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Silkworm-food plant-interaction: search for an alternate food plant for tasar silkworm (*Antheraea mylitta* Drury) rearing

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Abstract

An experimental rearing of tropical tasar silkworm, *Antheraea mylitta* Drury was conducted to study silkworm-food plant-interaction and thereby to search for an alternate silkworm food plant. The silkworm-food-plant-interaction was studied with six different food plant species viz. *Terminalia tomentosa*, *Terminalia arjuna*, *Terminalia belerica*, *Terminalia chebula* of Combretaceae family and *Lagerstroemia speciosa*, *Lagerstroemia parviflora* of Lythraceae family. The rearing performance of silkworm on *Lagerstroemia speciosa* in terms of cocoons per DFL and silk ratio was found comparable with *Terminalia tomentosa* and *Termonalia arjuna*, the primary tasar silkworm food plant species. These three plant species also possessed better results in terms of physiological (leaf moisture content and net photosynthesis rate) and biochemical (Chlorophyll, protein, carbohydrate and crude fibre contents) characteristics to support silkworm rearing than *Terminalia belerica*, *Terminalia chebula* and *Lagerstroemia parviflora*. The correlation study between silkworm rearing performance and food plant's constituents indicates commercial perspective of *Lagerstroemia speciosa* as an alternate food plant for tasar silkworm rearing.

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silk ratio,
photosynthesis,
transpiration,
stomatal conductance etc.

Introduction

Antheraea mylitta Drury (Order: Lepidoptera, Family: Saturniidae) is a sericigenous semi-domesticated tropical tasar silkworm, distributed all over India (12 – 31^{o}N latitude and 72 – 96^{o}E longitude). It is exploited commercially for production of tasar raw silk (Jolly *et al.*, 1974; Dash *et al.*, 1992; Suryanarayana and Srivastava, 2005). At lower altitude (30 – 50 above mean see level), it behaves as trivoltine (three crops in a year). However, it is exploited commercially as bivoltine reared two times in a year (July – August: Ist crop i.e. Rainy cocoon crop; September – October: IInd crop i.e. Autumn crop). There are about forty four ecoraces of tasar silk insect distributed over Jharkhand, Orissa, Chhattisgarh, Madha Pradesh, Andhra Pradesh, Bihar, Maharashtra, West Bengal and Uttar Pradesh of the country. Out of these ecoraces, only Daba and Sukinda are contributing in country's tasar raw silk (Rao *et al.*, 2004; Hansda *et al.*, 2008; Ojha *et al.*, 2009; Reddy *et al.*, 2010) production.

Sericigenous tasar silkworm is polyphagous, feeding primarily on *Terminalia tomentosa*, *Terminalia arjuna* and *Shrea robusta* and secondarily on more than 24 food plant species

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(Suryanarayana and Srivastava, 2005; Suryanarayana *et al.*, 2005; Reddy *et al.*, 2010). Due to existence of silkworm-food plant-interaction, the insect has food preference. The food plants, which silkworm normally prefers are known as primary food/host plants. Other food plants, where silkworms can sustain its life, but normally do not prefer, are called secondary food/host plants (Jolly *et al.*, 1974).

The constituents food plant affect silk production of the insect profoundly, affecting on survival behaviour, rate of quantity of food-intake, digestion and assimilation, which directly influence the growth and development of the silkworm (Krishnaswami *et al.*, 1970; Ray *et al.*, 1998; Sinha *et al.*, 2000; Rahman *et al.*, 2004; Saikia *et al.*, 2004). In order to increase the tasar raw silk production, exploitation of all the ecoraces and/or their food plant specificity should be established through bio-assay study of tasar silkworm on different food plant species. Therefore, for successful tasar culture both for commercial and seed crops; proper selection of food plant species is required. In the present study, an attempt was made to study the correlation between silkworm rearing performance and its food plant constituents; thereby to search for an alternate food plant silkworm rearing, commercially.

Materials and Methods

In the present study, rearing of Daba ecorace of tasar silkworm (*Antheraea mylitta* Drury) was carried out in the plant's germ-plasm-bank at Central Tasar Research and Training Institute ($23^{o}4'$ N, $85^{o}88'$ E and 708 m above mean see level), Ranchi, India during commercial rearing season. Silkworm rearing was carried out on six different food plant species viz. *Terminalia tomentosa*, *Terminalia arjuna*, *Terminalia belerica*, *Terminalia chebula* of Combretaceae family and *Lagerstroemia speciosa*, *Lagerstroemia parviflora* of Lythraceae family to evaluate the effects of food plant's constituents on rearing performance and cocoon characteristics. For this, 100 freshly hatched disease free silkworms were brushed on to each of the plant species during July – August following rearing protocol developed by CTR&TI, Ranchi, India (Gupta *et al.*, 2008). The meteorological data during silkworm rearing period are illustrated in Fig. 1.

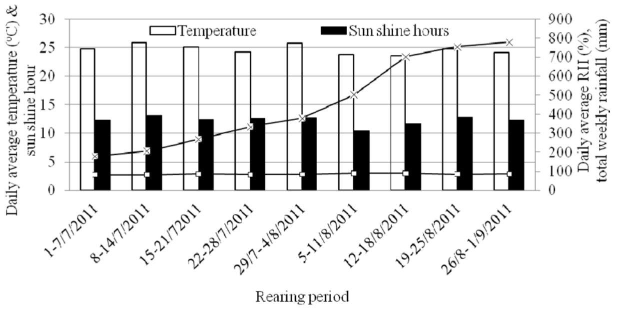

Fig. 1. Meteorological data during silkworm rearing period.

Evaluation of silkworm rearing performance

The silkworm rearing performance was evaluated by recording larval duration (from the date of brushing to cocoon formation), V^{th} stage larval weight, cocoon weight, shell weight, effective rate of rearing [ERR% = 100 × (Total number of cocoons harvested/Total number of larvae brushed)] and silk ratio [SR% = 100 × (Shell weight/Cocoon weight)].

Evaluation of physiological characteristics of food plant

Leaf moisture content (MC) was determined on fresh weight basis using following relation. To determine oven-dry weight, leaves were placed in an oven at 70^{o}C for more than 24 h till the constant weight was obtained.

MC (%) = [100 × (Fresh weight – Oven dried weight)/Fresh weight)]

Other physiological parameters viz. net photosynthesis rate, transpiration rate and stomatal conductance of leaf were evaluated using universally accepted CI-340 Photosynthesis System.

Evaluation of biochemical characteristics of food plant

Chlorophyll a, chlorophyll b and total chlorophyll content

Chlorophyll extraction and estimation (mg/g fresh weight) of leaf tissue was carried out according to spectrophotometric method (Anderson and Boardman, 1964).

Total soluble protein content

Total soluble protein (mg/g dry-weight) in the leaf was determined following the spectrophotometric method (Lowry *et al.*, 1951).

Table 1. Rearing data of tasar silkworm

Plant species	Date of brushing	Date of spinning	Larval period (d)	No. of worm brushed	No. of cocoon harvested	No. of cocoon/ DFL
T. tomentosa	11/07/2011	06/08/2011	27	100	43	86
T. arjuna	11/07/2011	07/08/2011	28	100	41	82
T. belerica	11/07/2011	15/08/2011	36	100	38	76
T. chebula	11/07/2011	20/08/2011	41	100	11	22
L. speciosa	11/07/2011	11/08/2011	31	100	40	80
L. parviflora	11/07/2011	29/08/2011	50	100	9	18

Total carbohydrate content

Total carbohydrate content (%) of leaf was determined following the Anthrone method (Hedge and Hofreiter, 1962).

Crude fibre content

The crude fibre content in leaf was determined according to oxidative hydrolytic degradation process (Maynard, 1970).

Statistical analysis

The correlation study between silkworm rearing performance and food plant's constituents was carried with standard statistical procedures. All other observed data with five (5) replications were analyzed statistically using the techniques of analysis of variance. The significance of treatment (food plant species) differences was judged by 'F' test (Cochran and Cox, 1963).

The standard error of the differences (SED±) was calculated by using following expression.

SED± = √(Error mean square × 2/pooled number of replications)

The critical differences[CD] were calculated to test the significant differences of the treatments. Critical differences were calculated by using following formula.

C. D. (5%) = (SED±) × 't'

where, t = 5% tabulated value of 't' at error degree of freedom.

Results and Discussion

The essential information regarding present experimental rearing is as follows.

1. No. of Disease Free Layings[DFLs]: 3
2. Fecundity: 200 (1 DFL is having 200 healthy eggs)
3. Source of DFLs: BSMTC, Bhagalpur, India

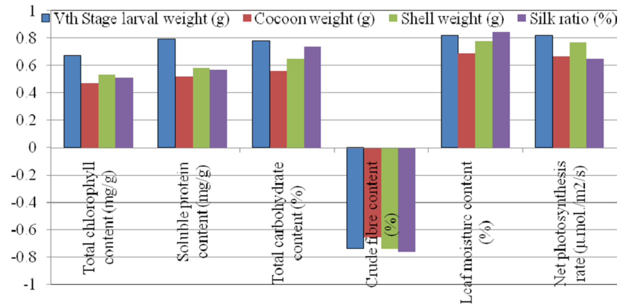

Fig. 2. Correlation between tasar silkworm rearing performance and food plant characteristics.

4. Date of coupling: 03.07.2011
5. Date of hatching/brushing: 11.07.2011

The rearing data of silkworm are presented in Table 1. It reveals that the lowest larval period of silkworm was recorded in *T. tomentosa* (27) followed by *T. arjuna* (28) and *L. Speciosa* (31). Table 1 also reveals that though *L. speciosa* is considered as secondary food plant, it resulted comparable numbers (80) of cocoons per DFL as that of the primary food plants, *T. tomentosa* (86) and *T. arjuna* (82). Likewise, number of cocoon per DFL was also higher for *T. belerica* than the nation's average value (40 – 50 cocoons/DFL).

The silkworms reared on different food plant species showed significant difference in rearing performance (Table 2). The correlation between silkworm rearing performance and food plant characteristics is depicted in Fig. 2. It shows that there is strong positive correlation between silkworm rearing performance (V^{th} stage larval weight, cocoon weight, shell weight & silk ratio) and physiological (leaf moisture content and net photosynthesis rate) and biochemical (total chlorophyll, soluble protein and total carbohydrate contents) characteristics of food plants. However, rearing performance of the silkworm is negatively correlated to crude fibre content of leaf of the food plant species.

Table 2. Tasar silkworm rearing performance on different food plant species

Plant species	Vth Stage larval weight (g)	Cocoon weight (g)	Shell weight (g)	Silk ratio (%)
T. tomentosa	41.98	12.82	1.57	12.25
T. arjuna	37.03	14.94	1.86	12.35
T. belerica	37.01	11.94	1.40	11.79
T. chebula	31.58	8.67	0.95	10.98
L. speciosa	31.91	9.25	1.21	13.05
L. parviflora	25.28	8.08	0.91	11.28
SED (±)	3.62	2.12	0.03	0.83
CD (5%)	6.24	3.66	0.05	1.43

Table 3. Physiological properties of different food plant species

Plant species	Leaf moisture content (%)	Net photosynthesis rate (µ.mol./m^2/s)	Transpiration rate (m.mol./m^2/s)	Stomatal conductance (m.mol./m^2/s)
T. tomentosa	72.07	21.56	4.71	179.11
T. arjuna	70.36	18. 32	6.11	449.19
T. belerica	70.21	15.71	3.21	109.66
T. chebula	65.24	16.12	3.39	188.94
L. speciosa	71.21	18.58	4.37	215.87
L. parviflora	64.23	12.86	4.63	103.98
SED (±)	0.44	2.12	0.03	1267.14
CD (5%)	0.76	3.66	0.05	2185.82

Comparatively, higher larval weights resulted higher cocoon weights in *T. tomentosa*, *T. arjuna* and *T. belerica*, which might be due to better rate of quantity of food in-taken, digested and assimilated (Krishnaswami *et al.*, 1970; Ray *et al.*, 1998; Sinha *et al.*, 2000; Rahman *et al.*, 2004; Saikia *et al.*, 2004) by silkworm. However, the highest value of silk ratio was recorded for the silkworm reared on *L. speciosa* (13.05%) followed by *T. arjuna* (12.35%) and *T. tomentosa* (12.25%), which might be due to better conversion of assimilated food in to raw silk by the silkworms reared on these plant species. The cocoon characteristics of the silkworms reared on the rest of the plant species were found inferior than that of above mentioned species (Table 2).

In the present experiment, all plant species showed significant differences in respect to physiological properties (Table 3). The leaf moisture content, which is having positive correlation with silkworm rearing performance (Krishnaswami, 1978; Thangamani and Vivekanandan, 1984) was recorded the highest in *T. tomentosa* (72.07%) followed by *L. speciosa* (71.21%) and *T. arjuma* (70.36%). Likewise, net photosynthesis rate was also found in higher side for the host plant species showing better rearing performance than other plant species, which indicates *T. tomentosa*, *L. speciosa* and *T. arjuma* provide better quantity of food to be assimilated by the silkworm (Tables 2, 3 and 4; Figs. 2 and 3).

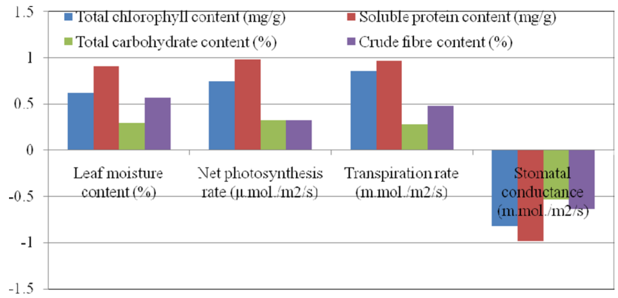

Fig. 3. Corellation between physiological and biochemical properties of different food plant species.

All the food plant species in the present experiment showed

Table 4. Biochemical properties of different food plant species

Plant species	Total chlorophyll content (mg/g)	Soluble protein content (mg/g)	Total carbohydrate content (%)	Crude fibre content (%)
T. tomentosa	2.69	15.94	8.54	9.49
T. arjuna	2.59	13.2	8.01	9.86
T. belerica	2.22	11.6	7.26	12.32
T. chebula	2.53	12.23	7.37	12.02
L. speciosa	2.56	13.37	8.27	10.23
L. parviflora	2.01	10.55	6.13	13.46
SED (±)	0.08	0.37	0.11	0.04
CD (5%)	0.13	0.64	0.20	0.07

significant differences in respect to biochemical properties (Table 4). The highest value of total chlorophyll content of leaf was recorded in *T. tomentosa* (2.69 mg/g) followed by *T. arjuna* (2.59 mg/g) and *L. speciosa* (2.56 mg/g). The total soluble protein content of leaf was found the highest in *T. tomentosa* (15.94 mg/g) followed by *L. speciosa* (13.37 mg/g) and *T. arjuna* (13.20 mg/g). The highest value of total carbohydrate content of leaf for *T. tomentosa* (8.54%) followed by *L. speciosa* (8.27%) and *T. arjuna* (8.01%) might be due to the highest values of net photosynthesis rate for these three plant species (Table 3 and 4) having positive correlation with silkworm rearing performance (Fig. 2 and 3). From data, it can be inferred that these three plant species supplied higher quantity of palatable food material to silkworm, which ultimately was reflected by better rearing performance of silkworm on these three plant species. However, crude fibre content of leaf, the higher dose of which causes detrimental effect on silkworm nutrition (Krishnaswami, 1978) was found the lowest in *T. tomentosa* followed by *T. arjuna* and *L. speciosa* with a value of 9.49, 9.86 and 10.23%, respectively (Table 4).

Antheraea mylitta is an important economic insect and also a tool to convert leaf protein of food plants into silk protein. It was reported that the larvae of *Bombyx mori* fed with mulberry leaves enriched with amway protein, showed significant enhancement of larval, cocoon and shell weight (Krishnaswami, 1978; Singhvi and Bose, 1991). Carbohydrate, protein and lipid are the main sources of energy at the time of larval-larval, larval-pupal, pupal-adult transformation (Krishnaswami, 1978; Thangamani and Vivekanandan, 1984).

In the present study, it was found that the leaf of food plant with more moisture, protein, carbohydrates and less crude fibre is the best from tasar silkworm nutritional point of view, which was reflected in terms of better rearing performance of the silkworm on *T. tomentosa*, *T. arjuna* and *L. speciosa*. Similar result was recorded in case of *Bombyx mori* silkworm nutrition, where the mulberry leaf with more moisture, protein, sugar and carbohydrates and less minerals and crude fibre content was found to be the best from silkworm nutrition point of view (Krishnaswami, 1978; Rai *et al.*, 2006). Thus, the higher leaf protein and carbohydrate and less crude fibre contents of *T. tomentosa*, *T. arjuna* and *L. speciosa* in our experimental study are found to be desirable for the healthy growth of tasar silkworm larvae and more cocoon production. The higher value of silk ratio recorded for silkworm reared on *L. speciosa* (13.05%) than on *T. arjuna* (12.35%) and *T. tomentosa* (12.25%), might be due to better conversion of assimilated food in to raw silk by the silkworms reared on *L. speciosa*.

Conclusion

From the present study, it can be concluded that the rearing of tasar silkworm, *Antheraea mylitta* on *L. speciosa*, which is yet to include under primary food plant group, is as profitable as the rearing of silkworm on *T. tomentosa*, and *T. arjuna*, the primary food plants. The numbers of cocoons harvested per DFL were found to be far higher than national benchmark from these three plant species. Silk ratio of cocoons, harvested from *L. speciosa*, was even found to be higher than the cocoons harvested from *T. tomentosa* and *T. arjuna*. The better rearing performance might be due to higher leaf protein and carbohydrate, and less crude fibre contents of *T. tomentosa*, *T. arjuna* and *L. speciosa* compared to other plant species. This condition of food plants is undoubtedly desirable for the healthy growth of silkworm larvae thereby resulting more cocoon production and silk ratio. However, the present experimental finding does not advocate *Terminalia chebula* and *Lagerstroemia parviflora* to be used for tasar silkworm rearing. The present finding recommends mass tasar silkworm rearing trial at farmer's level on *Lagerstroemia speciosa* for validation of this plant species as primary food plant for tropical tasar silkworm (*Antheraea mylitta* Drury) rearing, commercially.

Reference

Anderson, J.N., and Boardman, N.K. (1964). Studies on greening of dark brown bean plants. VI. Development of phytochemical activity. Aust. J. Bio. Sci. 17, 93-101.

Cochran, W.G., and Cox, G.M. (1963). Experimental design. John Willey and Sons, Inc. New York, USA.

Dash, A.K., Nayak B.K, and Dash, M.C. (1992). The effect of different food plants on cocoon crop performance in the Indian tasar silkworm, *Antheraea mylitta* Drury (Lepidoptera: Saturniidae). J. Res. Lepidopt. 31, 127-131.

Gupta, V.P., Mishra R.K., and Suryanarayana, N. (2008). Illustrated manual of tropical tasar culture technology. I. Host plant maintenance and silkworm rearing. Central Tasar Research and Training Institute, Central Silk Board, Government of India, Ranchi, India.

Hansda, G., Reddy, R.M., Sinha, M.K., Ojha N.G., and Prakash, N.B.V. (2008). Ex-situ stabilization and utility prospects of Jata ecorace of tropical tasar silkworm, *Antheraea mylitta* Drury. Int. J. Indust. Entomol. 17(2), 169-172.

Hedge, J.E., and Hofreiter, B.T. (1962). Carbohydrate chemistry. Whistler R. L. and J.N. Be Miller. 17 (eds.), Academic Press, New York.

Jolly, M.S., Sen, S.K., and Ahsan, M.N. (1974). Tasar culture. (1st Ed.), pp. 266. Central Silk Board, Bombay, India.

Krishnaswami, S. (1978). New technology of silkworm rearing. Indian silk. 16(12), 7-15.

Krishnaswami, S., Noamani, K.R., and Ahsan, M.N. (1970). Studies on quality of mulberry leaves and silkworm cocoon crop production. Part I. Quality difference to varieties. Indian J. Seric. 44(1), 127-130.

Lowry, O.H., Rosebrough, J.H., Farr, A.L., and Randall, R.J. (1951). Protein measurement with Folin-Phenol reagent. J. Bio. Chem. 193, 265-275.

Maynard, A.J. (1970). Methods in food analysis. Academic Press, New York.

Ojha, N.G., Reddy, R.M., Hansda, G., Sinha, M.K., Suryanarayana, N., and Prakash, N.B.K. (2009). Status and potential of Jata, a new race of Indian tropical tasar silkworm (*Antheraea mylitta* Drury). Academic J. Entomol. 2(2), 80-84.

Rahman, M.S., Bari, M.A., and Joarder, O.I. (2004). Studies on genetic variability and correlation of leaf yield and its contributing characters in Mulberry varieties, *Morus* sp. Indian J. Seric. 42(2), 151-154.

Rai, S., Aggarwal, K.K., and Babu, C.R. (2006). Influence of host plant (*Terminalia arjuna*) defences on the evolution of feeding behaviour in the tasar silkworm. Current Sci. 91(1), 68-72.

Rao, K.V.S., Mahobia, G.P., Roy, G.C., and Sinha, B.R.R.P. (2004). Relevance of in-situ conservation of wild tasar (*Antheraea mylitta* Drury) in India. Indian J. Ecol. 31, 127-131.

Ray, N., Bhattacharya, A., Senapati, S.K., and Deb, D.C. (1998). Selection of mulberry varieties (*Morus* sp.) based on yield, nutrition elements and its rearing upon biovoltine silkworm (*Bombyx mori* L) for larval traits. Environ. Ecol. 16(1), 91-94.

Reddy, R.M., Sinha, A.K., Kumar, R., and Prasad, B.C. (2010). Parental combination and rearing season compatibility for silk yield in tropical tasar silkworm, *Antheraea mylitta* Drury. World Applied Sci. J. 9(8), 855-859.

Saikia, S., Handique, R., Pathak, A., and Das, K. (2004). Rearing performance of muga on the primary and secondary food plants with an attempt for revival of new extinct mejankari silk heritage of Assam. Sericologia. 44, 373-376.

Singhvi, N.R., and Bose, P.C. (1991). Sericin – a deciding factor for the quality of cocoons and raw silk. Indian Silk. 26-28.

Sinha, U.P.S., Bajepeyi, C.M., Sinha, A. K., Chari, B.N.B., and Sinha, B.R.R.P. (2000). Food consumption and utilization in *Antheraea mylitta* Drury larvae. Int. J. Wild Silkmoth and Silk. 5, 182-186.

Suryanarayana, N., and Srivastava, A.K. (2005). Monograph on tropical tasar silkworm. Central Tasar Research and Training Institute, Central Silk Board, Government of India, Ranchi, India.

Suryanarayana, N., Kumar, R., and Gargi (2005). Monograph on Indian Tropical Tasar silkworm food plants. Central Tasar Research and Training Institute, Central Silk Board, Government of India, Ranchi, India.

Thangamani, R., and Vivekanandan, M. (1984). Physiological studies and leaf analysis in the evaluation of best mulberry varieties. Sericologia. 24(3), 317-324.