Chapter-1

Introduction

Sericulture is both an art and science of raising silkworms for silk production. It is an important employment generating, agro based, export oriented, commercial activity, falling under cottage and small scale sector, practiced in various countries, since playing an important role in poverty alleviation, generating employment in rural areas and helping in percolating economy from rich to poor (Rani, 2007; Gangopadhyay, 2008; Unni et al., 2009). The woman plays a vital role from production to consumption of silk. Industry provides useful employment in the activities such as, mulberry cultivation, silkworm rearing, reeling, spinning, weaving, printing, finishing and processing of silk fabrics (Upadhyay and Barman, 2013). There are many more ancillary activities encompassing the sericultural activity such as silkworm seed production, fabrication of rearing appliances, production of organic manures, development of irrigation methods, fabrication of garden mechanics, waste silk units, by-product utilization units, etc. (Anonymous, 2013a).

Silk, the “Queen of Textiles” a weavable fibre discovered by Chinese emperor, Xi Ling Shi is an outcome of sericulture activities has a number of applications. Silk from the mulberry silkworm, Bombyx mori L. (Lepidoptera: Bombycidae), is the most elegant textile in the world with unparalleled grandeur, natural sheen, inherent affinity for dyes, high absorbance, light weight, soft touch and high durability, comfort, adaptabilities to all climatic conditions are some of the qualities of silk that makes it unequalled textile material (Kumutha, 2009). It has several references in ancient history and was one of the major commodities traded between countries. Having originated in China about 2,700 BC by domesticating the wild silkworm, Bombyx mandarina Moore (Lepidoptera: Bombycidae), the art of
silkworm rearing was kept as a national secret for several years and death seems to have been penalty for carrying the secret of industry abroad. With the result, rest of the world remained unaware about sericulture for nearly 3,000 years. It is believed that in 419 AD, King of Khotan (Sinkiang province, Tibet) proposed the Chinese emperor for a princess in marriage. The request was accepted and the King sent a messenger to princess to bring with her some silkworm and mulberry seeds. While going to Khotan, princess concealed the seeds in her head-dress and thus sericulture moved outside China (Afifa and Masoodi, 2000). Later, the sericulture became exposed to Japan, Europe, South East Asia, Asia and Middle East. At present total world raw silk production was 1, 52,868 MT in 2012 and China ranks first among the silk producing countries of the world producing 1, 26,000 MT (82.41%). India is the second largest producer of silk in the world and has 15.49% share in global raw silk production. All the countries except China and India have been witnessing a declining trend in raw silk production in the last two decades (Anonymous, 2013b).

Five kinds of silk, mulberry, eri, muga, tropical tasar and temperate or oak tasar are being commercially produced throughout the world. India has the unique distinction of being the only country producing all these five kinds of silk. Production of raw silk in India was 23,679 MT in 2012-13 of which, mulberry raw silk output aggregated to 18,715 MT (79.04%). The remaining 4,964 MT (20.96%) was Vanya silks (Anonymous, 2013b).

1.1. SERICULTURE IN INDIA

India besides being the second largest producer of raw silk after china is the biggest consumer of raw silk and silk fabrics (Gangopadhyay, 2008). Domesticated mulberry silk (Bombyx mori L.), semi- domesticated Eri silk (Philosomia ricini Boisduval), wild tasar silk (Antheraea mylitta Drury) and muga silk the wild golden silk (Antheraea assama Hefler), being unique to India (Anonymous, 2013a).

In India, sericulture is practiced from ancient times. Some believe that silkworm rearing was introduced to India from China via Tibet, others hold the view that the mulberry silkworm originated from slopes of Himalayas on the Mount
Everest and later due to domestication by Aryans and other tribes, the insect spread to other parts, (Thangavelu and Joshi, 1983). As per the Hindu epic records available, sericulture was practiced in India much before its mention more than 2,000 years old. But, the activity acquired importance only 500 years back and the sericulture was flourishing in India long before the advent of Dutch and English trades. Amongst all the Indian states, West Bengal and Kashmir are the oldest silk rearing areas producing multivoltine and bivoltine silk, respectively. After taking over of industry by East India Company, Indian silk trade flourished further and India was in a position to export 2.54 lakh Kg of silk per annum during 1761 to 1795. De (1917) reported that, East India Company used to buy large quantity of raw silk and silken goods from India during 1600-1619. During the years 1772, 1785 and 1795, India exported as much as 1,80,000, 3,24,307 and 38,035 lb of raw silk to England, respectively. However, at present, besides these two states, mulberry sericulture is practiced in Karnataka, Kerala, Andhra Pradesh, Tamil Nadu, Assam, Uttar Pradesh, Uttaranchal, Madhya Pradesh, Bihar, Maharashtra, Manipur, Himachal Pradesh, Punjab, Meghalaya, Arunachal Pradesh, Gujarat, Mizoram, Nagaland, Orissa, Rajasthan and Tripura (Singh and Kumar, 2010) of which, Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu and Kashmir jointly account for about 97% of the total mulberry silk production in the country.

In recent years, India is observing a significant rise in practice of sericulture. The activity of mulberry sericulture has been pushed into non-traditional areas such as arid tracts of Rajasthan and Himalayan ranges of North-Eastern States. During pre-independence, India produced only 700 tons of raw silk which gradually enhanced to 1,480 tons in 1956. The production further shoot-up from 1,745 tons in 1968 to 3,475 tons in 1978. During the past years production increased manifold nearly to 13,000 tons in 1992. At present there is 1,97,000 hectares under mulberry cultivation holding more than 40 lakh of trees spread over 57,936 villages which are engaged in sericulture activity. The industry is a labour intensive in all its phases with employment generation of about 7.65 million persons per annum in rural and peri-urban areas of India (Anonymous, 2013a and 2013b). Since Labour Force Participation Rate (LFPR) in sericulture is far ahead in comparison to similar rural
avocations, it has significantly contributed to poverty alleviation thereby achieving the national agenda of inclusive development. The industry produces 2920.08 lakh of disease free layings (DFLs) of silkworm eggs, 23679 metric tons of raw silk which accounts for 15.49 percent of total raw silk production of the world and foreign exchange earnings of ₹ 2303.53 crores (Anonymous, 2013a and 2013b). In 2012-2013 the production of mulberry raw silk was 18715 metric tons which alone accounts nearly 80 percent of the total raw silk production in the country (Anonymous, 2013b).

Mulberry, *Morus alba* L. (Urticales: Moraceae) is the sole food plant for silkworm, *B. mori* and hence its cultivation is an essential part of sericulture. For the development of silk industry, production of quality silkworm cocoons is must. To achieve the production goal of good quality silkworm cocoon crop, certain factors play important role, mulberry leaf (38.2%), climate (37.0%), rearing techniques (9.3%), silkworm race (4.2%), silkworm egg (3.1%) and other factors (8.2%) in producing good quality cocoons (Miyashata, 1986). Hence mulberry leaf quality as well as quantity is one of basic prerequisites of sericulture and play a pivotal role for successful silkworm cocoon crop.

1.2. SERICULTURE IN JAMMU AND KASHMIR

Jammu and Kashmir state has a unique feature among the Indian states which is bestowed with the salubrious climate in line with China and Japan, world leaders of bivoltine mulberry silk production at present and past, respectively and ranks first amongst North Western states in terms of silk cocoon and raw silk production. Even with this advantage tag, Jammu and Kashmir stands fifth after Karnataka, Andhra Pradesh West Bengal and Tamil Nadu in production and productivity (Anonymous, 2013b). It is a well established fact that mulberry biomass production per unit area per annum is highest in Jammu and Kashmir among the sericultural states of India. The reasons for not converting this huge mulberry wealth in to silk include the subsidiary nature of sericulture in the state besides huge competition from cash rich horticultural and agricultural crops. Jammu and Kashmir has witnessed a drastic decline in silk production since last three decades until recent past, when it is stagnated. The present
production of silk in the state is 8.32 lakh Kg compared to 16.00 lakh Kg during 1960 (Nika, 2010). To achieve the goal of commercializing 2nd cocoon crop in the Jammu and Kashmir State, availability of quality mulberry leaf is one of the constraints which is affected by both biotic and abiotic factors (Bindroo and Khan, 2006; Farooq et al., 2006; Raina et al., 2006). Monocropping nature of silkworm rearing and lack of backward and forward linkages are equally limiting the state from harvesting the hidden potential. Lot of efforts are being pumped in to introduce second crop in the state with a summer crop in Kashmir valley and autumn crop in Jammu region in addition to the ruling spring crop (Malik et al., 2010, Khan, et al., 2010, Raina et al., 2011, Mohan et al., 2011, Wani and Jaiswal, 2011).

The silk industry in Jammu and Kashmir (J&K) state is of a very ancient origin. The mulberry trees, existed in the valley of Kashmir even before the Vedic times. Due to very fertile soil with natural irrigation system and highly salubrious climatic conditions spreading over four distinct seasons, the valley of Kashmir is very suitable for sustainable sericulture producing high grade raw silk of international standards.

The agro climatic conditions of Jammu and Kashmir State are most ideal for bivoltine silkworm rearing. Many silkworm races, released by various sericultural research stations at different time periods, have been reared in the Jammu and Kashmir State. In Jammu division, silkworm hybrids of local Jam races were reared for a long time. These hybrids were having poor yield and shell content (14 -15%) (Bakshi et al., 2003). Similarly, in Kashmir division, Japanese (J122, J112, B40, etc.) and Chinese (Hawlake, Yakwei, Chang Nang, etc.) silkworm races and their hybrids were in vogue for a long time (Saproo et al., 1986). But during 1980’s introduction of SH6 × NB3D2 hybrid was a big leap forward in cocoon production and till date this variety is the ruling silkworm hybrid of Jammu and Kashmir and adjoining states. This hybrid has a potential of producing up to of 72.5 Kg of cocoon /100 dfls (Quadir et al., 2002).

At present sericulture is practiced in Jammu and Kashmir divisions, sparing Ladakh division owing to the cold arid agro climatic conditions prevailing there.
Bivoltine sericulture is practiced by 22,282 rearers in Jammu division and 9600 rearers in Kashmir division covering 2540 villages. Annually about 27,049 ounces (one ounce about is equal to 100 dfs of silkworm seed) of bivoltine seed is being reared by 31,882 rearers in the state, involving 2540 villages, producing about 1021 metric tons of cocoons and 136 MT of raw silk, generating an income of about ₹2026.00 lakh by generating about four lakh man days in different departmental activities and one lakh man days in post cocoon sector (Anonymous, 2014a and 2014b). Average price for “A” grade silk cocoons during the 2012-13 financial year remained 510/Kg dry cocoon. The productivity has increased from 25 to 37 Kgs of cocoons per ounce of seed by introduction of latest technologies in different production processes combined with hybrid, $\text{SH}_6 \times \text{NB}_4 \text{D}_2$ (Anonymous, 2014a).

### 1.3. PESTS AND DISEASES OF MULBERRY

Mulberry is grown under a wide range of climatic conditions and is affected by a large number of diseases and pests and many of them are of greater economic importance. To get sustainable cocoon crop from silkworm rearing, various factors are responsible such as, ideal rearing house, quality mulberry leaf, proper hygienic conditions, sanitation and crop protection measures, which collectively determine the successful rearing and better cocoon yield. Among the factors, quality of mulberry leaf has got a greater significance under Indian rearing conditions. It influences the growth, development and quality of cocoons formed and thus decides the quality of silk to a greater extent (Khan et al., 2004). Hence, production of good quality leaves in terms of nutrition is very important for ensuring productive besides quality sericulture.

More than 300 species of insect and non-insect species are reported to infest one or the other part of the mulberry plant (Reddy and Narayanaswamy, 1999). Though the number of pests attacking mulberry are too high (in excess of 300), only a limited number of these are considered to be important. Major pests include leaf webber, *Glyphodes pyloalis* Walker, Bihar hairy caterpillar, *Spilosoma oblique* Walker, hairy caterpillar, *Spilosoma dalbergiae* Moore, etc. Some of the minor pests include semi looper, *Hemerophila atrilineata* Butler, black hairy caterpillar, red scale,
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mites, thrips, grasshopper, etc. Considering their feeding habits they can be classified into (a) sap feeders (b) foliage feeders (c) root and shoot feeders. In Kashmir valley, which enjoys the temperate climate, lesser mulberry pyralid, *Glyphodes pyloalis* Walker (Lepidoptera: Pyralidae) and mulberry looper, *Hemerophila atrilineata* Butler (Lepidoptera: Geometridae) are the major bottle necks for producing better leaf quality for silkworms (Anonymous, 1996; Illahi *et al*., 2011 and Mittal *et al*., 2011).

Many diseases caused by fungi, viruses, bacteria and nematode affect mulberry. To conduct multiple cocoon crops in Jammu and Kashmir which is one of the thrust areas for upliftment of sericulture in the state, certain diseases hinder (Illahi *et al*., 2010). In Jammu and Kashmir leaf spot and powdery mildew are the major foliar diseases of mulberry and acts as major threats for silk production (Anonymous, 1996 and Illahi *et al*., 2011). Sound silkworm seed, which is a prerequisite for the sound sericulture, could be obtained only when the silkworms are fed with diseases and pest free leaves (Illahi and Khan, 2009).

1.4. MITES

Mites are the tiny microscopic creatures belonging to order Acarina, subclass Acari of the class Arachnida. They are biologically the most diverse and dominant group which is worldwide in distribution (Chillar *et al*., 2007) and inhabiting in all types of terrestrial (plants, mountains, deserts, plains, pastures) and aquatic habitats (oceans, rivers, springs, streams and lakes). Mites have always attracted considerable interest because of their small size and remarkable habits of some species. Mites may be classified as phytophagous, predatory, parasitic, saprophytes, mycophagous, stored grain product pests, *etc*., on the basis of their feeding behaviour. Phytophagous mites damage the agricultural crops, vegetables, orchards, ornamentals and forest trees. They suck the cell sap with the help of their needle like cheliceral styles, modify the developing tissues, and inject toxins sometimes inducing galls. Their feeding results in speckling, stippling, blotching or bronzing of leaf which is generally followed by yellowing and leaf fall, premature flower and fruit drop, thus affecting quality and quantity of produce (Jeppson *et al*., 1975; Evans, 1992). Tetranychid mites are very important among phytophagous mites and are pests on 150 plant species ranging from
green house crops to small fruit and trees *viz.*, cotton, peanut, strawberry, bean, eggplant, squash, cucumber, corn, apple, peach, citrus, papaya, castor, mulberry, rose and many more (Naher and Haque, 2007, Ebara and Wongsiri 1975; Jeppson *et al*. 1975; Tanigoshi and Davis 1978).

The predatory mites of the family Phytoseiidae, Stigmaeidae are potentially important predacious mite species found throughout the world on many crops including apple, citrus grapes, tea, tomato, cotton, mulberry *etc.*, and control many phytophagous mite species naturally and augmentatively (Nelson *et al*., 1973; Childers and Enns, 1975; Muma, 1975; Krantz, 1978; Santos and Laing, 1985; McMurty and Croft, 1997; Villanueva and Harmsen, 1998 and Childers *et al*., 2001).

Two predatory mite species, *Typhlodromus mori, Typhlodromus transittans* have been reported on mulberry from Jammu and Kashmir (Gupta, 1980). Rai and Singh, 1999 observed that *Agistemus industani* fed voraciously on eggs of the prey mite (*Tetranychus ludeni* Zacher) in the fields of mulberry. Dar *et al*., (2012a) reported the *Agistemus* sp. and *Euseius* sp. from mulberry gardens of Kashmir, which fed on phytophagous mites, thrips and eggs of other insects.

**1.5. MITES AS MULBERRY PESTS**

Mites belonging to the families, Tetranychidae and Eriophyidae are known to cause mulberry leaf damage to the tune of 5-10 percent in India (Narayanaswamy *et al*., 1996). So far 16 species of mulberry mites have been recorded throughout the world, among them eight species are reported from India (Rajalakshmi *et al*., 2009). *Tetranychus equitorius* McGr and *Tetranychus ludeni* Zacher reported from India and *Tetranychus telarius* L. reported from Sri Lanka are common mite pests of mulberry. But a very little work has been conducted on mites of mulberry, in Jammu and Kashmir State in general and particularly in Kashmir region. Furthermore, alike damage symptoms caused by other insect pests of mulberry, the infestation of mites to mulberry foliage remains unnoticed for a certain period till the quality of mulberry leaf decreases drastically.
Recent studies in Kashmir valley revealed the threat from two mite species *viz.*, *Tetranychus* sp. and *Panonychus* sp. (Acari: Tetranychidae) which are impairing the quality of mulberry leaves and adversely affecting the biological and economic parameters of silkworm and resultant cocoon fed with mite infested leaves (Dar *et al.*, 2011, Ramegowda *et al.*, 2012a). Some predatory mites were also found associated with mulberry plants in Kashmir valley during these studies. In this background a study was executed with following objectives to understand the bio-ecology of phytophagous and predatory mites associated in mulberry and exploring the feasibility of their deployment in management of mulberry mites in Kashmir valley, India.

1.6. OBJECTIVES OF STUDY

1. To assess seasonal dynamics of mulberry mites and leaf damage.

2. To study life history of phytophagous mites, *Tetranychus turkestani* (Ugarov and Nikol.) and *Panonychus ulmi* (Koch) on Goshoerami variety of mulberry leaves, during different seasons of Kashmir under laboratory conditions.

3. To study biology and feeding potential of predatory mites *Agistemus* (*nr.*) *industani* (Gonzalez) and *Euseius* sp. on Goshoerami variety of mulberry leaves under laboratory conditions.

4. To document collateral host status of flora in mulberry ecosystem to mites and their role in mite pest build up and dynamics.