

## A study of variations in the behavioural performances of mutant strains of Indian Tasar Silkworm

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### Abstract

This review paper is an effort to study the relative variations in respect of rearing and reeling performances of three mutant strains viz; Daba–blue, Daba–yellow and Daba–almond of tasar silkworm, *A. mylitta* D. This paper will also discuss the impacts of zonal differences on the productivity and qualities of tasar cocoons of mutant strains of *Antheraea mylitta* D. The three mutant strains of tasar silkworm differ among themselves in respect of their rearing and reeling performances. The performances of Daba–blue in respect of rearing and reeling performances as well as productivity and qualities of tasar cocoons have been found evidently better than the Daba–yellow and Daba–almond. This is due to genetic variability among the three mutant strains of *A. mylitta* D. on account of relative differences in their physio–genetic makeup. The relative rearing performances of all the three mutant strains of *Antheraea mylitta* along with its control are by and large better during the commercial crop season than the seed crop season which reveals the significant impacts of seasonal differences on the rearing performances of mutant strains along with its control. Further, the productivity and quality of tasar cocoons of Jharkhand and Madhya Pradesh zones are relatively better and superior to Orissa, West Bengal and Bihar Zones of tasar producing states. This suggests that the zonal differences influence the relative performances of mutant strains of *Antheraea mylitta* D in respect of productivity and quality of tasar cocoons.

**Keywords:** ecotype, cocoon weight, shell weight, filament length, rearing, reeling

### Introduction

Silk is the most beautiful gift of nature produced by the sericigenous insects in the form of mulberry, tasar, eri and muga silk. It has great commercial importance as well as plays an important role for earning foreign currencies. In fact, the silk is the natural fibre that spells splendour lustre and elegance and it is an inseparable part of Indian culture and traditions since years together. Sericulture is the branch of Science dealing with culture of sericigenous insects producing beautiful natural silk of great commercial importance. It is practiced widely in developed countries such as Japan, Korea, Indonesia, and Malaysia etc. In developing countries, it is essentially a village based oriented industries capable of providing employment to large sections of the population.

Although sericulture has been considered as a subsidiary occupation in rural areas but recent technological developments have made it possible to practice sericulture on an intensive scale, producing greater profits than most other agriculture crops and it can be assessed for its feasibility for establishment in India. From the point of view of a national economy, one of the important advantages of sericulture is that it does not require much land. Indian environmental conditions are very suitable for the development of sericulture, which includes both silkworm rearing and host plants cultivation for silkworm food which are widespread in India but little development work has been undertaken on these resources until the present. The first step in the development is to identify the most productive strains of silkworms and their host plants. The second step is to increase the risk of disease affecting production and the third step is to increase production.

Among the different varieties of natural silks, the tasar has received vital importance in recent days next to mulberry

silk because it brings about an economic uplift of rural populace, especially among the tribals and poor section of our society. Tasar silk so named as golden fibre is produced by different species of *Antheraea* in the forest areas of tropical and temperate belts of our country. India ranks second in the production of tasar silk in the world. As a matter of reality, the emergence of three mutant strains from a locally adapted Daba ecotypes of *Antheraea mylitta* in the forms of Am-blue, Am-yellow and Am-almond based on different larval colour appears to be significant development in the field of tasar culture as it raises great prospect and desired opportunity for better quality of tasar yarn as well as for the productivity of the tasar silk to a desired extent. It is logical to assume that the three mutant strains so evolved as result of spontaneous mutation appear to be different in their biological manifestations than the normal daba- green on account of relative variations in their genetic makeup.



**Image 1:** An Adult Indian tropical tasar silkworm



**Image 2:** Larval Indian tropical tasar silkworm

## Review of Literature

Jolly *et al.* (1969)<sup>[19]</sup> observed that the mutant strains of tropical silkworm in spite of having the same chromosomal number differ among themselves in their behavioural manifestations. Further Jolly *et al.* (1985)<sup>[20]</sup> presented details of species variations in the genus *Antheraea* producing vanaya silks. Fristrom (1965)<sup>[14]</sup> found variation in morphological characters of mutant strains of *Drosophila melanogaster*. Krishnaswamy *et al.* (1973)<sup>[23]</sup> developed desired methods of silkworm culture under different conditions. Sharma *et al.* (1990, 1991)<sup>[40]</sup> reported significant variations in quantitative and qualitative characters among different ecotypes of *Antheraea mylitta* D. The significant impact of environmental conditions on the biological manifestations of tropical tasar silkworm, *A. mylitta* D. has been worked by Rahamthulla *et al.* (2004)<sup>[37]</sup>, Kumari *et al.* (2011)<sup>[25]</sup> and Sharma *et al.* (2013)<sup>[41]</sup>. Genetic variability among the ecoraces of tropical tasar silkworm has been reported by Renuka *et al.* (2015, 2016)<sup>[38]</sup>. Pandey (2012)<sup>[33]</sup> has studied the impact of subtropical environment on the silkworm survival. Alam *et al.* (2018)<sup>[1]</sup> have reported about the biodiversity status and conservational requirements of tropical tasar silkworm (*Antheraea mylitta* D).

Sharma *et al.* (1998)<sup>[42]</sup> have studied on the prospect of tasar silkworm culture in some explored areas in Central Bihar. Bambhanian (2014)<sup>[2]</sup> has dealt with rearing performances of Tasar Silkworm (*Antheraea mylitta* D) on Arjuna (*Terminalia arjuna*) under South Gujrat Condition. Nasreen *et al.* (1999)<sup>[32]</sup> have studied rearing of silkworm *Bombyx mori* L on alternate food plants. Evaluation of genetic potential of inbred pure lines of silkworm for breeding and cocoon production in Pakistan has been reported by Hussain *et al.* (2011)<sup>[17]</sup>. Jadhav *et al.* (2014)<sup>[18]</sup> have studied the rearing performances of tasar silkworm *Antheraea mylitta* Drury on different food plants from Kolhapur. Elangovan *et al.* (2010)<sup>[24]</sup> has studied the rearing performance of eri silkworm *Philosamia ricini* in Monsoon season of Uttar Pradesh.

Influence of seasonal variation on cocoon silk filament and economic traits of *Bombyx mori* L has been studied by Bashir *et al.* (2014)<sup>[3]</sup>. Rahamtullah (2012)<sup>[36]</sup> has studied the management of climatic factors for successful silkworm (*Bombyx mori* L) crop and higher silk production. Burhoo *et al.* (2017)<sup>[4]</sup> has studied rearing performance of some popular bivoltine silkworm breeds during spring season. Chaudhary (2008)<sup>[6]</sup> has studied the evaluation of impact of weather on the cocoon and shell weight of muga silkworm. Seasonal climatic influence on the leaf biochemicals of Sal (*Shorea robusta*) flora and in situ breeding behaviour of Laria ecoraces of tropical tasar silkworm *Antheraea mylitta* have been studied by Lokesh *et al.* (2016)<sup>[26]</sup>. Kalita *et al.* (2017)<sup>[45]</sup> have made a comparative study on the rearing performances of six strains of eri silkworm *Samia ricini*, Donovan in four different seasons. Thiagarajan *et al.* (1993)<sup>[49]</sup> have reported the differences in seasonal performance of 26 strains of silkworm, *Bombyx mori*.

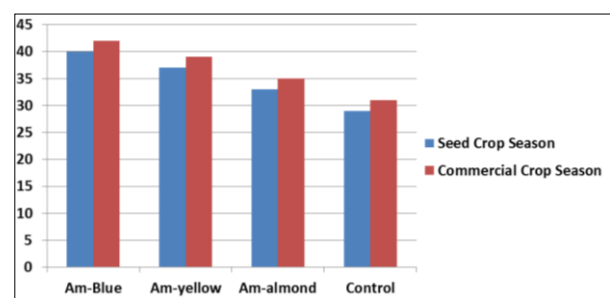
El Shewy (2017)<sup>[11]</sup> has studied the effect of alternative plants on physiological and biological characters of silkworm *Bombyx mori* L. Chakrabarty (2015)<sup>[5]</sup> dealt with

Genetic analysis of Indian tasar silkworm (*Antheraea mylitta*) populations.

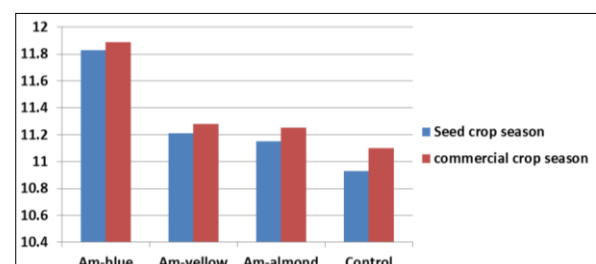
Dong *et al.* (2017)<sup>[16]</sup> have observed metabolomics differences between silkworms reared on fresh mulberry leaves or artificial diets. Kamraj *et al.* (2017)<sup>[22]</sup> has studied on performance of tasar silkworm *Antheraea mylitta* Drury under different chawki rearing methods. Naik and Somashekar (2008)<sup>[31]</sup> have studied the effect of degree of cocoon drying and cocoon cooking conditions on reeling performances and quality of raw silk of Indian bivoltine hybrid cocoons. Vanitha *et al.* (2017)<sup>[50]</sup> have studied the rearing performances and its commercial silk properties of tropical tasar silkworm (*Antheraea mylitta* Drury) on cashew (*Anacardium Occidentale* L.).

## Variations in the behavioural performances of mutant strains of Indian Tasar Silkworm

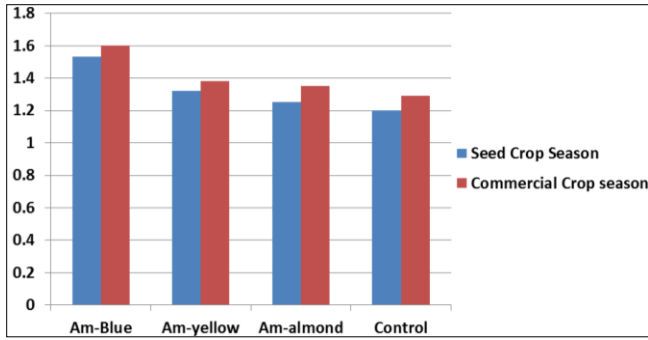
Among the three mutant strains of *Antheraea mylitta* the rearing performances of Am-blue mutant strain is relatively better than Am-yellow and Am-almond mutant strain. The rearing performances of all the three mutant strains in spite of their differences have been evidently found superior than the control during both the seasons of rearing. The relative productivity and quality of tasar cocoons are significantly superior to control. The relative rearing performances of all the three mutant strains of *Antheraea mylitta* along with its control are by and large better during the commercial crop season than the seed crop season which reveals the significant impacts of seasonal differences on the rearing performances of mutant strains along with its control (Mishra, 2020)<sup>[28]</sup>. The comparative analysis of rearing performances of three mutant strains of *Antheraea mylitta* in respect of Effective Rate of Rearing (E.R.R%), cocoon weight and shell weight have been evaluated during the seed crop and commercial crop seasons and the results obtained have been represented in Fig. 1 to 3.



**Fig 1:** Comparative analysis of E.R.R. of mutant strains of *Antheraea mylitta* D during both the season (in % age)



**Fig 2:** Comparative analysis of cocoon weight of mutant strains of *Antheraea mylitta* D during both the season (in gm)



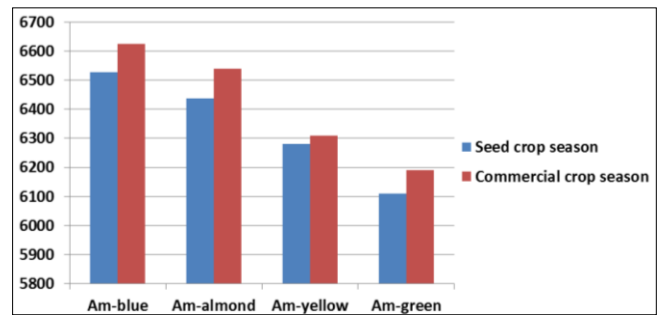
**Fig 3:** Comparative analysis of shell weight of mutant strains of *Antheraea mylitta* D during both the season (in gm)

The results obtained become very clear when we consider the under given facts

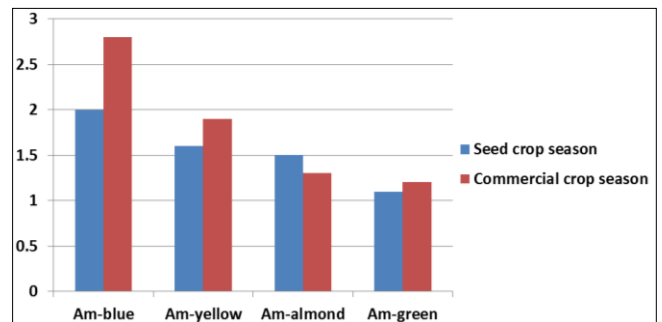
1. It is very much crystal clear that the origin and evolution of mutant strains are the outcome of natural selection caused by the change in gene or alteration in genes resulting into genetic diversities in the genetic constitution of mutant strains. As a result the mutant strains have followed different metabolic manifestations and variations in their behavioral action including rearing performances. Further, it is also an admitted fact that mutagens creating mutability among the individual may have different mutation pressure of different nature and potential for causing mutation. As a result, the physio-genetic makeup of individual in course of emergence having different genetic makeup initiates the growth and development with relative differences in their behavioural action. Mukherjee *et al* (2000) [29] has studied the impact of genetic variability in cocoon shape, size and weight variables in multivoltine silkworm *Bombyx mori* L. In view of aforesaid valid arguments, it is very much logical to assume that the emergence of three mutant strains of *Antheraea mylitta* is the outcome of mutation causing genetic variability among them with different genetic architecture. As a result, relative variations in the rearing performances of three mutant strains have taken place in respect of their quantitative and qualitative characters of tasar silkworm. The results obtained are very much supported by the earlier works of Jolly (1985) [21], Sinha *et al* (1976) [46] and Singh *et al* (2003).
2. The better relative rearing performances of all the three mutant strains of *Antheraea mylitta* and also its control in the commercial crop season as compared to seed crop season are probably due to differences in climatic and environmental factors and also dietary qualities between the two seasons. It appears that commercial crop season provide relatively better and conducive environment as well as dietary conditions suitable to tasar worms than the seed crop season.
3. Superiority of all the mutant strains of *Antheraea mylitta* over the control is perhaps due to variations in the genetic constitution of mutant strains of *Antheraea mylitta* emerged due to stimulating forces of mutation under evolutionary processes and have acquired greater potentialities, compatibilities and genetic vigour on account of useful and desired degree of mutation than the non-muted control as such the relative rearing performances of all the three mutant strains in spite of

Their relative differences are by and large better than the control.

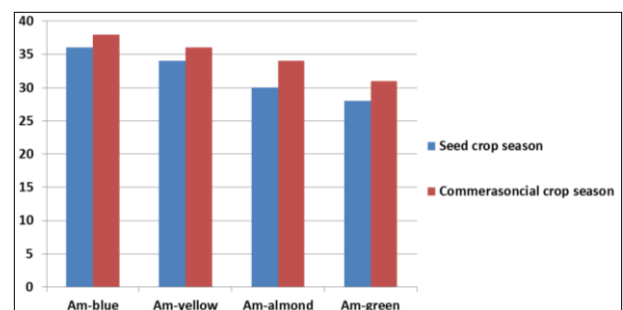
Similarly, all the three mutant strains of *Antheraea mylitta* have different reeling performances in respect of quality of tasar cocoons in which the performances of Am-blue mutant strains of *Antheraea mylitta*. All the three mutant strains of *Antheraea mylitta* have registered their supremacy over control in respect of reeling performances (Sharma *et al*, 2020) [43]. The comparative analysis of reeling performances of three mutant strains of *Antheraea mylitta* in respect of filament length, size of fibre and elongation percentage of fibre have been evaluated during the seed crop and commercial crop seasons and the results obtained have been represented in Fig. 4 to 6.



**Fig 4:** Comparative analysis of length of filament during reeling of mutant strains of *Antheraea mylitta* D during both the season (in mtr.)



**Fig 5:** Comparative analysis of size of fibre during reeling of mutant strains of *Antheraea mylitta* D during both the season (in D)



**Fig 6:** Comparative analysis of elongation of fibre during reeling of mutant strains of *Antheraea mylitta* D during both the season (in % age)

Results so obtained become clear when one takes note of the following facts

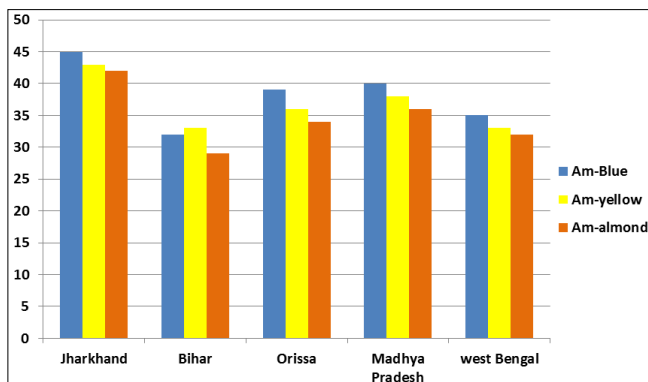
1. The quality of tasar silk yarn is associated with the

Quality of tasar cocoons having silk yarn as fibronin and sericin as its composition.

- The quality of tasar cocoons having fabrics largely depends on the geneic architecture of tasar silkworms providing strength for reeling manifestations.

Thus, the genetic variability of three mutant strains influencing the tasar cocoons with variations in their qualities of cocoons are supposed to be the instrumental cause for the results obtained concerning the relative variations in the reeling performances of mutant strains of *Antheraea mylitta*. Choudhary (1968)<sup>[7]</sup>, Sharma *et al* (1991)<sup>[40]</sup> and Singh *et al* (2003) hold the similar views in respect of cocoons based on the physio genetic makeup among the sericigenous insects.

Zonal differences influence the relative performances of mutant strains of *Antheraea mylitta* D in respect of productivity and quality of tasar cocoons. The results have clearly shown that the productivity and quality of tasar cocoons of Jharkhand and Madhya Pradesh zones are relatively better and superior to Orissa, West Bengal and Bihar Zones of tasar producing states (Mishra, 2020)<sup>[27]</sup>. Graphical representation of zonal differences on the productivity and qualities of tasar cocoons in respect of E.R. R. of three different mutant strains of *Antheraea mylitta* has been recorded in Fig. 7.



**Fig 7:** Graphical representation of zonal differences on the productivity and qualities of tasar cocoons in respect of E.R. R. of three different mutant strains of *Antheraea mylitta*

The results so obtained may be justified on the basis of under given facts and arguments

- The mutant strains of *Antheraea mylitta* successfully exists in different tropical tasar producing zones of our country since years together under different under ecological conditions.
- The environmental conditions of different tasar producing zones are not constant and uniform rather it has diverse ecological and environmental scenario influencing the biological manifestations of mutant strains accordingly in different ways related to their relative metabolic performances.
- The tasar producing zones of Jharkhand and Madhya Pradesh provide better conductive, favourable and desired environmental and ecological conditions than the tasar producing states of Bihar, Orissa and West Bengal resulting in to better productivity and qualities of tasar cocoons and tasar yarns of mutant strains of *Antheraea mylitta* in Jharkhand and Madhya Pradesh Zones.

The results obtained are in conformities with the earlier works of Sen *et al* (1973), Narsimhana *et al* (1969) and Singh *et al* (2012) who have reported the impacts of environmental factors on the biological performances of different tasar producing insects.

## Discussion

The three mutant strains of tasar silkworm differ among themselves in respect of their rearing and reeling performances. The results obtained appear to be the outcome of genetic variability among the three mutant strains of *A. mylitta* D. on account of relative differences in their physio-genetic makeup. The forces and factors of mutant action in a natural process of selection appear to be the vital and potent factor for the evolution of three mutant strains of *Antheraea mylitta*. The genetic variability of mutant strains may be supposed due to differential action of mutagens causing mutability with different degrees of mutations as such all the three mutant strains are different in their relative architectures. Since all the three mutant strains have different genetic makeup, thus they have better scope to differ in their behavioural manifestations. However, the successful survival of the three mutant strains with better genetic vigour as compared to control is supposed due to the useful mutation in genotypes under the evolutionary process guided and controlled under the selective action of natural forces of evolution (Haldane, 1932 and Wright, 1931)<sup>[15]</sup>.

Further, the result obtained may be put in the sphere of discussion in the light of earlier relevant investigations and concept furnished by different workers. Katsumata (1968) believes that the different ecotypes of a species have really evolved under the influence of different climatic and environmental conditions. The different ecological factors are presumed to put their profound effects and stresses on geographically or ecologically isolated ecotypes with different physiogenetic makeup. Therefore, the ecotypes have purely adaptative characters fixed in a genetic set up of the species and occur in distinctive environmental conditions. Choudhary (1962, 1965)<sup>[8]</sup> assume that the ecotypes have evolved as a result of interaction of the genetic set up of a species on account of variations in the habitats having different environmental conditions. Thus the ecotypes of species are supposed to be the ecological races in which variations associated with certain factors of environment are genetically fixed. A widely distributed species encounters a variety of environmental conditions and a series of variations in characters which develop in the course of the species evolution with desired adjustment. These variations associated with ecological conditions become genetically fixed and such variants with different gene pools may be called ecotypes (Pandey, 1989)<sup>[33]</sup>.

In the light of aforesaid information, it is logical to assume that a population of *Antheraea mylitta* under the influence of certain factors has first dispersed to different ecological zones of tropical tasar belts and in course of time, adjusted and acclimatized accordingly in their respective ecological conditions. The stress and strain of different environmental factors have probably succeeded in dividing the population of *Antheraea mylitta* into different ecotypes with changed genetic architecture and also dividing the gene pool of a population in different groups. It may thus be acknowledged as probable arguments for the genesis of different ecotypes of *Antheraea mylitta* in the light of relevant investigations as

mentioned in the support of the assumption.

### Role of mutation and natural selection as the factor of genetic variability

The spontaneous emergence of three mutant strains with larval body colour yellow, blue and almost as contrast to normal green is supposed to be the logical outcome of spontaneous mutations. The unknown natural mutagenetic factors are supposed to influence the gene pool of Daba ecotype of *Antheraea mylitta* D. existing in different ecological localities. The relative changes in the gene frequencies of different gene pool of Daba favoured by differential selection appear to be the basic factor for the evolution of three mutant strains of *Antheraea mylitta* with different genetic architecture or genetic constitution.

Crow (1961)<sup>[10]</sup> assume that the existence of mechanism for heredity and variation requires into the ways in which the genetic makeup of the population is altered or is held in equilibrium by the multiple influence of selection, migration and breeding structure. The so called Darwinian fitness of an individual is measured both by his capacity to survive and his capacity to leave descendants. Ideally, a particular fitness value (or adaptive value) of an individual should refer to his whole genotype. In any population, the various genotypes, with respect to a simple locus, may differ in their Darwinian fitness i.e. one genotype may have an advantage over any other due to high fertility or lower mortality.

Unlike Darwin, we now know that in any population there are genotypes that differ from one another and that the differences are due to mutation from one another and that the differences are due to mutation. Mutation provides the raw material of evolution in the form of alleles and selection the fate of these alleles in a gene pool. The interaction of mutation and natural selection in population was originally formulated mathematically in the work of Ronald Fisher (1930)<sup>[12]</sup> and was subsequently elaborated by the geneticists namely Wright (1931) and Haldane (1932)<sup>[15]</sup>. Assuming that all genetic fitness originates with mutation, Fisher calculated the arithmetical probabilities that a mutation might be established in the gene pool of a population. Under his formulation, harmful mutants are constantly eliminated or maintained at low frequencies by natural selection but advantageous mutants, often effecting imperceptible changes in the organism, are incorporated into a population's gene pool at a regular rate which can be mathematically defined.

Selection may, therefore, operate as both a stabilizing and a dynamic force in a population. In either role, it inserts systemic pressure on the gene pool so that the direction and magnitude of genetic changes are determinate in principle. As a stabilizing agent, it eliminates deleterious mutations each generation (normalizing selection) and maintains a gene pool's existing allele frequencies through time in equilibrium with the environment (Stabilising selection). Simultaneously, selection is also an important dynamic agent of evolution, changing a population's genetic composition as the environment changes (Directional mutation). A disadvantageous allele may increase in a gene pool and attain a frequency greater than that which can be maintained by recurrent mutation alone. If the later situation occurs, the result is genetic polymorphism, which is defined as the occurrence together in the same habitat at the same time of two or more distinct forms of a species in such proportions that the rarest of them cannot be maintained

merely by mutation.

However, the classic concept of mutation and natural selection continues to provide the framework within which genetic change in population may be theoretically predicted. But a large gap exists between this mathematical deductive theory of natural selection and the documentation of its actual operation in natural populations "Evolution in Process". The most famous case of "Evolution in Process" is Ford (1953)<sup>[13]</sup> documentation of the dramatic changes in the moth population living in the industrial area of England from a typical white form to melanic form. Field studies showed that in an environment of increasing smoke and soot, the melanic moths were protected by their colouring from predatory birds and in some areas the better adapted mutant carbonaria form attained a frequency of over 90% in the population. The document spread of the mutant form through the moth populations provides a unique example of natural selection observed to be operating dynamically, as directional selection, to produce a transient polymorphism as the populations genetically change in response to a changing environment.

The above said information have led us to believe that the three mutant strains of *Antheraea mylitta* are the logical outcome of the genetic selection factors of the environment constantly and regularly and operating upon the population of species. It is further believed that the divisions of the gene pool of population of *Antheraea mylitta* into ecotype and subsequent influence of different mutagenic factors of the environment have insisted Daba population to transform into three distinct mutant strains. Since the mutant strains with a different genotype do exist, the influence of differential selection on their biological performances appears to be the natural expectation. Therefore, the evolution of this new genotype to meet the new challenges calls for concerted efforts or the assemblance of gene pool. This enables us to understand the extent of genetic divergence in their behavioural differences.

### Conclusion

A comparative analysis in relation to behavioural performances of three mutant strains of *Antheraea mylitta* along with its control during the seed crop and commercial crop seasons reveals the under given facts:

- All the three mutant strains of *Antheraea mylitta* differ among themselves in their relative behavioural performances during the seed crop and commercial crop season.
- The rearing and reeling performances of all the three mutant strains in spite of their differences have been evidently found superior than the control during both the seasons of rearing. The relative behavioural performances of all the three mutant strains of *Antheraea mylitta* along with its control are by and large better during the commercial crop season than the seed crop season which reveals the significant impacts of seasonal differences on the rearing performances of mutant strains along with its control.
- Zonal differences influence the relative performances of mutant strains of *Antheraea mylitta* D in respect of productivity and quality of tasar cocoons. The results have clearly shown that the productivity and quality of tasar cocoons of Jharkhand and Madhya Pradesh zones are relatively better and superior to Orissa, West Bengal and Bihar Zones of tasar producing states.

- Among the three mutant strains of *Antheraea mylitta* the rearing and reeling performances as well as productivity and qualities of tasar cocoons of Am-blue mutant strain is relatively better than Am-yellow and Am-almond mutant strain. It follows the given preferential order:

Am-blue > Am-yellow > Am-almond

The results obtained appear to be the outcome of genetic variability among the three mutant strains of *A. mylitta* D. on account of relative differences in their physio-genetic makeup. Mukherjee *et al* (2000) [30] has studied the impact of genetic variability and selection indices for economic quantitative traits of multivoltine mulberry silkworm genotypes. It further appears that the Am-blue mutant strain as compared to Am-yellow and thereafter Am-almond is more robust in its genetic architecture as such it has shown relatively better performances in various behavioural parameters. Results obtained are indicative of the fact all the three mutant strains of *A. mylitta* D. in spite of relative differences have registered their supremacy over the control (Daba-green) on account of desired beneficial mutation in relation to their behavioural performances. Thus the evolution of three distinct mutant strains of tropical tasar silkworm is in the larger interest of tasar culture.

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