CHAPTER I
INTRODUCTION
Sericulture, a combination of agriculture and industry, is both art and science of rearing silkworms for production of “Silk” the queen of textiles which is adored by the million of people across the world. The two distinct sectors of sericulture, the mulberry and non-mulberry or wild, now called ‘Vanya silk’ is being practiced in various magnitudes to provide gainful occupation to more than five million persons in the rural and semi urban areas in different states of India. In the global scenario, India continues to be the second largest silk producer in the world (13.4%) mainly due to mulberry raw silk produced by certain major silk producing states. The production of silk in India during 2011-12 was recorded to the tune of 23000 MT, out of which the mulberry silk production was 18186 MT, while non-mulberry silk i.e. Tasar, Eri and Muga produced 1577 MT, 3110 MT and 127 MT, respectively (Source: Regional Office, Central Silk Board, Guwahati, Assam). In fact, India has the distinction of being the only country in the world, producing all the five commercially exploited silk varieties viz. Mulberry silk produced throughout the country, Tropical Tasar, Temperate/Oak Tasar, produced by tribal inhabiting Central India and Sub-Himalayan Region, Eri Silk (spun silk produced mainly in N. E. Region, now practiced in many other states) and Muga-Golden silk produced mainly in the Brahmaputra valley of Assam province in NE Region. The golden yellow muga silk of Assam is unique product of India and nowhere in the world is available due to peculiar insect behavioural adaptation and requisite climatic condition (Ahmed and Rajan, 2010). During 2011-12, the contribution of mulberry, muga, eri and tasar silk from north
eastern region to respective variety of silk production in India was only 1.08%, 99.81%, 98.23% and 0.38%.

Muga culture has been practiced by about 44,000 families in the different states of north eastern region out of which Brahmaputra valley of Assam is the main production zone and contributes to about 90.55 percent of the India’s total muga silk production. Muga production in Assam is mainly concentrated in the districts of Tinsukia, Dibrugarh, Sivasagar, Jorhat, Golaghat, Lakhimpur, Dhemaji, Kokrajhar, Udalguri, Goalpara and Kamrup. It is a continuous chain of several production activities starting from egg production to rearing of Antheraea assama West wood (= Antheraea assamensis Helfer) in the raised flora by rearers for production of cocoons. These cocoons are utilized by reelers and weavers for production of yarn and fabrics. Earlier, economics from muga culture could not be compared to the income from other agricultural/horticultural crops mainly because the muga farmers used to practice muga culture as an alternative source of livelihood and not as main source. Muga culture is practiced as a seasonal activity and in general farmers take up two to three crops, which involves hardly two to three months of family labour.

Muga food plants are perennial tree and are available in wide range of geographical region. While Persea bombycina Kost (Som) and Litsea polyantha Juss (Soalu) are predominantly used as the primary food plants for rearing of muga silkworm, Litsea salicifolia Roxb. (Dighloti) and Litsea citrata Blume (Mejankari) are considered as the secondary food plants. Due to continuous
insect-plant interaction in wild, muga silk worms have adopted to different food plants for their survival in different ecological habitats recognizing many more new tertiary food plants such as *Litsea nitida* Roxb. (Kothalua), *Litsea glutinosa* Lour. (Bodokaki), *Cinnamomum glanduliferum* Meissn. (Gansarai), *Actinodaphne obovata* Blume (Patihonda), *Actinodaphne angustifolia* Nees. (Baghnala), *Actinodaphne sikimensis* Meissn., *Michelia champaca* Linn. (Champa), *Zizyphus jujuba* Lamk. (Bogori), *Zanthoxylum rhetsa* DC. (Barjamani), *Celastrus monosperma* Roxb. (Bhomloti), *Magnolia sphenocarpa* Wall. (Panchapa), *Gmelia arborea* Linn. (Gumbharee), *Laurus obtustifolia* Roxb (Gamari), *Sarcostemma brevistigma* W & A (Gummari), *Symplocos grandiflora* Wall (Griffith), *Symplococos paniculata* Wall., *Persea duthei* King., *Michelia oblonga* Wall (Phul-sopa), *Persea glaucescens* Nees. (Bondasum), *Plumeria acutifolia* Poiret (Gulnch), *Xanthoxylum armatum* Roxb. (Isamoti), *Phoebe lanceolata* Nees., *Lindera latifolia* HK., *Polyathia siniarum* Benth & HK. etc. (Thangavelu et al., 1988; Bindroo et al., 2006).

The nutritive value of host plants and their seasonal variability are closely related to that of the silk worm (Yokoyama, 1963). The growth, development and economic characters of silkworms are influenced to a great extent by the nutritional content of the leaf (Krishnaswami *et al.*, 1971; Muthukrishnan and Pandian, 1987; Reddy *et al.*, 1989; Maribashetty *et al.*, 1999). The success of muga culture mainly depends on the accessibility of food plant and their leaf nutritional status, as the consequent silkworm rearing on them could
result to higher number of cocoons or the cocoons of superior quality in terms of pupation or silk content. Importance of these food plants and their preference on muga silkworm rearing is thus mainly characterized by foliar constituents like moisture, nitrogen, protein, minerals, fat, crude fiber, sugar and starch content etc. Since quality of leaf has got a direct influence on the health, growth and survival of silkworm, selection of the food plants possessing superior nutritive value is of great importance for the healthy development of silkworm and in obtaining quality cocoon crops (Dutta et al., 1997). Inspite of having certain significant variation on foliar constituents of Persea bombycina (Som) and Litsea polyantha (Soalu), both host plants contribute good nutritional value to muga silkworm resulting better rearing performance and silk content (Yadav and Goswami, 1992). Hazarika et al. (1995) found some relationship between soluble protein and total phenol content of Som with the feeding behaviour of muga silkworm. Sharma and Devi (1997) observed that the Som leaves were ideal during autumn while Soalu leaves were suitable in the late spring for rearing the muga silkworm. While analyzing the foliar constituents of different muga host plants, Dutta et al. (1997) revealed that with significant low percentage of crude fiber and high amount of total nitrogen, protein, starch and calcium content, Mejankari (Litsea citrata) leaves were the best in nutritive value followed by Som and Soalu and Dighloti (Litsea salicifolia) occupied last position in this respect. While emphasizing on continuous use of Som and Soalu plants for quality muga cocoon production, Ghose et al. (2000) observed that cocoons produced in Mejankari and
Dighloti plants were more lustrous due to higher sericin content in the cocoon shell and in the raw silk. Siddique et al. (2000) estimated the biochemical composition of 14 morphovariants of *Persea bombycina* and identified at least 4 high yielding, nutritive as well as palatable and superior variants for sustainable yield and cocoon production. On the basis of number of dependent characters including different nutrient contents, Sinha et al. (2000) ranked and identified nutritively superior morphotypes of muga host plant *Machilus bombycina* King. Das et al. (2000) identified 8 morphovariants of Som on the basis of different chemical parameters in Assam. Chowdhury et al. (2000) studied the effect of the essential oils of *Litsea cubeba* Pers. (=*Litsea citrata* Blume) on rearing performance of muga silkworm and silk quality in Assam. Neog et al. (2007) indicated superiority of tetraploid genotypes over diploid plants in terms of rearing performance as well as in content of biochemical constituents and inferred that leaf biochemical constituents have influence on the rearing of muga silkworms.

Sustainable development of muga silk industry depends on production of large quantity of commercial cocoons with their uninterrupted flow from producer to consumer level through enormous product diversification and capacity to resist its vulnerability to rapidly emerging urban industrialization. Success of commercial cocoon productivity of multivoltine muga silk worm in turn is determined by the availability of quality seed cocoons in the pre seed and seed crops and is measured in terms of productivity potential realized from egg layings
laid by a particular mother moth which is the most important factor for both commercial and seed rearers in any crop (Chaudhuri, 1999). One of the major factors affecting the muga silk industry is the gap in seed cocoon production as both the seed crops (either pre-seed or seed crop) always fall either in the hot and humid summer or in extreme cold and foggy winter making these crops uncertain. The climatic conditions during the commercial crops should remain within optimum limit (temperature 20-31°C and relative humidity 65-95%) and has been observed that temperature between 18°-26°C and a relative humidity between 70-85% shows the best conditions for the commercial rearing (Zamal et al., 2010). However, during last few decades, atmospheric pollution and the resultant variability in temperature and relative humidity due to global warming along with abnormal rainfall pattern, drought and flood has caused continuous failure of the crop or low crop yield in spite of all efforts and utilization of resources. Besides abnormal increase in temperature, the other reasons enlisted for the heavy loss of muga silkworm were air pollution caused by rampant use of pesticides in neighbouring tea gardens, pollution from the bricks kilns and burning of natural gases emitting from oil wells and seismic survey by ONGC for oil exploration (Annonymous, 2010). Being reared in outdoor, muga silk worm may not be able to adjust to the new changing environment (Singh and Maheshwari, 2003) and thus the differential seasonal conditions greatly influence the growth and development of muga silkworm in the form of cocoon weight, pupa weight, shell percentage, potential fecundity, reelability and denier of the silk (Chiang, 1985;
In an analytical study conducted on relationship between various parameters of muga silkworm and different environmental factors, Zamal et al. (2010) observed that the fecundity, hatching percentage, moth emergence, and cocoon yield have declined with the rise of temperature over the years and the higher trend in temperature attributed for production of a lesser yielding crop. The relation between cocoon weight and shell weight of muga silkworm are significant and that their variations are significantly correlated to geographical area, host plant and environmental conditions during rearing period. While several muga seed farms are established in different places of Assam, the irony of the fact that, the strong scientific reasons of having clear cut demarcation of seed and commercial zone for muga silk worm rearing is not adhered to except for a few ones. Hence, quality muga silkworm seed, which plays vital role in productivity, sustainability and profitability of muga industry, continue to be the main constraint. The seed multiplication in muga sector is an important area, which calls for immediate attention and improvement to reduce the wide gap between the demand and supply of disease free layings (dfls) for commercial cocoon production.

Having suffered from the negative impact of climate change and other anthropogenic reasons, the traditional commercial muga growers of Assam generally visit foot hills as well as higher altitudinal areas of neighbouring hilly states like Meghalaya, Arunachal Pradesh and Nagaland to collect wild, healthy seed cocoons for conducting commercial crop which emphasize that altitudinal
effect, climatic variation and host plant preference play a great role in muga cocoon production. Unlike *A. mylitta* which has 34 ecoraces (Thangavelu *et al.*, 1993), *A. assama* is believed to be a single race; however its wild counterpart is found in higher altitudinal areas of Meghalaya, Nagaland and Arunachal Pradesh showing wide range of colour polymorphism and voltinism (Sengupta *et al.*, 1975; Goswami *et al.*, 1987; Thangavelu *et al.*, 1987; Borah *et al.*, 1990; Sengupta *et al.*, 1995; Sahu and Bindroo, 2007). The topographical and climatic differences among different north eastern states provides enormous opportunities for exploration of wild muga silkworm races which can be used along with the cultivated ones for the improvement of muga silk industry through hybrid vigour and production of disease resistant high yielding variety. While diapause is a rare occurrence in the cultivated population, the wild population enters diapauses in the pupal stage during the winter (Thangavelu *et al.*, 1986). In a bid to induct diapauses through preservation of muga seed cocoon at high altitude, Prasad and Sinha (1982) observed a variation of 12.3% to 83.2% of pupal mortality during May-June exhibiting late emergence after 12 to 16 days. They inferred that preservation of pupae at high altitude in winter season (December-January) was detrimental and pupae of domesticated muga silkworm did not either over winter or diapause at high altitude. Yadav and Sampson (1987) reported that hot and humid climatic condition of Mamit sub division located at an altitude of 2978 m above sea level in Mizoram was quite sustainable for Muga culture. Reddy (1999) reported that even when the seed cocoons/pupae were preserved at low
temperatures for longer duration, egg parameters like fecundity, unfertilized eggs and hatchability were adversely affected irrespective of age of pupae and temperature of preservation. Further increase in the duration of preservation led to aging of male moths which was also attributed to less pairing efficiency and less productivity (Haniffa and Thatheyus, 1992). Choudhury et al. (1999) while analyzing the muga cocoon productivity in nine locations in Assam, Meghalaya and Arunachal Pradesh, highlighted pronounced effect of altitude, diurnal shift in temperature, variation of humidity and quantum of rainfall and rainy days. Sengupta et al. (1995) successfully conducted trial rearing of muga silkworm on Persea bombycina and Litsea polyantha in Dehradun, Uttarkhand a cooler place. Khatri (2003) also reported that rearing and grainage performance of muga silkworm during four crops viz, Aherua, jarua, Bhodia and Kotia over a period from 1998-2000 in Doon valleys were found to be better than those done in Assam. Biswas and Roy (2006) studied the effect of environment factors on seed production of muga silkworm in Terai region of West Bengal. Recently, muga culture has been introduced in Cochbehar in the state of West Bengal and Sikkim; however production is yet to reach commercial scale due to many constraints in its cultivation.

Muga silk worm fed with leaves of Persea bombycina and Litsea polyantha produces golden yellow silk, however when reared on Litsea citrata, the secondary host plants produce a kind of silk known as Mejankari silk which is admired for its durability, luster and glossy creamy white shade (Saikia and
Goswami, 1997). At one time, Karbi Anglong, Sivasagar, Jorhat, Golaghat, Dibrugarh and Tinsukia districts of Assam; Tirap and Changlang districts of Arunachal Pradesh; Mokokchung district of Nagaland and Ri-Bhoi district of Meghalaya were abundant with *Litsea citrata* (Mejankari) plantation. However, due to large scale deforestation, recurrence of severe flood, occupations of vast tracts of land by tea industry and Jhum (shifting) cultivation in the hilly states Mejankari trees are depleted now particularly in plains of Assam (Choudhury, 2005). Since only the healthy and vigorous larvae have been found to thrive on Mejankari leaves, the worms hatched out of poor quality of muga seed are unable to survive on this tree (Choudhury, 1981).

Nagaland lies at varying altitude from 199 to 3048 m above mean sea level. The topography of the state is characteristically hilly, which is instrumental in shaping the cool and pleasant climatic conditions. Various factors like the altitude, geographical coordinates, distance from the sea and the wind direction influence the climate in Nagaland. Preliminary studies in Nagaland have ascertained that, rearing of cultivated variety of muga silkworm is comparatively new and conducted on Som (primary host plant) in certain government farm, however, the natural plantation of Mejankari food plant available in Mokokchung, Wokha and Tuensang district has not been used for muga silk worm rearing (Kakati and Chutia, 2009). Blessed with serene, isolated pollution free natural environment Nagaland also provides an exclusive niche for wild counterpart of *Antheraea assamensis*, the rearing potentiality of which is not yet evaluated.
Further, the soil quality has an influence both on yield as well as quality of leaves which in turn influences the growth of silkworm as well as the quantity and quality of cocoons produced by them (Mahobia et al., 2003). Thus, muga culture in Nagaland has ample scope for the development because of the locational characteristics and climatic parameters of the state. It is often suggested to conduct rearing of summer crop in cold climate (at high altitude) as mortality and flies, wasps etc. are more during summer in hot places and will also provide hill amelioration to the worms. In this context, a separate rearing schedule and technology for muga crops per year has to be standardized to suitably adjust the local conditions so that the crucial gap between demand and production of seed cocoons during pre-seed and seed crops could be reduced by taking up seed crop rearing in certain area of Nagaland to cater the requirement for each commercial crop in Assam. While certain studies have been reported on rearing performance and host plant preference on Som, Soalu, Dighloti, Mejankari and Gonsoroi from Assam (Barah et al., 1992; Saikia and Goswami, 1997; Gogoi and Goswami, 1998) and also from other part of India (Jaya Prakash et al., 2004; Khatri et al., 2004), no detailed study has been undertaken on comparative analysis on altitudinal effect and host plant preference of growth and production of A. assama. Hence a comparative and systematic study on A. assama is undertaken on three host plants in two locations at North Lakhimpur, Assam (low altitude) and Mokokchung, Nagaland (High altitude) for two consecutive years with the following objectives:
1. Analysis of physico-chemical characteristics of soil and food plants in low and high altitude

2. Seasonal and altitudinal variation on morphometric characteristics of *A. assama* on three host plants

3. Seasonal variation on rearing performance of *A. assama* with reference to three host plants: Som (both locations), Soalu (Low altitude) and Mejankari (high altitude)

4. Comparative rearing performance of cultivated and wild population of *A. assama* on Som and Mejankari in high altitude

5. Comparative analysis of altitudinal effect on growth, life cycle and production parameters of *A. assama* (cultivated population)

6. Comparative analysis of host plant effect with reference to Som and Soalu in low altitude (cultivated population) and Som and Mejankari in high altitude on growth, life cycle and production parameters of *A. assama* (both cultivated and wild population).