1.573	1.394±0.114	22.40	4.00	2.28	13.37	7.75	0.278	829
2	P2 Daba-TV	8.962±0.973	7.343±1.032	1.161±0.059	12.95	4.22	2.61	7.76	9.07	0.192	690
3	F1 DTV♀× AL♂	7.746±1.808	6.704±1.574	1.042±0.234	13.45	3.75	2.40	8.06	9.07	0.160	620
4	F2 AL♀× F1♂	5.603±1.157	4.861±1.016	0.742±0.141	13.24	3.60	2.33	7.92	9.08	0.20	441

\*The values are expressed in terms of Standard Error of the mean.

### IV. DISCUSSION

Among other ecoraces of Tasar silkworm, *Antheraea mylitta* D, Andhra local ecorace is a tropical tasar variety available only in Warangal and Karimnagar districts of Telangana state. Andhra local, the exclusive ecorace of Telangana state is well known for its remarkable commercial characters like compact and hard cocoons, high reelability, high shell ratio, low denier and high filament length. It is on the verge of extinction due to certain weaknesses like poor egg - laying behavior, voltinism, erratic emergence, non-uniform silk deposition in cocoons and pupal mortality. It shows heavy mortality of larvae due to predators, parasites and climatic hazards (Thangavelu, 1991, 1992; Jayaprakash, 1995). Due to these reasons robust ecoraces like Daba and Sukinda are commercially exploited in these regions by the farmers.

In general, the aim of silkworm breeding is not only to enhancement of fecundity, continuance of quality cocoon production in variable climatic and geographic conditions leading to genetic improvement of traits either incorporating desirable genes and subsequently profitability of sericulture industry. In an attempt to overcome the problems faced by Andhra local ecorace, a comprehensive breeding program was suggested by earlier works (Shamitha *et al.*, 2008, Shiva *et al.*, 2011).

In the present breeding programme, which envisages evolution of not only a stable cocoon crop of tasar silkworm, *Antheraea mylitta* (Andhra local ecorace) with better egg - laying behavior and uniform emergence but also at reducing larval and pupal mortality, leading to viable breed.

Genetic variants in the natural population and diverse gene in the individual of the population are the prime need for evolving improved breeds and cross breeds with better tolerance and quantitative traits. Since, tropical tasar silkworm *Antheraea mylitta* D is under commercial exploitation in the country, improved breeds/races are need of the hour (Reddy *et al.*, 2010).

The tasar silkworm, *Antheraea mylitta* D has wide genetic as well as phenotypic variability in its population; also a good material for the exploitation of heterosis, besides it has many constraints in silkworm hybridizations (Siddiqui, 1997).

During breeding, selection is the process of choosing the superior quality of parents, based on phenotypic traits, in the desired direction aiming for improvement in the genetic structure and productivity.

In the present studies, the selection of parents was based on the synchronisation of emergence pattern of the Andhra local and Daba TV ecoraces of Tasar silkworm, *Antheraea mylitta* D (Table.1). The breeding trials was done consecutively *i.e.*, F1 in the seed crop (July-August, 2015, first crop season) and F2 on commercial crop season (September- October, 2015, second crop season) during which the temperature was 28-32°C and relative humidity was 88-91%. In an attempt to synchronise the moth emergence, the parental ecorace-Andhra local, female was preserved in cool conditions, till the F1 male emerged during F2 Backcrossing, as it was showing the tendency of early emergence of 6-7 days, when compared to that of F1.



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The following observations were made during the rearing of F1 and F2 hybrid populations of Tasar silkworm *Antheraea mylitta* D (Tables. 1- 4).

The percentage of hatching was more in F1 than F2, pupal duration was also lengthened in F1 14 -15 and F2 hybrids by 15-17 days, when compared to 7-10 days of parental stock. The percent mortality has decreased from first to fifth instars, which is a significant observation. Though it was lesser in F1 when compared to F2 populations. The larval life span was more or less the same in both F1 and F2. The larval weight was more in F1 during second and fifth instars, while it was more in F2 during third and fourth instars. The larval length was greater in F2 than F1 in all the instars except the second instar.

The cocoon yield was also more in F1 when compared to F2 generation. The percent mortality has increased from F1 to F2 generation. The cocoon and pupal weights were greater in F1 when compared to F2 populations, while it was more than the parental Andhra Local. The shell weight has decreased gradually from F1 to F2 and also when compared to parental Andhra local and Daba TV. Shell ratio was almost the same in F1 and F2, but decreased significantly when compared to the parental Andhra local and Daba TV. Reelability of F1 and F2 has increased than Andhra local parent, Denier of F1 and F2 is similar to that of Daba TV, Shell thickness of F2 has shown considerable improvement. Cocoon length, Cocoon width decreased gradually from F1 to F2, while cocoon length, width greater in parental Daba TV and Andhra local and Cocooning and pupal duration in F1 was 7-9 days time while it has prolonged in F2 to 9-10 days. The pupal formation in F1 Hybrids was 14-15 days while it prolonged in F2 Hybrids to 15-17 days, which was higher when compared to that of parental ecoraces (6-7 days). Moth emergence was also greater in F1 than F2. (Table. 5)

**No. of male moths emerged is significantly greater than females in both F1 and F2.** The percentage mortality was greater in early instars *i.e.*, first to third instars due to diseases, pests and predators and a low mortality in fourth and fifth instars was seen in both F1 and F2 hybrid populations

The duration of development of first, second, third and fourth instars worms of F1 Hybrids took 7 days, 9 days, 7 days and 6 days respectively while the fifth instar took prolonged time (10-14 days) and F2 worms are took 7 days, 6 days, 7 days and 7 days respectively while the fifth instar took prolonged time {(12-14 days) (Table. 4)}.

In F1 generation it was observed that out of 325 (2 dfls) taken, 298 eggs have been hatched, which is an important aspect of the present studies. The significant observation of the present studies is that the **cocoon and pupal weights in F1 hybrid are higher** than that of parental ecorace (Table. 6). Andhra local, which may be due to increased larval period; though it is lower than that in Daba TV, while in F2 it was found to be lower than the parental stock. The **cocoon yield** of F1 and F2 hybrids has been increased when compared to parental Andhra local ecorace. The above results are in corroboration with the view that, for breeding, selection of the parent is the basic tool for improving the genetic structure and improving the productivity status of animal stock in desired direction. Silkworm hybrids have shown improved reeling performance (Takabayashi *et al.*, 1994), over pure races.

In the two backcross generations, *i.e.*, F1 and F2 denier is similar to that of Daba TV parent (though less denier of AL parent is preferable). Based on the recent study, that the commercially important finer denier of tasar silk filament can be attained with minor reduction in silk yield of wild Jata ecorace by adopting repeated backcrossing for four generations with semi domesticated Daba ecoraces (Manohar, 2009), the present breeding method can be further standardized and prolonged to attain superior phenotype quality.

During breeding, the moths of Andhra local male and Daba TV female were allowed to mate for the F1 generation. In the next season the F1 male and Andhra local female were allowed to mate to obtain the F2 generation. The oviposition lasted for 1-2 days in F1 and 3-4 days in F2, in contrast to 6-7 days of normal layings. The fecundity obtained in the two crop seasons in F1 and F2 were 325 and 170 respectively. This is in corroboration with the earlier reports 150-220 (Renuka, 2014), in which fecundity of F1 and F2 hybrids is more than the parental stock (AL-150 and Daba TV-250).

It may also be noted that the fecundity in the first crop was enhanced significantly which eventually has led to F2 generation. Hence from the present studies, it may be inferred that breeding during first crop season maybe beneficial from fecundity point of view. Moreover, specific parents is an impending tool to optimize heterosis for genetic improvement in the desired direction to augment fecundity and shell weight, the most desired traits of commercial importance in tropical Tasar silkworm. The prospects of Jata and Daba ecoraces as material source for backcross breeding to improve filament quality, besides the possibility of exploiting heterobeltiosis for filament yield at F1 level was also reported (Manohar *et al.*, 2008 & 2009). A recent study has revealed that, Sal based Laria can be used as breeding component with Daba and Raily ecoraces of *Antheraea mylitta* D to enhance tasar silk production (Lokesh *et al.*, 2015).

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In a recent study based on genetic diversity, which revealed that, for the purposes of commercial exploitation and conservation, genetically divergent silkworm races can be used for developing hybrids with better silk productivity and adaptability (Srivastava *et al.*, 2011).

The present study is based on hybridization between genetically divergent races Andhra local (pop1) and Daba TV (pop2) ecoraces of Tasar silkworm, *Antheraea mylitta*, as revealed by SSR and ISSR based phylogenetic analysis, yielded F1 and F2 hybrid cocoons with pupal weight, shell ratio, cocoon width, reelability and shell thickness, which have shown considerable increase when compared to either or both of the parents. However, other post-cocoon parameters like cocoon weight, shell weight, cocoon length, denier and filament length have decreased when compared to the parental types. Therefore, the present breeding method, based on emergence pattern and compatibility of the two ecoraces, can be improved further by marker assisted evaluation, followed by screening of two or more characteristics of interest (Li *et al.*, 2015). The present study gives scope for marker assisted selection for the preparation of tasar hybrids and in future, which will help the breeder to incorporate specific traits in the direction of enhancing silk yield and quality and make tasar culture a commercially more viable industry.

The present investigation, on breeding as one of the strategies for enhancing the productivity and quality of tasar raw silk, is aimed at improvement of Andhra local ecorace in order to bestow it with superior characters like survivability and fecundity of Daba TV in lines with preliminary studies (Renuka, 2014), further improved and standardized with backcross method, resulted in yielding better quality cocoons and cocoon yield in the commercial crop seasons.

## V. CONCLUSION

In the present studies, the selection of parents was based on the synchronisation of emergence pattern of the Andhra local and Daba TV ecoraces of Tasar silkworm, *Antheraea mylitta* D. The breeding trials was done consecutively *i.e.*, F1 in the seed crop (July-August, 2015, first crop season) and F2 on commercial crop season (September- October, 2015, second crop season) during which the temperature was 28-32°C and relative humidity was 88-91%.

In F1 generation it was observed that out of 325 (2 dfls) taken, 298 eggs have been hatched, which is an important aspect of the present studies. The significant observation of the present studies is that the **cocoon and pupal weights in F1 hybrid are higher** than that of parental ecorace, Andhra local, which may be due to increased larval period; though it is lower than that in Daba TV, while in F2 it was found to be lower than the parental stock. The **cocoon yield** of F1 and F2 hybrids has been increased when compared to parental Andhra local ecorace. In the two backcross generations, *i.e.*, F1 and F2 denier is similar to that of Daba TV parent. In the next season the F1 male and Andhra local female were allowed to mate to obtain the F2 generation.

The fecundity obtained in the two crop seasons in F1 and F2 were 325 and 170 respectively, fecundity of F1 and F2 hybrids was found to be more than the parental stock (AL-150 and Daba TV-250). The present study yielded F1 and F2 hybrid cocoons with pupal weight, shell ratio, cocoon width, reelability and shell thickness, which have shown considerable increase when compared to either or both of the parents. The post-cocoon parameters like cocoon weight, shell weight, cocoon length, denier and filament length have decreased when compared to the parental types.

***From the present studies, it may be inferred that breeding during first crop season maybe beneficial from fecundity point of view.***

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