Top: Mass rearing of young age silk larvae using chopped mulberry leaves.

Bottom: Mass rearing of the late age silk larvae using mulberry shoots, which helps to reduce the rate of secondary contamination and the spread of diseases, as handling of the silkworms is reduced. With this method, the silkworms are separated from the faeces and diseased larvae with every feed. Mass rearing is also economical.

paper to maintain the moisture content. The larvae are fed two times a day, except when moulting. Young-age rearing requires a temperature and relative humidity of 25–28°C and 85–90%, respectively.

Late age rearing

Late stage rearing starts from the fourth to the fifth instar, and the worms are fed on whole mature mulberry leaves. As the fifth instar silkworms consume large quantities of mulberry leaves, shoot rearing is required. Silkworms lose water and require low temperatures and relative humidity of 23–25°C and 70–75%, respectively, to stay moist.

Cocoons

At the end of the larval stage, silk larvae develop unique characteristics to indicate that they are ready to start spinning cocoons. These include a colour change from white to a translucent-opaque colour, no feeding, and loss of body mass. This is the stage where they are selected and transferred to mountages for spinning in a well-ventilated room.

Top: *Bombyx mori* sillk larvae spinning silk in a wooden mountage. After the fourth moult, the mature silk larvae stop feeding on mulberry leaves, and search for a corner to start spinning cocoons.

Bottom: Dried *B. mori* cocoons in trays after harvesting, and three wooden mountages (foreground). Cocoons are harvested 6 – 7 days after spinning, to allow the larvae to change into pupae.

Each larva spins a silk cocoon in 24 hours, before changing into a pupa. Cocoons are kept at room temperature and harvested on the fifth day, then dried in the sun for three days (or in an oven at 60°C for the first hour, adjusted to 100°C for the next hour).

Economics

One acre of mulberry can yield up to 4 boxes of silkworms per cycle. With good quality silkworm hybrids and proper rearing skills, each box can produce an average of 20–30 kg wet weight of cocoons depending on weather conditions, which translates to 80–120 kg of cocoons per cycle. Assuming there are 5 rearing cycles a year, a farmer can produce 400–600 kg of cocoons, at US$ 3 per kg, thus earning approximately US$ 1200–US$ 1800 annually.

Farm-Based Silk of Bombyx mori as Alternative Livelihood Option

icipe – Working in Africa for Africa…

icipe – African Insect Science for Food and Health – was established in 1970 in direct response to the need for alternative and environmentally-friendly pest and vector management strategies. Headquartered in Nairobi, Kenya, *icipe* is mandated to conduct research and develop methods that are effective, selective, non-polluting, non-resistance inducing, and which are affordable to resource-limited rural and urban communities. *icipe*'s mandate further extends to conserving and utilising the rich insect biodiversity found in Africa.

icipe contributes to sustainable food security in Africa through establishment of insect-based enterprises, such as sericulture, that are sustainable, eco-friendly and synergistic, and that provide quick economic rewards to communities living in these forest areas. The underlying principle is to assist rural resource-poor communities to improve their livelihood, and to protect the natural environment, thus increasing the productivity and resilience of their farming systems and the natural resources, through uptake of these techniques.

Top left: A pair of mating *Bombyx mori* moths: Male and female moths almost look alike, are flightless, and lack functional mouthparts. The female has a larger abdomen holding hundreds of eggs, whereas the male has a much larger pair of antennae.

Top right: These silk scarves were woven from *B. mori* yarn that Kenyan farmers produced, dyed and printed in various colours and patterns to add value to the product.

Bottom left: A farmer demonstrates young age rearing of *B. mori* larvae using trays.

Bottom right: Silk farmers in Kakamega with their *B. mori* cocoon harvest, ready for sale to silk producers.

Donors: European Union, IFAD, WTO-Enhanced Integrated Framework (EIF), UNDP-GEF, Biovision, AusAID, CordAid, USAID, CEPF

Collaborators (including communities): AU-IBAR, Ministries of Agriculture, Animal Industry, Fisheries and Environment, NARS, NGOs, Kenya Organic Agriculture Network, Farmers' Federations (FF), and local community groups.

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Farm-Based Silk

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Background

Sericulture is the practice of raising silk larvae to produce raw silk. In developing countries, agriculture and agro-based industries play vital roles in improving the rural economy. Because of the limited availability of land and cash returns, and because agriculture is confined to one or two seasons in a year, villagers can count on alternative income-generating activities, such as sericulture, to supplement their income. Where the ecological conditions are favourable, farmers can adopt agriculture concurrently with farm-based sericulture (FBS) of *Bombyx mori* silk larvae.

Silk larvae farming using *Bombyx mori* is labour-intensive, and suited to Africa, as it can provide income and self-employment in rural and semi-urban settings. Farmers can undertake FBS as rural microenterprise initiatives, together with their normal farming activities, which can provide gainful employment year round for 4 people in a family.

Left: A silk larva (or caterpillar) of the domesticated silkmoth, *Bombyx mori*. This species is an economically important insect for farm-based sericulture (silk production). The larval period is 25–30 days during which time the silk larva moults four times by casting off old skin, up to five times. The gap between two moulting periods is called an instar.

Top and Bottom: A healthy *Morus alba* plant. Mulberry leaves are the unique food of *B. mori* silkworms. The mulberry plant is fast-growing plant and can reach heights of 20 m. The shape of the branches and form of the leaves depends on the cultivar.

Planting mulberry to feed *Bombyx mori*

Cultivating mulberry *(Morus alba)*, the food plant for *B. mori*, is the first step in farm-based sericulture. Mulberry is grown using the vegetative plant parts, direct to the farm or in nursery beds. A minimum one-acre of mulberry is recommended for initiating FBS for economic gain. (One acre is 40% of a hectare.) Before the onset of rains, the land is prepared by weeding, ploughing, digging, and levelling. Seven tonnes of farmyard manure per acre per annum is mixed with the soil.

The mulberry cuttings are planted at the onset of the rains. The type of mulberry variety used depends on the climate and soil type. If the soil is fertile, 5000 mulberry cuttings per acre in 3 x 3 feet rows are planted; but if the soil is less fertile, 11,000 cuttings per acre in 2 x 2 feet rows are planted. Only the mulberry cuttings that have 5 or 6 buds are selected. On average, in 7 to 8 months, the new mulberry plants will have sufficient foliage to support rearing of one box of 20,000 silkworms. If the rains fail after planting, the land is irrigated once every 15 days. Prunning is recommended after the mulberry is one year old; and plants can, thereafter, support up to 4 boxes of silkworms. Subsequent pruning is done twice a year.

Top: A tin roof mud house for rearing silk larvae in Kakamega, western Kenya. An ideal rearing house should ensure sufficient aeration to maintain the recommended temperature and relative humidity (RH), and protect the larvae from the elements. It is built away from any sources of pollution, and is easy to disinfect.

Bottom: Silk larvae mass rearing technology using rearing beds and mulberry shoots.

NPK fertiliser (5 to 8 g), is added 60 days after planting around each plant (approximately 50 kg per acre).

Raising *Bombyx mori* larvae

Rearing house and appliances

A rearing house, either of mud or wood, which is at least 25 x 20 x 10 feet, and with adequate ventilation, is required to rear the silk larvae. This house should have the capacity to hold 2 to 3 boxes of silk larvae. The rearing equipment includes three-tier rearing wooden or bamboo bed racks for tray rearing, mountages, wooden or bamboo trays, knives, cleaning nets, baskets for collecting the leaves, a leaf chamber (4 x 3 x 2 feet), and ant wells to protect the larvae.

A high level of hygiene is required inside the house; and a disinfectant (2% solution of formalin and lime powder), is sprinkled on the floors before initiating rearing. In the first year, if the rains are favourable, one cycle of silk larvae rearing is possible. As one gains experience, 4 to 5 rearing cycles per year are achievable.

Top: Disease free egg laying. A female moth can lay an average of 400 – 500 eggs. The eggs of *Bombyx mori* are small and hard, about the size of a pin head, and resemble a poppy seed. The egg shell provides a protective covering for embryonic development.

Bottom: Brushing of newly hatched larvae. Young larvae are transferred from the egg card to the rearing tray with a fine brush or feather, and then fed with finely chopped tender mulberry leaves.

Egg incubation

Purchase silkworm eggs from high yielding bivoltine *Bombyx mori* hybrids sourced from a reputable silk larvae egg production grainage, where the eggs are stored at 3°C. Prior to incubation and supply to farmers, eggs are removed from the cold storage and brought to room temperature. These eggs should be transported to the rearing farm during the cool hours of the day, to avoid drying out.

Eggs are incubated at 20 – 22°C for 5 days and 25 – 26°C for another 4 – 5 days at a relative humidity of 80%, with a cycle of 12 hours light: 12 hours dark so that 98% of the silkworm eggs hatch. They are placed in a black box or covered with black paper, 24 hours before hatching, to ensure uniform embryonic growth. On the day of hatching, eggs are exposed to light.

Young age rearing

Young age silkworm rearing is the period till the third instar. When the larvae hatch, they are brushed with a fine feather onto a rearing tray, and fed on chopped young tender mulberry leaves with a high moisture content. The trays are covered with polythene