Research Paper

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Silkworm Bombyx Mori – An Economic Insect

Zoology

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G. SAVITHRI Department of Sericulture, S.P. Mahila Visvavidyalayam, (Women's University) Tirupati -517502,Andhra Pradesh, INDIA

P. SUJATHAMMA Department of Sericulture, S.P. Mahila Visvavidyalayam, (Women's University) Tirupati -517502,Andhra Pradesh, INDIA

V.Asha Krishna Department of Sericulture, S.P. Mahila Visvavidyalayam, (Women's University) Tirupati -517502,Andhra Pradesh, INDIA

ABSTRACT

The historical links between the United States and India can be traced to the year 1492, the year when Christopher Columbus discovered America in the course of his search for a new route to India. But the official and formal links began after India gained independence. American contacts with India had started before the American Revolution through soldiers and seamen who had lived both in the American colonies and in India later both countries had mutual contacts through various agencies such as missionaries, tourists, intellectuals and Indian freedom fighters

Introduction

Silk, considered as the queen of fibres, is proteinaceous in nature. The bulk of commercial silk is produced from the mulberry silkworm Bombyx mori, of which there are many strains ranging from the exotic high-yielding bivoltines to the sturdier, native multivoltines. The other silkworms commercially exploited for silk production are eri

(Philosamia species), and tasar and muga (Antheraea species) India is unique in producing all these varieties of silk. India is home to vast variety of silk secreting fauna which also includes an amazing diversity of silkmoths. This has enabled India to achieve the unique distinction of being a producer of all the commercial exploited varieties of natural silks namely mulberry and non-mulberry (tasar, oak tasar, eri and muga). Non-mulberry silkworms are known as "Vanya silkworms".

Mulberry

The bulk of commercial silk produced in the world is mulberry silk that comes from the domesticated silkworm, Bombyx mori L. which feeds solely on the leaves of the mulberry plant.

Tasar: Tasar (Tussah) is copperish colour, coarse silk mainly used for furnishings and interiors. Tasar silk is less lustrous than mulberry silk, but has its own feel and appeal. Tasar silk is generated by the silkworm, Antheraea mylitta which mainly thrive on the food plants Asan and Arjun. The rearings are conducted in nature on the trees in the open.

Oak Tasar: It is a finer variety of tasar generated by the silkworm, Antheraea proyeli J. in India which feed on natural food plants of oak. China is the major producer of oak tasar in the world and this comes from another silkworm which is known as Antheraea pernyi.

Eri: Eri silk is the product of the domesticated silkworm, Philosamia ricini that feeds mainly on castor leaves. A multivoltine silkworm known for its white or brick red silk. Eri cocoons are open-mouthed and are spun. The silk is used indigenously for preparation of chaddars (wraps) for own use by these tribals. Eri culture is a household activity practiced mainly for protein rich pupae, a delicacy for the tribal.

Muga: This golden yellow colour silk is prerogative of India and the pride of Assam state. It is obtained from semi-domesticated multivoltine silkworm, Antheraea assamensis confined to north-eastern states of India, is the least understood and unique species among saturnid moths. The silk proteins of these species have not been studied so far despite their unique properties of providing golden luster to the silk thread. These silkworms feed on the aromatic leaves of Som and Soalu plants and are reared on trees similar to that of tasar. Muga culture is specific to the state of Assam and an integral part of the tradition and culture of that state. The muga silk, a high value product is used in products like sarees, mekhalas, chaddars, etc.

The domesticated silkworm Bombyx mori L., a member of the family Bombycidae, is a well-studied lepidopteran model system with rich repertoire of genetic information on mutations affecting morphology, development, and behavior (Arunkumar et al., 2006). This species has been used as a source of silk, and has lost some characteristics due to long-term breeding under artificial conditions. Though there are many types of silkworms, only mulberry silkworm has enjoyed a large share of the patronage of the global scientific community. As a result the mulberry silkworm has achieved the distinction of being a "lepidoteran model system". As an insect scientific research resource, it is next only to the most well studied insect, Drosophila.

The wild silkmoth, Bombyx mandarina M., is believed to be the ancestor of B. mori (Banno et al., 2004), as these two species can cross-breed and yield fertile hybrid offspring. B. mandarina includes significant variation within species (Yukuhiro et al., 2002). From the aspect of morphological and physiological characteristics, B. mandarina was very similar to B. mori (Astaurov et al., 1959; Yoshitake, 1968). The mulberry silkworm belongs to Phylum: Arthropoda, Class: Insect, Order Lepidoptera, Family: Bombycidae, Genus: Bombyx and Species: mori . The domestic silkmoth, Bombyx mori, is a member of the family Bombycidae of about 300 moth species under the order Lepidoptera. Vanya silkworms belong to family Saturnidae.

Life Stages of Silkworm Bombyx mori

Silkworms are lepidopteron insects. The larvae are caterpillars, which, at the end of the larval stage, spin a cocoon of silk, and transform into pupae and finally into adult moths. The silk proteins are synthesized in the silk glands. Larvae possess a pair of silk glands, which are long complexly folded tubular structures located parallel to the gut, extending nearly throughout the entire length of the larvae, but much longer, may be up to seven times the length of the caterpillar itself! being coiled in the posterior silkglands are divided into anterior, middle and posterior silkglands. The gland is a tube made of glanular epithelium with two rows of cells surrounding the lumen. The silk fibre protein, fibrion, is synthesized in cells of the posterior silk glands, and secreted into the lumen and transported to the middle silk gland for storage. The middle region acts as a reservoir of fibroin and the fibroin matures in this region during the storage period. Further, this region synthesizes the glue proteins called sericins and coat the fibroin in three layers accumulating there. The sericin is sub-divided into 1. Sericin –I (inner most layer) secretion of posterior part of middle region, 2. Sericin –II

(Middle layer) secreted by the middle portion of middle region, 3. Sericin –III (outer most of layer) secreted by the anterior portion of the middle region. The two anterior silk glands, which serve as ducts, converge near the oral cavity, farming a scleroid structure, and open at the base of the median projection in the labium called spinneret which the silk is extruded as fibre. The hind part of the spinneret has muscles which contract, forcing silk into the tube-like front part of the spinneret. The caterpillar then moves its head to draw more silk outward. The threads of two sides are called the brins and the sercin layer bind the two brins into a single filament which is known as bave. "Spinning of the cocoon is accomplished by movement of the head. The silk itself is a double-stranded, since it comes from two separate glands. Spinning of cocoon is completed in 2-3 days, at the end of which changes taking place with in the larva culminate in the transformation to a pupa. The cocoon is thus one long silk fibre, from about 600 meter in the local races to about 1,600 meters in high –yielding bivoltine races.

Silk fibre is produced at the end of the larval life of these insects and is woven in the form of cocoon in which the larva is metamorphosed into pupal form. Silk cocoon is woven by the insect larva to safeguard the sedentary, non-feeding phase of insect's life cycle. The life cycle of silkworm represents the most advanced form of metamorphosis. Termed holometabolous, the silkworm completes life cycle through serial progression of four distinct stages of development; egg, larva, pupa and adult. The number of life cycles (generations, which is termed as voltinism) per year depends on the silkworm strain and it varies with the environmental conditions particularly temperature. Silkworm strains which go through multiple generations (5-6) in a year are polyvoltines or multivoltines. These strains do not undergo egg diapause, which is an adaptation to tropical condition in which there is no severe winter. Under natural conditions, silkworm strains which undergo only one generation in a year are univoltine strains. This is an adaptation to overcome harsh winters in temperate countries. Artificially, these eggs which hibernate during winter are stored at 4oC. After removal from cold storage to room temperature (25oC), about two weeks later ova in diapause eggs begin final development until hatching. The egg is tiny measure 1 to 1.3mm in length and 0.9 to 1.2 mm in width and resembles a poppy seed. The egg shell provides a protective covering for embryonic development. When first laid, an egg is light yellow in colour. Fertile ova darken to a blue-grey before hatching. The larva is an elongated caterpillar, the only feeding stage in the life cycle. Newly hatched larva is black in colour and it has large head and the body is densely covered with bristles so that it looks like a hairy caterpillar. As larva grows, it becomes smoother and lighter in colour due to the rapid stretching of the cuticular skin during the different instars of the larval stage. The larva is monophagous, feeds only on mulberry (Morus alba). During larval life, the larva sheds its skin (molt) 4 times to accommodate growth. The period between successive molts is called an instar. At the end of final instar (fifth instar), larvae cease feeding, and their bodies become shorter, stouter, and transparent. These larvae are called mature larvae, the larva spins a silk cocoon of one continuous fibre within which it undergoes pupation. Silk cocoons are the commercial source of silk. From the time larva hatches out from the egg up to the time of spinning silk thread at the end of larval life, grows about 10,000 times. Bred in captivity for thousands of years on trays of mulberry leaves, B. mori is fully domesticated and cannot survive without the assistance of man. The silk cocoon serves as protection for the pupa. Cocoons are shades of white, cream and yellow depending on silkworm variety. After a final molt inside the cocoon, the larva develops into a brown, chitin covered structure called the pupa. Metamorphosis of the pupa results in an emerging moth or adult. The moth is covered with heavy, round, furry scales and lacks functional mouthparts, so are unable to consume food. The forewing has a hooked tip, which is a characteristic feature of this family; however it is flightless. Wings and body are usually white, but may vary in shades of light brown. Wingspan is 1.5 to 2.5 inches. (4-6cm). It is the reproductive stage where adults mate and females lay eggs. Adult is the final stage in the life cycle of B. mori with short life span of 4-6 days.

Silk and its addition uses

Silk and silk fabric are the product of a series of stages involved in the production process derived from the cultivation of mulberry trees as a feed to the domesticated silkworm, Bombyx mori (Agriculture based activities) and post cocoon processing is industrial activity very much fit into the rural structure of India. During the caterpillar phase, the worm wraps itself in a liquid protein secreted by two large glands. This secreted protein hardens upon exposure to the air. The resulting filament is bonded by second secretion, sericin, which forms a solid sheath or cocoon. Under natural conditions, a moth eventually breaks through the cocoon. Production of cocoon the basic raw material for the silk industry is agriculture based activity. Then the cocoons are taken for silk extraction. To unwind the silk, the larva is killed in the cocoon by steam or hot air in the chrysalis stage before its metamorphosis. Sustained heat processing softens the hardened sericin so that the filament can be unwound. The silk filament is a continuous thread of great strength measuring from 500-1500 metres in length. Single filaments are too thin for utilization; several filaments are combined for the production of the raw silk this process is known as "silk reeling ". Raw silk passes through series of industrial activities viz., twisting, warp making, weft making, dyeing, printing, fabric making, finishing etc to get silk fabric for marketing. A tiny cute worm is the basis of the silk industry which is providing livelihood for 6 million people in India in various stages of production process.

The silkworm is a small and highly domesticated insect and plays a main role in production of Queen of textiles. Currently, it is the major economic resource for more than 30 million families in countries such as China, India, Vietnam, and Thailand. The silkworm which has traditionally produced rich silks can now be manipulated as an ideal laboratory tool. B. mori possesses excellent characteristics as an experimental animal; it can be reared and bred under complete human control and is an ideal organism for research in various fields of sciences. Silkworm is the well studied insect model system because of its rich repertoire of well characterized mutations affecting virtually every aspect of the organisms' morphology, development and behavior and its economic importance. Well characterized and physical mapping of chromosome mutants in silkworm offers excellent opportunities for understanding basic concepts of cytological and molecular studies. The implications of physiological studies in silkworm have found their applications in pharmaceutical and medical fields. Silkworm is an excellent laboratory tool for conducting various bimolecular as well as toxicological studies. It is the genetically best known insect next to Drosophila melanogaster. Apart from this, an upcoming field where transgenic silkworm is used for production of life saving drugs in pharmaceutical industry deserves special and careful attention. The silkworm can now be manipulated to produce a vaccine for hepatitis B. Researchers at the Indian Institute of Science (IISC) in Bangalore have been successful in making the silkworm produce an antigen for hepatitis B, a blood-borne viral infection whose rising incidence is a cause for concern in the country.

Silkworm genomics has been used to unravel the lepidopteron specific genes like novel insecticide target genes, pheromone binding genes, etc. which have found tremendous applications in the field of Agriculture. Apart from these, there are several other frontiers where sericulture can be mended using modern tools of biotechnology to suit the needs of man and industry.

Some of the research reviews on the use of silkworm as a model are discussed. Not many are aware that silkworms can be used, as effectively in place of mice, or guinea pigs or higher vertebrates in the study of pathogens and drugs. Recently, the use of invertebrate models for study of infection has given exciting insights into host pathogen interaction for a number of bacteria and this has revealed important factors of the host response with parallels in higher organisms. The advances attained in understanding the virulence determinants of a major human pathogen, staphylococcus aureus in relation to invertebrate models, the silkworm (Bombyx mori), the fruit fly (Drosophilamelanogaster) and the round worm (Caenirhabditis elegans))

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are reviewed by Jorge Garcia-Lara and others. It was concluded that use of silkworms is technically convenient, ethically acceptable, a valuable first tool to discriminate molecules as well as speedy screening method for antimicrobials. Katio and others of Graduate School of Pharmaceutical Sciences, University of Tokyo examined silkworms as an animal model of human infection with pathogenic bacteria. Barman et al , Indian researchers from the New Drug Discovery Research Unit of Ranbaxy Research Laboratories used the silkworm as an alternative animal model for testing the efficacy of novel oxazolidnones, which are used as antibiotics. The minimal lethal dose for Staphyllococcous aureus was 1.5 × 107 CFU per larva, exhibiting more than 90% mortality within 2 to 4 days post-infection. Treatment with vancomycin, linezid, and novel oxzolidinones, under development, showed survival in a dose-dependent manner. The antibacterial effect of the new molecules was compared with that of vancomycin and linezoilid, and the Effective Doses (ED50) obtained. ED50 values showed a similar trend in murine model (i.e., using mouse or similar animal) of infection. Owing to the small amounts of new chemicals were required to test their in vivo efficacy in this model. The silkworm model may, therefore, be used in the early stage of new discovery research.

With development of modern scientific technology silkworm is being used to develop products with functionality besides the traditional cocoon production. In recent years, more and more efforts have being made by the scientists to non-fibre utilization of silkworm. A series of functional products such as silkworm powder, pupal amino acids, silk cosmetics and gene engineering product of silkworm etc have been developed. Gui et al (2001) Chen et al (2002) studied the effect of silkworm powder on type- 2 diabetes mellitus for further development of anti-diabetic agent. The results showed that silkworm lowers blood-glucose of diabetes mellitus animals effectively by partially related to the inhibition of - maltase glycosidase activity in the small intestine in order to delay of the absorption of glucose by blood or tissues. Silkworm powder has also some effects proved by therapy in immunization stimulation (T-lymphocyte transformation rate was elevated by 35%), lowering blood lipid, recovering fatigue and improving resistance of insulin etc, (Gui et al., 2001). It is believed that silkworm powder is one kind of nature and multi-effect anti-diabetic agent without side effect. Meanwhile, IGF-1 (Insulin Growth Factor-1) was successfully expressed in silkworm larvae with baculovirus expression system and used to lowering blood-glucose for diabetic patients.

Dried dead larvae or pupae of silkworm infected with Beauveria bassiana is widely used in traditional Chinese medicine with much advantage in detoxification, lowering cholesterol, and effective to apoplexy, convulsions, parotitis mumps, tonsillitis, diabetes mellitus etc. It also inhibits respiration cancer cells (Jiang, 1996).

Silkworm faeces are utilized as the material for extraction of chlorophyll, which is widely used medical and food industries. It enhances metabolism, activates cells and inhibits bacterial growth in human body, which is helpful for treatment of some diseases such as hepatitis, gastric ulcer, nephitis and others, and also to increase the synthesis of haemoglobin. Silkworm pupa is a potential bio-resource with plenty of high quality protein to be exploited. The pupae protein is used to produce pupae cans and pupa amino acids for soft drinks and additives for the functional food and medicine. The chitin of pupa is one of the primary material for surgical line, vector of stationery enzymes, artificial skin etc. Fibroin, main protein of silk decomposed into oligopeptide or aminoacids by chemical and biological methods for further use in cosmetic material, functional food and medical substance etc. Because of its excellent properties in skin affinity, ultraviolet ray blockage, moisture retention, skin adhesion, silk fibroin is used as additives to produce many kinds of cosmetics. Scientists, Japan Science and Technology Corporation in Hiroshima inserted a human gene for collagen into silkworms. Genetically modifies silkworms secrete the human protein collagen in their cocoons. The insects produced both silk and collagen, which is used to generate artificial skin and cartilage and in cosmetic surgery to fill out lips and wrinkles. The silkworm nuclear polyhedrosisvirus (baculovirus) has been used as a potential expression system for various proteins of pharmaceutical interest. Already, more than thirty five proteins of pharmaceutical interest have been expressed in a biological active and useable form in silkworm using baculovirus as vector signaling the importance of using baculovirus as vector signaling the importance of using silkworm as bioreactor.

Silkworm produces a fine, glistening, fabulous proteinous silk thread the fabric made of which is regarded as the queen of textiles and has made great contribution to the human civilization, biologically, silkworm innovates as potential insect system for production of high cost proteins and currently silkworm is technically convenient, ethically acceptable a valuable laboratory animal model to discriminate molecules as well as screening antimicrobials, evaluating the efficacy of novel antibiotics for pathogenic bacterial infection in humans, screening of drugs etc. Still there is a vast scope to explore the tiny insect for the welfare of the mankind.

SILKWORM BOMBYX MORI IS PRECIOUS NATURE'S GIFT OF GOD

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