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Behavioural Analysis of Genetic Variants of Drury in a Natural Population: Similipal Biosphere Reserve a Case Study

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Abstract: Modal is a *Shorea* based ecorace of tropical tasar silkworm *Antheraea mylitta* Drury, exclusively wild, multiplies sou moto in nature, univoltine, almost disease free, produces the heaviest cocoon with highest silk content among all the sericigenous lepidopterans of world and contributes 19% to raw silk production of India. There is a great variation in the genotypes of Modal in the varied ecological conditions of Similpal forest. However tussar silk has been fascinating the human society since time immemorial and it is regarded as "Queen of textiles". Silk is the most elegant textiles in the world with unparalleled grandeur, natural shine, inherent affinity for dyes and high absorbance. It is of light weight, soft in touch and has high durability besides organic in nature The Demand for it is growing constantly at the present time, However Tussar silk is very much associated with Indian tradition and culture. It always enriches sacredness, religious faith and it promotes the progress of science, technology and economics. So, it is treasured like gold and offered as gift by each and every nation of all over the globe. The sector of sericulture has been emerged to explore more in this field to boost the contribution for mankind. It includes both agriculture and industrial activities. Sericulture involves the raising of food plants for silkworm, silkworm rearing for production of cocoons, reeling and spinning of cocoon for products of yarn, weaving of silk yarn for production of fabric etc. The genus Antheraea is very important from economic point of view since this produce Tasar and Muga silks and has a direct bearing on sustainable resource management and ecosystem development. Tropical tasar silkworm Antheraea mylitta Drury is exploited in country for commercial silk production and improved by means of optimial utilisation of the ecosystem.The Modal unique Ecorace which is found in Similipal Biosphere Reserve (SBR) of Mayurbhanj district. It predominantly feeds on sal producing very high quality of cocoons rich in silk content. However this has a strong impact on the local economy of the immediate community. So there is a urgent need of studying the behavioural pattern of drury in the SBR.Here in this study an attempt has been made in this context.

Index *terms*: Queen of textiles, Sericulture, cocoons, Ecorace

INTRODUCTION

Silk is one of a natural fibre with glorious tradition of fashion.The most unique feature of this is that it is the only fibre which can be woven directly into fabric. Silk is mostly preferred much than others for its lusture and texture since a long time. Silk has been used since the reign of kings and emperors. In the holy festivals and rituals, silken clothes and strings are used. The guests present wedding couple with silken robes to wear and to enhance their love. Natural animal silk (O. E. *seolc* – silk; L. *sericum* – silk; Gr. *serikos* – Chinese silkworm) is a fibre produced by the larvae of a silkworm moth, consisting mainly of fibroin coated with sericin, formed by the hardening of a liquid emitted from the spinning gland (salivary gland). In cross section, the silk filament under the microscope shows a figure just like the Arabic numeral eight (8). There is a central core of fibrous protein with surrounding gum like sericin.

Sericulture includes the scientific method of rearing the food plants, production of silkworm eggs, conservation and rearing of silkworms, culminating with the production and dispersal of silk cocoons. It is a labour intensive, export oriented, employment creating and income generating agro based cottage industry providing quick returns in shorter duration and does not involve utilization of sophisticated machinery. In India, sericulture is as old as the Indian civilization. The knowledge of silkmoth and silk was known to Indians years ago. Nanavaty (1965) stated that India cultivated wild silk independent of China from very ancient times. The domestication of silkworm *Bombyx mori* is thought to have originated in the Himalayan foot-hill (Thangavelu and Joshi, 1983) and that the Aryans first discovered the silkworm in the Sub-Himalayan regions.

Indian silk is known all over the world for its quality, quantity and design. However sericulture is being practiced in dozens of countries world over. Countries like India, Japan and China has international institutions and training centres. The natural silk is broadly of two types namely plant silk fibre and animal silk fibre. The natural silk of plant origin is obtained from the members of the family *Bombacaceae*. The animal silk is further of two types such as mulberry and non-mulberry. Mulberry silkmoth is a domesticated type whereas non-mulberry is universally known as "wild silk" .The non-mulberry variety is classified into two types, that is, insect and non-insect types. The insect type of silk is obtained from nine different types of insects. These are named as (i) eri (ii) muga (iii) anaphe (iv) cricula (v) fagara (vi) coan (vii) weaver ant silk (viii) green lacewing fly silk and (ix) tussar. The non-insect type of silk is of two types namely (i) mussel silk obtained from molluscas and (ii) spider silk obtained from spiders. Insect type of silk is again classified as (i) commercial and (ii) non-commercial type. Eri, muga, tussar, anaphe, fagara and coan are commercial types of insect silk whereas the non-commercial type of silk is produced from the weaver ant and green lacewing fly. The non-insect silk obtained from mussel and spider is non-commercial type. Recently the wild silks, viz., tasar (both tropical and temperate or oak tasar), eri and muga have been given a new name "vanya silk" (Anonymous, 2006). Mulberry silk insect is monophagous whereas the non-mulberry silk insects are polyphagous. Similipal Biosphere Reserve of Mayurabhanj district of Orissa is one of a most suitable place for Modal cocoons. The tribals of this place made this as their part of livelihood.

IMPORTANCE OF SERICULTURE

Sericulture, the cultivation of silk is an agro-industry, the economic end product of which is silk. It is highly viable, employment creating and income generating industry providing quick returns in shorter duration. Undoubtedly, it plays a pivotal role in reducing unemployment and in assisting the poorest to make a decent living. Today, sericulture is the main source of livelihood either directly or indirectly for a large number of people, the majority of whom are from the economically retarded section of the society – the Scheduled Castes (SCs) and Scheduled Tribes (STs). It is such a product that it is exclusively prepared by poorest of the poor but luxuriously used by the rich. Sericulture, thus, plays an important role in transferring wealth from rich, the consumers, to the poor, the rearers. China is now the biggest silk producing country in the world where about 20 million people are engaged in sericulture and India, ranking second, provides employment to about 5.5 million people. Silk, as an agro-based industry, is a natural fibre for the integration of a set of interdependent rural and semi-urban based activities such as cocoon production, cocoon reeling, yarn twisting, weaving and finally trading. While the cultivation of the food plants and raising of cocoons are agricultural in nature, the production of raw and spun silk are cottage industry based. All these activities result in employment at the rate of 13 work-year per hectare.

The Forest Conservation Act 1980 adjudicates the fact that "tasar cultivation in the forest area by the tribals as a means of their livelihood without taking monoculture, Asan and Arjuna plantation shall be treated as forest activities. Therefore, no prior approval of the Central Government under the act is necessary (Section 1.5 (1))".

Sericulture can be started by anyone interested in its culture; women, men, young, children, working class, retired or even handicapped. Very easy to acquire and cultivate, sericulture has tremendous scope for the development of ancillary industries like pharmaceuticals, cosmetics, food industry etc. and can contribute greatly to the welfare and economy of mankind. In view of its immense uses and output involving less input, time and energy, serious attention is being paid to promote both the exploited and unexploited potential of sericulture in India and elsewhere not only to earn foreign exchange but also alleviate poverty among rural.

LITERATURE REVIEW

There are many reports on different scientific aspects of tussar silkworm A. mylitta. However, studies are mostly confined to semi-domestic Daba ecorace for example the reproductive characters are reported by Dash and Nayak, 1990; Mishra et al., 1993; Ojha et al., 1994, 1999; Khan et al., 2000 and Narain et al., 2003. The reports on the wild silk moths of tasar silkworm are scanty. Nayak et al., 1993 and Dash et al., 1994 studied the reproductive behaviour of wild tasar silk moth. Foraging of silkworm on variety of food plants, annual precipitation, day length, plant succession *inter alia* factors like latitude, longitude, altitude etc of different areas lead to marked life cycle differences expressing wide variations in phenotypic, physiological and behavioural traits resulted in formation of ecoraces (Srivastava *et al.*, 2004). Cryptic variability adjudicates that 19 ecoraces out of 44 are Sal fed (*Shorea robusta*) and occur naturally in wild form. Sharan *et al.,* (1994) observed that by scheduling the period of brushing in Daba ecorace of *A. mylitta* voltinism of tasar silkworm can be regulated at a particular location whereas Dash *et al.* (1994) evaluated crop performance of *A. mylitta* (=*A. paphia*) on food plants Asan (*Terminalia tomentosa*) and Arjun (*T. arjuna*) in different seasons. Efficiency of rearing of non-mulberry silkworms, Muga, Eri and Tasar on five host plants of each species was studied by Srivastava *et al*, (1994). Srivastava *et al.*, (2000) recorded that various environmental conditions influence qualitative and quantitative characters of *A. mylitta*. Kar *et al.* (2010) emphasized the need for conservation of Sal fed ecoraces of *Antheraea mylitta*. Modal when reared under semi-domesticated condition on Sal the race rather give low yield but having the gain in the yield traits indicated that quality of leaves play a major role in the cocoon production (Kohili *et al.*, 1969; Sinha and Jolly, 1971; Agrawal *et al.*, 1969; Yadav *et al.*, 1992, 1996; Somsundaram *et al.*, 1996). Studies of Kar *et al.*, (2000) indicated that latitude and thermo-period forms the basis of voltinism in ecoraces of *A.*

mylitta. Effect of Latitude and altitude related factors like photoperiod and temperature were studied by Singh *et al.,* (2005) on diapause induction in tropical tasar silkworm, *A. mylitta*. The result showed that the resultant contribution of altitude, latitude, temperature, photoperiod and larval duration influence the diapause behaviour of *A. mylitta*. Further it was inferred that photoperiod and latitude causes variability in quantitative traits of *A. mylitta* too. Alam *et al.* (2000) observed rearing performance of Modal ecorace of *A. mylitta* on different food plants and their combination during different seasons having the leaves of different age of maturity and inferred that Sal flora can be exploited for Modal rearing by pruning or defoliation of the leaves to get the leaves of optimum maturity for the feeding of silkworm that is within 45 days from the date of sprouting.

OBJECTIVES

- To trace the life cycle and behavioural traits of Tasar Silk worm in SBR.
- To focus the climatological and geographical factors for the modal ecorace.
- To highlight productivity of modal ecorace in natural habitat.
- To ascertain the most conducive habitat for its conservation.

STUDY SITE

Tussar culture is predominantly practised by the tribal people of India, mainly of Bihar, Orissa, Madhya Pradesh, Andhra Pradesh, Maharashtra and West Bengal. Orissa ranks third among the dominant Tussar producing states of India. The present study and observations have been taken in five potential eco-places.These are Lulung, Talbandh, Sarat, Thakurmunda and Gudgudia in Similipal Biosphere Reserve of Mayurabhanj district of Orissa on the basis of availability of Modal cocoons. These are located at the altitudes of 95, 150, 310, 485 and 623 meters ASL respectively. Out of them, three study areas were selected for grainage and rearing experiments. These places are Lulung in "Core zone", Sarat in "Transitional zone" an Gudgudia in "Buffer zone" of the Similipal Biosphere Reserve.

Tussar culture is a traditional practice of the tribals of Orissa. The Similipal Biosphere Reserve of Odisha is rich in sericigenous flora as well as fauna. Similipal forest, being the natural habitat of modal ecorace, is situated in between 21^0 28′ to 20^0 08′ north latitudes and 86^0 04′ to 86^0 37′ east longitudes with compact block of virgin, moist dry deciduous and semi-evergreen forests in an altitude ranging up to 1182 meters above ASL (Khairiburu). Biogeographically, Similipal forest is classed under Biogeographic zone: Deccan Peninsula zone, Biogeographic province: Chhotanagpur province and Biogeographic region: Mahanadian region. The geological formation of the Similipal forest is a unique feature in the world holding three huge impervious quartzite bowls concentrically placed and their inter spaces filled with impervious volcanic rocks. The metamorphic rocks inter bedded with sub metamorphic layer, helps to increase the water holding capacity. Out-crops of metamorphics, stones and quartzites produce a reddish and sandy soil with high biotic activity where sal trees grow luxuriously. Soils are acidic in nature with pH varying from 4.8 to 6.8 in most of the areas. It enjoys an average annual rainfall of 2200 mm in 124 rain days and annual rainfall of 2698 mm is also experienced in some pockets and even more in higher elevations.

The unique geomorphic advantages are responsible for the development of rich flora and fauna where the flora and fauna are interconnected, interrelated and interdependent. The semblance of plant biodiversity is exhibited by the presence of 1076 plant species and 93 varieties of orchids out of 3000 plant species reported from Orissa state and fauna of 44 species of mammals, 29 species of reptiles and 231 species of birds. From density of trees, shrubs and herbs, it is revealed that there are 790 trees, 9400 shrubs and 81000 herbs per hectare.

The Similipal forest has eight forest types of which six types are of sal based only. Sal (*Shorea robusta*) trees which grow abundant in vast expanse of stately sal forest is the principal food plant of Modal ecorace of tropical tasar larvae which is a *Shorea* based ecorace and prefers sal leaves before feeding on other plant leaves. Sal is the principal plant species which constitutes almost 90% of the vegetation. In Similipal, sal comes up very well in ferruginous loams and loamy clay soils, with more aggressive than its competitors in its gregarious habits, coppicing power, resistance to burning and grazing, adaptability to variety of soil, longevity, good quality, adequate regeneration and economic value.

By considering the genetic diversity as one of the factors, Similipal forest has been gazetted as a Biosphere Reserve in 1994. The Similipal Biosphere Reserve (SBR) is the conglomeration of a National Park, a Project Tiger and a Sanctuary and divided into three zones, viz., (i) Central Core Zone (with 845.70 sq km area where no human activity is permitted and gazetted as a National Park under the provisions of Wildlife (Protection Act), (ii) Middle Buffer Zone (with 1904.30 sq km of area is gazetted as a Sanctuary and restricted for conservation, research, environmental education and training, tourism and recreation) and (iii) Peripheral Zone (with 77.07 sq km of area is restricted to research, sustainable resources development, people participation, sylvicultural operations and management of settlements).

MATERIALS

The study site for the observation and analyses was in Similipal Biosphere Reserve and the materials used for this investigation was Modal ecorace of tropical Tussar silkmoth, *Antheraea mylitta* Drury. During the course of investigation, the

eggs, different stages of larvae from first to fifth instar, pupae and adults of Modal ecorace of tropical wild Tussar silkmoths *Antheraea mylitta* were observed. For metrical analysis, the instruments like monopan digital balance, slide callipers, screw gauge and measuring cylinder were used. The room thermometer, wet and dry bulb hygrometer, wall clock and rain gauge were used for recording the environmental parameters like temperature, relative humidity, photoperiod and rainfall respectively at the study site daily. Cocoons of Modal ecorace constitute the important material for the detailed morphology, colour, quality and quantity of fibres. Physical characteristics such as length, breadth, weight, shell ratio, filament length, nature and type of loop and peduncle of cocoons were also studied as the material.

Modal is a *Shorea* based ecorace of tropical tasar silkworm *Antheraea mylitta* Drury, exclusively wild, multiplies sou moto in nature, univoltine, almost disease free, produces the heaviest cocoon with highest silk content among all the sericigenous lepidopterans of world and contributes 19% to raw silk production of India. There is great variation in the genotypes of Modal in the varied ecological conditions of Similpal forest. Modal ecorace is characterized by fecundity of eggs laying up to 390 in number; larvae of polyphagous nature but prefer to sal leaves before feeding on other leaves, highly variable in morphological features, clothed with numerous setae on whole body and of varied colour patterns, viz., brownish-yellow, green, leafy green and deep green; cocoons of large, oval upto 7.31 cm in length, 5.38 cm in diameter and 20 cc (male) to 50 cc (female) in volume and of varying colours; peduncle of cocoon strong and stout with one ring; pupae of robust and almost spherical with brunt sienna body colour; cocoon shells of thick and compact, thermo and hygro-proof; higher shell weight (males upto 16.7 gm and females upto 21.5 gm), silk content of 2.375 kg of reeled yarn from 1000 cocoons and silk ratio percentages of 25.68; filament of a single cocoon upto 1600 meters in length, coarse and heavier with average denier of 12; moths either brick red or brown in colour in males and polymorphic in colour, viz., yellow, pink, sepia etc. in females; moths emerge after nine months of diapause period with emergence and coupling percentages of 86 and 42 respectively.

METHODS OF STUDY

During the study, the climatological parameters such as temperature, humidity, photoperiod and rainfall of the viable ecopockets were taken into account. The temperature was measured by centigrade thermometer. The maximum and minimum temperature was recorded at three different timings such as 6 am, 12 noon and 6 pm everyday during the crop period. Then the mean or average value of maximum and minimum temperature was calculated each day. Similarly, the mean value of temperature was recorded for the entire crop period. In this way the maximum and minimum temperature along with its range during the study period were recorded for each crop of three successive years from 2007 June to 2009 June at the study site.The second climatological factor is relative humidity, which was measured by the wet and dry bulb hygrometer. The dry and wet temperature were measured and recorded with the help of sling psychrometer for measuring wet and dry temperature. The relative humidity was recorded with the help of humidity standard table.

The third regulating climatological parameter for the crop cycle is photoperiod. The length of the day or photoperiod is the time of sunrise and sunset, which was recorded everyday in various brood periods. The photoperiod is basically the length of day that is the difference of time from sunset to sunrise. The day length was determined with the help of the clock. On the basis of above method, the photoperiod was recorded daily during brood periods and the average photoperiod was calculated in each crop from 2009 to 2018.The fourth parameter to study the life cycle was rainfall, which was measured by rain gauge at rain gauge station at Gudgudia. The precipitation is stated in units of inches or centimeters that falls per unit of time. The amount of rainfall was recorded by rain gauge at rain gauge station at Gudgudia during the crop period in each day. The average rainfall was calculated and recorded for each crop cycle in successive three years from 2009 to 2018.

For the study of larval growth and development, the tussar cocoons were collected from the study site. The brood period was started from the day of egg laying till the formation of cocoon which indicated the larval span. For analysis of cocoons, the tussar cocoons were collected randomly from the different study site of Similipal Biosphere Reserve.The grainage performance of Modal ecorace was studied in three consecutive years 2016, 2017 and 2018. The cocoons collected from the vicinity of study areas during the month of August were preserved (100 in each place) to evaluate the grainage behaviour and preservation effect. In all the study areas, the cocoons preserved with due care and grainage operations were conducted during September and October.

Rearing was conducted at three places, viz., Gudgudia, Sarat and Lulung during rainy seasons on sal and asan plants to study the effect of altitude, season and food plant.The Similipal forest is divided into three divisions, viz., eastern, southern and north eastern. It is ranging from 50 m to 1000 m ASL and forest is full of sal and other tasar food plant. Due to abundance of available of sal tree the tasar silkworm which are eating sal leaf for food are called Modal Eco-races of *A. mylitta* D. when reared above 600 meter ASL exhibit univoltine character. Some ecorace in ex-situ condition when bring down to level between 400-600 behave bivoltine and called Nalia and when reared within 400 meter ASL behave trivoltine and called Bogai. In all the cases silkworms feed upon sal leaf and called “Modal Gutti” and on the contrary the same species when feed upon asan or arjuna called Daba Gutti in some place. Due to variation in ecological condition in Similipal Biosphere Reserve, there is a wide variation of genotype of Modal ecoraces. The typical micro-climatic condition of Biosphere Reserve is best owed of God for abundance and survival of Modal eco-race. This race is popular among the rearers for high disease resistance, higher silk yield, low larval mortality and guaranteed crop. Generally in in-situ condition rearing conducted in June to July and then pupa under diapauses till May to June. In May to June it emerges from cocoon in nature and laid eggs on leaf of sal trees. The tribal people

collect the green cocoon during March to April at the time of leaf fall and sold to weavers due to its high demand by which population of Modal eco-race is in downward stream. A commercial rearing was taken up in specific areas adjacent to peripheral biosphere zones during September to October 2007 resulting in production of cocoons during October to November 2007. These cocoons locally known as "Bogai" are popular among reelers but do not have any seed value due to continuous and erratic moth emergence during preservation period.

In order to exploit this elite ecorace commercially in other areas of low altitude plains, attempts were made to understand the grainage and rearing behaviour of Modal during second crop season (September to October). Nature grown Modal cocoons were collected from Similipal Biosphere Reserve during August and subjected to indoor grainage at RTRS, Baripada (65 m ASL). Cocoons after sex separation (60:40) were woven into garlands and hanged inside nylon net of 6′ x 6′x 6′ to increase mating. All recommended conditions for indoor grainage were followed during the entire grainage period. A total of three grainages were conducted in August to September during 2009 to 2018. The relevant grainage parameters were recorded.DFLs produced from the above grainages were reared at RTRS farm, Rangamatia (65m ASL) in the second crop season during 2009 to 2018. Asan plants at 8′ X 8′ spacing pruned during March and maintained under recommended package of practices were utilized for rearing. Worms after hatching were brushed on asan plants in such numbers so as to minimize handling. All precautionary measures were taken to restrict predator attack. Meterological parameters were also recorded during the entire rearing period. The relevant rearing parameters were recorded.

A comparative study of reeling performance of nature grown modal tasar cocoon with cocoons of semi-domesticated tasar ecoraces like Daba and Sukinda was done. Cocoon samples of semi-domesticated ecoraces of tasar like Daba TV, Sukinda TV and Daba BV were collected from BSM and TC, RTRC and TRCS during different crops between 2007 and 2009 had compared with cocoon samples of Modal ecorace collected from TRCS located in the zone of Baripada and Keonjhar. Cocoons were sorted by visual method for defective percentage. The shell ratio percentage which plays a vital role for selection of seed cocoon and fixation of cocoon price had been calculated very precisely by selecting 20 cocoons randomly from a lot on the basis of the average weight of the green cocoons collected for assessment. The electronic weighing balance was used for measurement of cocoons weight and shell weight.

The performance of Modal ecorace of *A. mylitta* will be studied in terms of following aspects by adopting standard procedures mentioned in tussar culture practices:

- Reproductive efficiency such as percentage of consignment of seed cocoons,
- Emergence behaviour,
- Coupling behaviour,
- Oviposition and hatching of larvae,
- Clipping of eggs in leave cups,
- Host plants frequency and area of coverage,
- Larval growth rate
- Effective rate of rearing (ERR),
- Cocoon and pupation rate,
- Frequency of cocoons per plant,
- Availability of cocoons on next generation,
- Status of diapause (voltinism studies) etc.
- Temperature, humidity, rainfall, duration of sunshine hours per month (photoperiod) are observed at the different locations.

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Table 1-- Rearing performance of *A. mylitta* fed on different host plant in rainy season during 2016 to 2018

Year	Host plants	No. of worms brushed	Total no. of cocoons harvested	Wt. of cocoon (g)	Wt. of shell (g)	Shell ratio %
2016	Asan	100	66 (5.10)	9.38 (0.085)	1.22 (0.022)	14.56 (0.882)
	Sal	100	58 (4.546)	9.95 (0.568)	1.85 (0.062)	17.43 (0.753)
2017	Asan	100	63 (5.89)	8.95 (0.13)	1.48 (0.028)	15.77 (0.23)
	Sal	100	59 (1.886)	10.31 (0.136)	1.65 (0.037)	16.41 (0.755)
2018	Asan	100	61 (2.16)	8.61 (0.062)	1.11 (0.046)	13.63 (0.901)
	Sal	100	48 (3.266)	9.75 (0.131)	1.69 (0.01)	16.84 (0.302)

- Figures in parentheses indicate SD values

Table 2--- Metrical analysis of loop of Modal feeding on sal plants during first brood period

Sl No	**Year**	**First brood period**				
		Weight (gm)	**Diameter (cm)**			**Thickness (cm)**
		Average	Horizontal	Vertical	Average	Average
1	2016	0.22	1.13	1.15	1.14	0.055
2	2017	0.21	1.22	1.30	1.26	0.070
3	2018	0.23	1.18	1.16	1.17	0.045
4	Mean	0.22	1.17	1.20	1.19	0.056
5	SD	0.01	0.04	0.08	0.06	0.01

Table 3-- Metrical analysis of loop of Modal feeding on asan plants during first brood period.

Sl No	Year	First brood period				
		Weight (gm)	Diameter (cm)			Thickness (cm)
		Average	Horizontal	Vertical	Average	Average
1	2016	0.13	1.03	1.05	1.04	0.075
2	2017	0.14	1.12	1.20	1.16	0.075
3	2018	0.12	1.08	1.06	1.07	0.060
4	Mean	0.13	1.07	1.10	1.09	0.070
5	SD	0.008	0.037	0.069	0.051	0.019

Year	Grainage	No.of mated female moths taken	No. of egg laying in different days and different photoperiod															
			During total darkness								During total illumination							
			1st Day	2nd Day	3rd Day	4th Day	5th Day	6th Day	7th Day	Total	1st Day	2nd Day	3rd Day	4th Day	5th Day	6th Day	7th Day	Tot
2016	I	20	2567	1012	595	588	210	125	57	5154	149	1967	1435	384	470	390	93	4888
	II	20	2496	990	540	613	184	117	70	5110	132	2000	1395	403	455	341	87	4813
	III	20	2510	977	558	590	200	105	78	5018	150	1953	1386	389	447	359	102	4786
2017	I	20	2562	1044	600	653	210	105	48	5222	142	2015	1640	327	482	397	33	5000
	II	20	2593	1018	575	621	197	100	36	5140	165	1983	1455	370	476	380	115	4944
	III	20	2493	985	620	641	183	88	47	5057	120	1945	1509	338	522	345	88	4867
2018	I	20	2636	1002	609	635	215	110	52	5259	178	1982	1574	359	453	408	120	5074
	II	20	2580	998	615	627	220	120	29	5189	148	1984	1511	366	478	402	97	4986
	III	20	2521	970	612	658	195	106	40	5102	160	1957	1450	343	500	388	117	4915
Average no. of egg laying		20	2551	1000	592	625	202	108	51	5139	149	1977	1480	364	476	379	95	4919
% age of egg laying			49.64	19.459	11.519	12.161	3.93	2.101	0.992	-	3.029	40.191	30.08	7.399	9.676	7.704	1.931	-
SD			46.160	21.510	26.293	23.539	12.392	10.552	14.838	72.717	16.323	21.30	71.199	23.795	22.555	23.325	24.770	87.11

Effect of photoperiod on egg laying

Table 4-- Status of eggs and hatching in different days and different grainages during three successive years.

Year	Grainage	No. of mated female moths taken	No of eggs produced in different days and No. of hatchings from eggs of different days.							Total no. of eggs produces and total no. of hatchings
			1st Day	2nd Day	3rd Day	4th Day	5th Day	6th Day	7th Day	
2016	I	20	3722 (3443)	625 (472)	469 (347)	208 (130)	101 (38)	51 (10)	29 (4)	5205 (4444)
	II	20	3745 (3400)	563 (425)	411 (304)	226 (140)	115 (46)	57 (9)	20 -	5137 (4324)
	II	20	3618 (3256)	528 (396)	433 (314)	196 (119)	126 (51)	79 (16)	45 (5)	5025 (4157)
2017	I	20	3890 (3618)	586 (451)	479 (359)	181 (116)	107 (45)	61 (12)	24 (3)	5328 (4640)
	II	20	3802 (3460)	498 (377)	471 (348)	202 (127)	121 (50)	97 (18)	53 (5)	5244 (4385)
	III	20	3720 (3412)	519 (389)	465 (339)	217 (135)	131 (52)	75 (14)	39 (4)	5166 (4345)
2018	I	20	3796 (3485)	606 (464)	423 (317)	211 (129)	119 (49)	70 (14)	47 (6)	5272 (4464)
	II	20	3731 (3405)	627 (483)	470 (357)	183 (112)	115 (41)	56 (11)	35 (5)	5217 (4414)
	III	20	3627 (3290)	590 (443)	458 (334)	229 (139)	100 (41)	56 (10)	31 (3)	5091 (4260)
Average no. of egg laying and hatching in different days.			3739 (3419)	571 (433)	453 (335)	206 (127)	115 (46)	67 (13)	36 (4)	5187 (4377)

Average %age of egg laying and hatching.	72.080 (78.11)	11.014 (9.89)	8.737 (7.65)	3.969 (2.9)	2.216 (1.05)	1.289 (0.3)	0.691 (0.09)	-
SD	80.245 (100.016)	44.482 (36.377)	23.039 (18.601)	16.155 (9.147)	10.077 (4.724)	13.947 (2.867)	10.407 (1.662)	88.178 (20.618)

Number in parentheses indicate the number of hatching in different days.

RESULT DISCUSSION

The Modal ecorace cultivated in the peripherial regions which are situated at 625 m ASL experienced the temperature regime of 25 to 300C. The mean relative humidity of the place is 80% with a range of 75 to 85%. The average day length of the place is 10.09 hours with average rainfall of 314.3 mm. When this ecorace was reared in indoor grainage at low altitude plains, deterioration in all the economic characters of the cocoons was observed because of the frequent fluctuation in temperature and humidity. The study thus indicates that the modal ecorace is very sensitive to change in climatological condition and human interference. Looking at the nature of voltinism, the voltine frequency at lower altitude is three, at middle altitude, it is two and at higher altitude, it is one. That means, the higher the altitude the lower is the voltinism and the lower the altitude, the higher is the voltinism. This implies that the voltinism is dependent on the altitude. Of course, the altitude means the impact of environmental factors such as temperature, relative humidity and photoperiod in particular on the life cycle and voltinism of the organism.However this study may be more relevant in further research.

CONCLUSION

From the entire analyses obtained from the rearing of A. mylitta larvae on sal and asan plants during rainy season, it was observed that the host plant plays major role in the food, feeding, growth and development of larvae and quantity and quality of cocoons. Worms reared on sal and asan plant behaved differently in cocoon production and rearing on sal plants have a significantly higher value as compared to rearing on asan plants. The characters like larval growth of different instars and economic values of cocoons like loop diameter, peduncle length, shell weight, shell ratio, cocoon weight, pupa weight were higher in sal compared to asan. This is probably due to better nutritive quality leaves of sal. The superior quality of cocoons (highest cocoon weight, shell weight and shell ratio) from sal fed larvae indicates that sal based species if reared on any other food plant, the cocoon characters deteriorate drastically. This indicates the adaptability of the species in nature by the preference of the food plants in its natural habitat. Hence tropical wild tussar ecorace i.e. Modal culture is suggested on sal plants for better yield with higher quantum of silk fibre according to ths study but this study significantly reflects the scope of further more intensive study.

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