Host Plant Suitability and Altitudinal Variation in Cocoon Size of the Indian Tarsar Silk Moth Antheraea mylitta Drury (Lepidoptera: Saturniidae)

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Source: The Journal of the Lepidopterists' Society, 71(3) : 182-188

Published By: The Lepidopterists' Society

URL: https://doi.org/10.18473/lepi.71i3.a10

Journal of the Lepidopterists' Society
71(3), 2017, 182–188

HOST PLANT SUITABILITY AND ALTITUDINAL VARIATION IN COCOON SIZE OF THE INDIAN TARSAR SILK MOTH *ANTHERAEA MYLITTA* DRURY (LEPIDOPTERA: SATURNIIDAE)

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ABSTRACT. An experimental rearing of *Antheraea mylitta* Drury was carried out in the rearing fields at Similipal Biosphere Reserve, Mayurbhanj, Odisha, India, during the rainy season under somewhat natural conditions on live host plants. Female larvae were reared at three elevations utilizing the same eight host plant species, viz. Asan (*Terminalia alata* W. & A.) in family Combretaceae, Arjun (*Terminalia arjuna* W. & A.) (Combretaceae), Sal (*Shorea robusta* Gaertn) (Dipterocarpaceae), Ber (*Ziziphus jujuba* Gaertn) (Rhamnaceae), Sidha (*Lagerstroemia parviflora* Roxb.) (Lythraceae), Dha (*Anogeissus latifolia* Wall.) (Combretaceae), Bahada (*Terminalia belerica* (Gaertn) Roxb.) (Combretaceae) and Jamun (*Syzygium cumini* (L.) Skeels) (Myrtaceae) at each location. The larval growth on various host plants was evaluated in terms of the size, weight, and volume of the resulting cocoons. The host plant that produced the highest quality cocoons at all the elevations is Sal (*Shorea robusta*). The least suitable host plant at all the elevations is Jamun (*Syzygium cumini*). Results for all the eight species of host plants and the influence of parameters related to elevation are presented in detail. The data may be useful for selecting alternate host plants that might aid the sericulture industry in those situations when the "optimal" plant species are not available.

Additional key words: *Ziziphus jujuba* Gaertn, foliovorous, trivoltine, rainy, fifth instar

The present study was carried out during rainy season in order to assess the growth of female larva of "Daba ecorace" of *A. mylitta* in terms of the size, volume, and weight of the resulting cocoon on different food plants at different altitudes for proper gradation of food plants and altitudes. *Antheraea mylitta* Drury (Satuniidae) which produces the traditional Indian tasar silk is a foliovorous semi-domesticated tropical tasar silk moth. It is distributed in the form of about 44 ecoraces over varied geographical tropical zones of our country, particularly in the states of West Bengal, Jharkhand, Bihar, Madhya Pradesh, Odisha, Andhra Pradesh and Maharashtra. The State of Odisha has two ecoraces, viz. Daba and Sukinda (semi domesticated varieties) under *Antheraea mylitta* Drury. In India, it is trivoltine (TV) (three generations produced in a year) at lower altitude (50 – 300 m ASL). However, it is exploited as bivoltine (BV), reared during July–August (first crop or rainy cocoon crop) and September–October (second crop or autumn crop) for the commercial production of tasar silk without utilizing the third generation. Though polyphagous in nature, it is usually reared on primary tasar host plants viz; *Terminalia alata* (Asan), *Terminalia arjuna* (Arjun) and *Shorea robusta* (Sal) by aboriginals during seed crop (July–August) and commercial crop (Sep.–Oct.) seasons. However, nearly two dozen food plants like *Ziziphus jujuba* (Ber), *Lagerstroemia parviflora* (Sidha), *Anogeissus latifolia* (Dha), *Terminalia belerica* (Bahada), *Syzygium cumini* (Jamun), etc. of secondary importance for *A. mylitta* silk worm are also abundant in the natural forests at different altitudes (Sinha & Jolly 1971). The vast availability of these unutilized food plants can be exploited sustainably by the local tribes for the rearing and cocooning of *A. mylitta*. Feeding of nutritionally enriched leaves shows better growth and development of silkworm larvae which directly influences the quality and quantity of silk production. Hence evaluating ecoraces in relation to larval host plant suitability may have a positive impact on the quantity and quality of silk produced by local tribes.

Studies on the cocoon crop performance of *A. mylitta* reared on a few additional food plants like Ber (*Ziziphus jujuba*), Sidha (*Lagerstroemia parviflora*) and Dha (*Anogeissus latifolia*) at lower altitude during different rearing seasons have already been conducted (Dash et al.1992). Information are also available on induction of biomolecules in mature leaves of *Terminalia arjuna* (Abraham et al. 2004), evaluation of Novel Tasar

Silkworm Feed (Kumar et al. 2013), effect of Feeding Trial (Singh et al. 2011), comparative Study of the Effect of Different Food Plants (Deka & Kumari 2013), altitudinal and seasonal Effects on Growth (Jena et al. 2014), evaluation of cocoons preservation (Dinesh et al. 2012), development of fifth instar female larva (Jena et al. 2015), tropical wild silk cocoons (Mohanty 2003), wild silks of the world (Peigler 1993), studies on cocoon characteristics (Nishide 1998), preservation of seed cocoons (Kapila et al.1992), rearing and cocooning of tropical tasar silk worm (Ojha et al.1994), cocoon and post cocoon studies (Rao & Shamitha 2000), but no information is available on the growth performance of larvae in terms of size parameters of resulting cocoons on different primary as well as unutilized secondary host plants at different altitudes during different seasons.

MATERIALS AND METHODS

The rearing of larvae of "Daba ecorace" of *A. mylitta* during rainy season was conducted selecting a number of healthy food plants having identical age and growth at random from each of the eight species at three different altitudes i.e. lower altitude (50–300 m ASL), medium altitude (301–600 m ASL) and higher altitude (601–900 m ASL). The food plants in wild condition were kept under watch and ward activity throughout the rearing process to protect the larvae from predators and parasitoids. The rainy crop experiment was started with 3000 hatchlings of the same age hatched from 5 B.V. (bivoltine) dfls (disease free lyings) of different females of 'Daba ecorace' of *A. mylitta* supplied by Research Extension Centre, Central Silk Board, Bangriposi, Mayurbahnj, Odisha. The larvae were reared as per recommendation of FAO manual and guidelines published by Regional Tasar Research Station, Central Silk Board, Baripada, Mayurbhaj, Odisha, up to mature fifth instar stage when prominent sexual markings appeared. The mature fifth instar female larvae on each food plant were selected and were marked separately by use of level cards bearing serial number. The larval survival rates related to the different host plants and elevations was about 100%.The larvae allotted with different serial numbers were allowed to grow up to cocoon stage. The percentage of healthy vs unhealthy cocoons for each host plant and elevation was about 99%. The healthy cocoons selected on basis of morphological scoring were collected from each type of food plant and were stored in the grainage house according to their serial numbers. The larval growth was measured in terms of length (cm), diameter (cm), volume (cm^3) and weight (g) of the resulting cocoon. The length and diameter of the cocoon were measured by using millimeter scale and slide caliper respectively. The weight of cocoon was determined gravimetrically by using 0.001 mg sensitive digital balance after removing the pupa by cutting open the shell cover of each cocoon. The volume of cocoon was measured by using water displacement technique. The data so obtained were subjected to calculation of mean and standard deviation ($\bar{x} \pm SD$) values for each growth parameter in each type of food plant at different altitudes. Further, the data were analyzed by using standard t-test and analysis of variance (Sokal & Rohlf 1969). The graphical presentation was also prepared by use of the data to study and establish the correlation of growth performance with food plants and altitude. Further, in order to study the effect of environmental parameters on growth, the air temperature (0 C), RH (%) and rain fall (mm) were recorded at each elevation and the mean ($\bar{x} \pm$ SD) value of each was calculated.

RESULTS

Lower Altitude. The growth of female larvae of *A. mylitta* was evaluated in terms of length (cm), diameter (cm), volume (cm^3) and weight (g) of the resulting cocoons during rainy season at lower altitude when the mean ($\bar{x} \pm SD$) air temperature, RH and rain fall were 31.83 ± 0.54 °C, 83.47 ± 1.31% and 300.32 ± 41.31mm respectively. The highest values of length (4.98 ± 0.02), diameter (2.97 ± 0.02), volume (28.33 ± 0.12) and weight (10.64 ± 0.06) were observed in case of the cocoon resulting from the Sal grown larva (Table 1). The cocoon from the female larva raised on Jamun showed the lowest values of length (3.98 ± 0.04), diameter (2.01 ± 0.06), volume (25.92 ± 0.14) and weight (8.98 ± 0.07) (Table 1).

Significant ($p < 0.05$) difference in length, diameter, volume and weight of the cocoons resulting from the female larvae raised on different food plants was indicated by the t-test. The ANOVA test also showed significant ($p < 0.01$) interaction between the food plants and the size parameters of the cocoons grown at lower altitude during rainy season. In view of comparatively superior performance of the size parameters of cocoons from female larvae of *A. mylitta* during rainy season at lower altitude the food plants were graded in the order Sal > Asan > Arjun > Ber > Sidha > Dha > Bahada >Jamun.

Medium Altitude. The growth of female larvae in terms of length (cm), diameter (cm), volume (cm^3) and weight (g) of the resulting cocoons during rainy season at medium altitude was also assessed when the mean ($\bar{x} \pm SD$) air temperature, RH and rain fall were 26.08 ± 0.32 °C, 80.15 ± 1.64 % and 407.86 ± 32.64 mm respectively. The cocoon from the female larva grown on Sal showed the highest size parameters in terms of

TABLE 1. Growth ($\bar{x}$ ± SD) of female larva on various host plants measured in terms of size parameters of the resulting cocoon during rainy season at lower altitude

Food plants	Length (cm)	Diameter (cm)	Volume (cm 3)	Weight (g)
Asan	4.83 ± 0.03	2.86 ± 0.03	28.02 ± 0.11	10.41 ± 0.04
Arjun	4.71 ± 0.04	2.74 ± 0.01	27.71 ± 0.13	10.23 ± 0.03
Sal	4.98 ± 0.02	2.97 ± 0.02	28.33 ± 0.12	10.64 ± 0.06
Ber	4.57 ± 0.03	2.62 ± 0.04	27.36 ± 0.09	10.06 ± 0.04
Sidha	4.46 ± 0.02	2.49 ± 0.03	27.07 ± 0.11	9.82 ± 0.07
Dha	4.31 ± 0.04	2.34 ± 0.02	26.74 ± 0.13	9.51 ± 0.06
Bahada	4.12 ± 0.03	2.18 ± 0.04	26.33 ± 0.12	9.27 ± 0.08
Jamun	3.98 ± 0.04	2.01 ± 0.06	25.92 ± 0.14	8.98 ± 0.07

TABLE 2. Growth ($\bar{x}$ ± SD) of female larva on various host plants measured in terms of size parameters of the resulting cocoon during rainy season at medium altitude

Food plants	Length (cm)	Diameter (cm)	Volume (cm 3)	Weight (g)
Asan	5.26 ± 0.02	3.02 ± 0.02	33.01 ± 0.13	10.57 ± 0.06
Arjun	5.13 ± 0.02	2.91 ± 0.03	32.67 ± 0.11	10.26 ± 0.04
Sal	5.42 ± 0.03	3.13 ± 0.02	33.41 ± 0.16	11.84 ± 0.07
Ber	5.01 ± 0.04	2.77 ± 0.04	32.29 ± 0.14	10.01 ± 0.03
Sidha	4.88 ± 0.03	2.64 ± 0.02	31.92 ± 0.13	9.72 ± 0.06
Dha	4.76 ± 0.02	2.49 ± 0.03	31.53 ± 0.12	9.43 ± 0.07
Bahada	4.61 ± 0.03	2.32 ± 0.04	31.16 ± 0.11	9.11 ± 0.04
Jamun	4.46 ± 0.04	2.18 ± 0.03	30.74 ± 0.11	8.78 ± 0.08

TABLE 3. Growth ($\bar{x}$ ± SD) of female larva on various host plants measured in terms of size parameters of the resulting cocoon during rainy season at higher altitude

Food plants	Length (cm)	Diameter (cm)	Volume (cm 3)	Weight (g)
Asan	5.68 ± 0.04	3.18 ± 0.03	38.16 ± 0.14	12.49 ± 0.07
Arjun	5.56 ± 0.02	3.06 ± 0.02	37.77 ± 0.12	12.22 ± 0.04
Sal	5.84 ± 0.04	3.31 ± 0.04	38.56 ± 0.11	12.81 ± 0.06
Ber	5.43 ± 0.03	2.93 ± 0.03	37.41 ± 0.13	11.94 ± 0.03
Sidha	5.31 ± 0.02	2.78 ± 0.02	36.96 ± 0.16	11.67 ± 0.08
Dha	5.17 ± 0.03	2.64 ± 0.03	36.42 ± 0.12	11.43 ± 0.04
Bahada	4.98 ± 0.04	2.47 ± 0.04	36.08 ± 0.11	11.15 ± 0.07
Jamun	4.79 ± 0.03	2.29 ± 0.06	35.63 ± 0.13	10.78 ± 0.09

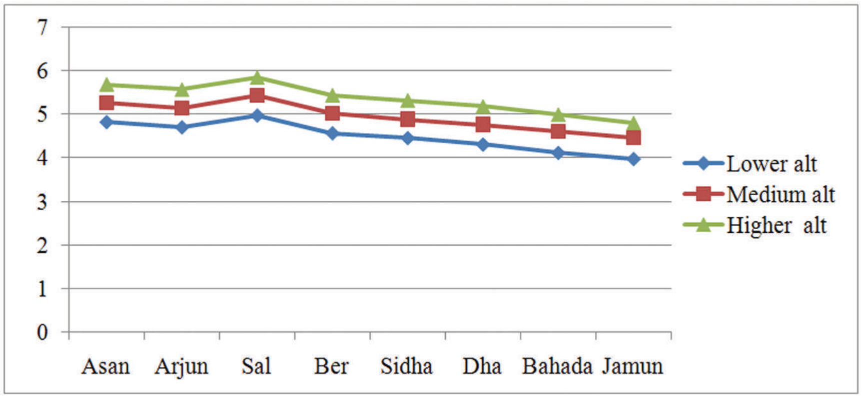

FIG. 1. Growth in length (cm) of cocoon resulting from female larva on various host plants during rainy season at different altitudes.

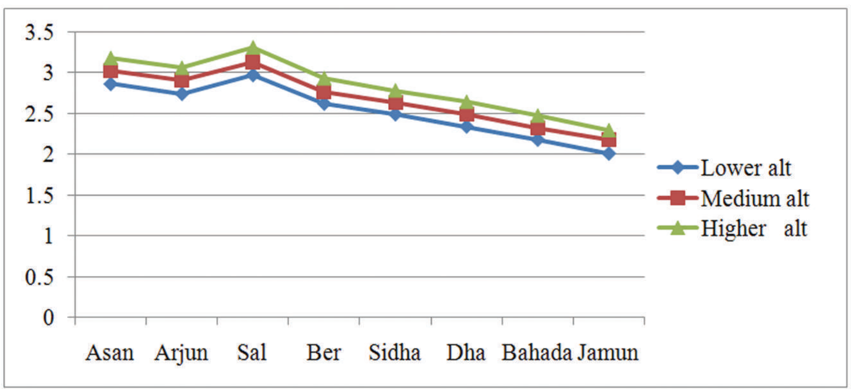

FIG. 2. Growth in diameter (cm) of cocoon resulting from female larva on various host plants during rainy season at different altitudes

length (5.42 ± 0.03), diameter (3.13 ± 0.02), volume (33.41 ± 0.16) and weight (11.84 ± 0.07) (Table 2). The lowest values of length (4.46 ± 0.04), diameter (2.18 ± 0.03), volume (30.74 ± 0.11) and weight (8.78 ± 0.08) were observed in case of the cocoon procured from Jamun (Table 2).

The t-test showed significant ($p < 0.05$) difference in length, diameter, volume and weight of cocoons from female larvae raised on various host plants. Significant ($p < 0.01$) interaction between the different food plants and the size parameters of cocoons spun by female larvae grown at medium altitude during rainy season was also observed from ANOVA test. On the basis of comparatively higher values of growth indices of cocoons resulting from female larvae during rainy season at medium altitude, the experimental food plants were ranked as Sal followed by Asan, Arjun, Ber, Sidha, Dha, Bahada and Jamun.

Higher Altitude. Likewise, at higher altitude during rainy season, the growth of female larvae in terms of length (cm), diameter (cm), volume (cm3) and weight (g) of the resulting cocoons was also evaluated when the mean ($\bar{x}$ ± SD) air temperature, RH and rain fall were 22.86 ± 0.47 °C, 86.67 ± 1.62 % and 608.38 ± 49.91 mm respectively. The highest values of length (5.84 ± 0.04), diameter (3.31 ± 0.04), volume (38.56 ± 0.11) and weight

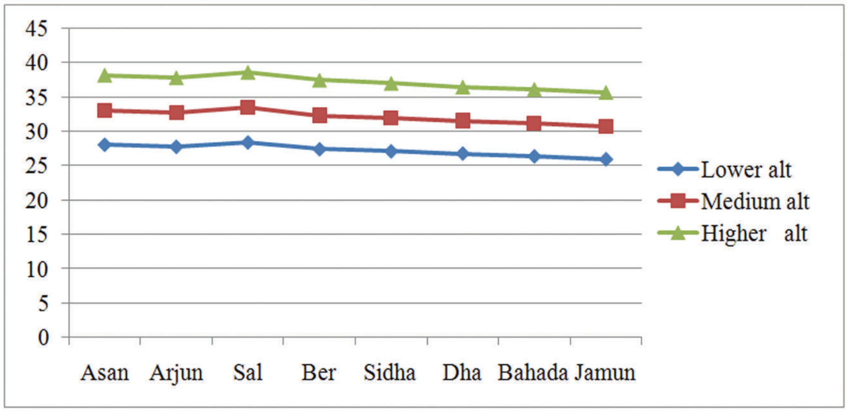

FIG. 3. Growth in volume (cm^3) of cocoon resulting from female larva on various host plants during rainy season at different altitudes.

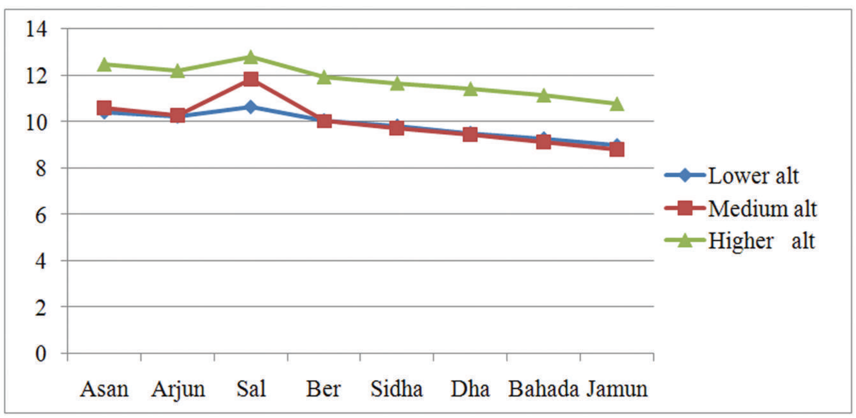

FIG. 4. Growth in weight (g) of cocoon resulting from female larva on various host plants during rainy season at different altitudes.

(12.81 ± 0.06) were observed in case of cocoon from female larva grown on Sal (Table 3).The cocoon procured from Jamun exhibited the lowest length (4.79 ± 0.03), diameter (2.29 ± 0.06), volume (35.63 ± 0.13) and weight (10.78 ± 0.09) at higher altitude during rainy season (Table 3).

The t-test indicated significant ($p < 0.05$) difference in all the size parameters of the cocoons resulting from female larvae grown on different food plants. The ANOVA test also showed significant ($p < 0.01$) interaction between the food plants and the growth indicators of cocoons from female larvae at higher altitude during rainy season. Considering the overall performances of size parameters of cocoons during rainy season at higher altitude, the food plants were graded in the order Sal > Asan > Arjun > Ber > Sidha > Dha > Bahada >Jamun.

At all the three altitudes, during the rainy season, larval growth was superior on Sal and lowest on Jamun hosts, as judged by cocoon length, diameter, volume and weight. (Fig. 1, Fig. 2, Fig. 3 & Fig. 4).

DISCUSSION

Production of better quality cocoons spun by larva of *A. mylitta* during winter season was earlier reported (Sengupta 1986, Dash et al. 1992). Jolly et al. (1974)

reported a superior cocoon crop when larvae raised on Sal. Dash et al. (1992) recorded superiority of Sal for cocoon crop parameters (weight of cocoon, pupa and shell) at lower altitude during rainy season only; whereas superiority of Asan was observed during autumn and winter season in the same altitude. In the present investigation the growth of female larva in terms of length, diameter, volume and weight of resulting cocoons during rainy season at lower, medium and higher altitudes was observed to be the highest in Sal. This shows the superiority of Sal among all the host plants for cocoon crop performance of *A. mylitta*. This might be due to better nutritional supplement obtained from Sal leaf for growth of cocoon favoured by prevailing optimum climatic conditions which can be ascertained by further biochemical investigation.

Nayak et al. (1992) reported that voltinism in wild silk moth *Antheraea paphia* L. is primarily governed by altitudinal gradient as well as the changing environmental factors. Change of attitude also influences the change of body size in many lepidopterans and there is a positive size to altitude relation (Sullivan & Miller 2007). The life span and growth of different stages of *Antheraea paphia* L. varies at different altitudes (Dey et al. 2010).The present findings reflect the highest growth of female larvae in terms of size parameters of resulting cocoons in all respect at higher altitude during rainy season when the mean ($\bar{x}$ ± SD) air temperature, RH and rainfall were 22.86 ± 0.47 °C, 86.67 ± 1.62 % and 608.38 ± 49.91 mm respectively irrespective of the species of host plants. The lowest larval growth in terms of size parameters of cocoons spun was recorded at lower altitude during rainy season when the mean ($\bar{x}$ ± SD) air temperature, RH and rainfall were 31.83 ± 0.54 °C, 83.47 ± 1.31% and 300.32 ± 41.31mm respectively. The probable reasons for the greater performance of growth parameters of cocoons from female larvae of *A. mylitta* with increase in altitude might be due to decrease in temperature but increase in RH as reported by many earlier workers in different Antheraea species.

Jolly (1966) reported that Asan, Arjun and Sal host plants are of primary importance and are most often used for cocoon crop performance. Dash et al. (1992) reported acceptable cocoon crop performance on the food plants like Asan, Arjun, Sal, Ber, Sidha and Dha only. But the present study indicates consideration of Ber, Sidha and Dha as alternate hosts for rearing activities of *A. mylitta* when there is inadequacy of primary host plants in the rearing field without significantly reducing the cocoon crop yield, although they are graded as secondary food plants by Jolly (1966). The present finding further indicates encouraging results on Ber which can be also included as a primary food plant of *A. mylitta*, since the overall performance on it remains very much at par with Sal and Arjun. However, in case of acute shortage of food plants during peak period of rearing seasons, the consideration of food plants like Sidha and Dha for rearing purpose is suggested here. In the present study the growth performance of female larvae in terms of size parameters of resulting cocoons on Bahada food plant indicates acceptable results for its utilization at the time of severe scarcity of food plants. The growth performance was unsuitable on Jamun (*Syzygium cumini*) at all the three altitudes during rainy season which indicates the commercial non viability of this food plant for rearing activities. In order to draw a concrete conclusion, further investigation on the above growth parameters at the other stages of life cycle of the silk worm during different rearing seasons may be carried out.

ACKNOWLEDGEMENTS

The authors are thankful to the authorities of Regional Tasar Research Station (RTRS), Central Silk Board, Baripada, Mayurbhanj, Odisha, India for providing field facilities and the Head, Post Graduate Department of Biosciences and Biotechnology, Fakir Mohan University, Nuapadhi, Balasore, Odisha, India for the technical assistance.

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Submitted for publication 10 April 2016; revised and accepted 3 December 2016.