Spin·off Presents:

All About Silk

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Isn't it fascinating that one of the most luxuriously soft, fine fibers comes from a worm? Well, not really a worm, but a silk moth in larva form (the most common is the *Bombyx mori*). Imagine that process of discovery, when humans first figured out how to remove the glue (called sericin) that holds the cocoon together and reel off fine threads and then reweave them into incredibly fine fabrics that are also strong and warm. We owe so much to that humble silkworm—not only for the miles and miles of fabric that the cocoons have yielded throughout the ages, but also because by studying how the silkworms extrude the liquid protein that then hardens into a fine thread, humanity has been able to mimic the process leading to the manufacture other fibers.

Spinners usually spin silk first in a wool/silk blend—and what an excellent pairing that is! Blending wool and silk brings forth the best qualities of each fiber—warmth, elasticity, luster, and loft.

While spinning pure silk is a little trickier than spinning a blend, it is a very rewarding process with beautiful results. After you try that, you might want to dabble in dyeing silk as the fiber takes dye beautifully. Be prepared for vivid, lustrous colors. Pretty soon you may find yourself in charge of your own little "flock" of silkworms—providing a steady supply of silk.

Whether you're simply interested in the history of silk, learning how to spin it, or raising your own silkworms, this eBook is a great place to start on your journey. We culled the best silk articles published over the last thirty-five years in *Spin-Off* magazine just for you.

Happy spinning,

Amy

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it's about making yarn by hand

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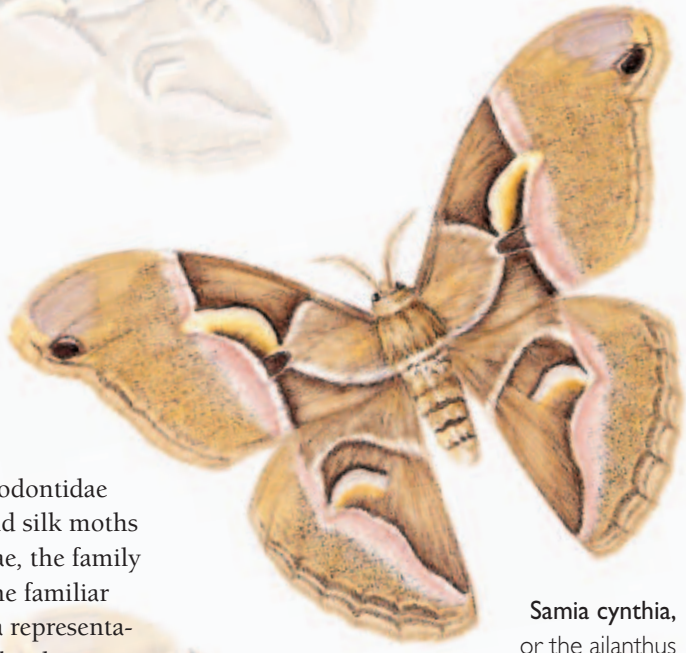
Wild Silks of the World

BY RICHARD S. PEIGLER



Samia cynthia, or the ailanthus silk moth, at life size. For more information on this particular wild silk moth, see pages 5-6

A single species, called the silkworm or mulberry silk moth, *Bombyx mori,* probably produces more than 99 percent of the silk used commercially today. This species is believed to have been cultivated for almost 5,000 years in China, and like many domesticated animals or cultivated plants, it has become dependent on human care. The caterpillars cling to branches poorly and would fall off if placed on a mulberry tree. Their white color provides no camouflage. They make no attempt to escape from the rearing pans. The white (uncamouflaged) moths do not fly, and sometimes mate even before they have expanded their wings. Such helpless creatures would not survive long in the wild.

However, there are many kinds of wild silk moths, sometimes called nonmulberry silk moths, that generally are not reared in captivity. Instead, native peoples collect the cocoons from wild moth populations. Sometimes a certain amount of rearing is done, but this often takes place outdoors with little or no protection of the larvae.

Most wild silk moths belong to the family Saturniidae. The common name in the United States for this group of more than 1,500 species is *giant silk moths* (although more than half of the species pupate in soil without forming cocoons). Other wild silk moths belong to the Lasiocampidae family, which includes the well-known tent caterpillars. The moth family Notodontidae contains two genera of wild silk moths used in Africa. The Pieridae, the family of butterflies containing the familiar whites and sulphurs, has a representative in Mexico whose silk has been used to make fabric and paper.

AN OVERVIEW OF WILD SILK USE

Historical and present-day documentation mentions at least twenty-five or so kinds of wild silks. It's possible that many other kinds have been used but not recorded. Some of these wild silk-producers have only ancient historical significance. Others have been used well into this century, although little if any use is made of them today. A few species still do have immense economic importance in much of India and China and in smaller regions of Japan.

Amid the rapid technological advances of today's world, in which small aspects of human culture in the Third World are increasingly exterminated, some localized techniques for silk rearing and processing have been lost. Moreover, international trade now reaches most human populations, decreasing the demand for fine or unique products that are handmade.

It is only because of cultural tradition and ritualistic significance that certain wild silks continue to be produced and marketed successfully in Africa, India, and Japan. None of the wild silkworms are reared on the huge scale of the mulberry silkworm, in which various levels of mechanization

in Asia, artificial diets, and the low cost of labor contribute to a very profitable multi-billion–dollar industry. The wild silks are generally produced through cottage industry, in which people in particular regions raise or collect modest numbers of larvae or cocoons to supplement their incomes by sale of the unprocessed cocoons.

For historical, cultural, and economic reasons, India is clearly the leading country in production of wild silks. The Indian government promotes these cottage industries by establishing and funding experiment stations and training centers throughout that vast country. Likewise, the government of the People's Republic of China is aware of the economic potential of tussah production and strongly supports this ancient industry. I am not aware of government promotion of wild silk production in Japan, Madagascar, or any African countries.

Muga Silk

Muga silk (also spelled mooga and moonga, all derived from an ancient Sanskrit word meaning amber) is a coarse golden-brown or amber-colored silk from the silkworm Antheraea assamensis, which feeds primarily on plants in the laurel and magnolia families. It is produced only in the Assam region of northeastern India. The light brown cocoon is easily reeled, and the fabric—sometimes called "the Pride of India"—is durable and strong.

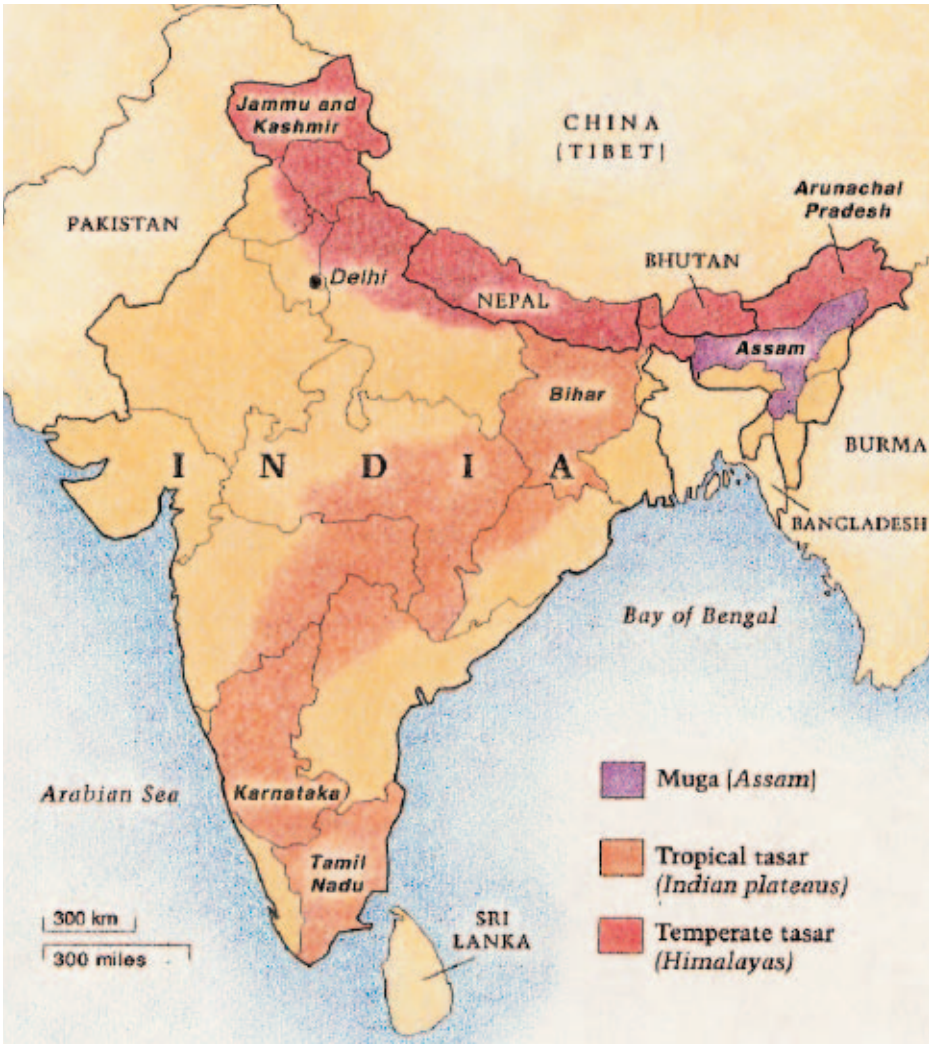
Muga silk has been produced for several centuries. During the nineteenth century and before, it was generally used for clothing by the middle classes of Assam, but it has recently become too expensive for the average person. In the past as well as today, almost all of this silk was and is used locally, leaving virtually none for export to other parts of India or outside India.

The decline of mugaculture in recent decades has resulted from a combination of factors, including floods, drought, and the indiscriminate felling of the host-plant trees. Today the reeling and weaving of muga fabric is done on a large scale only in the Assamese village of Sualkuchi, but the Indian government is actively promoting the development of mugaculture, with research programs aimed at developing cultivated varieties more suited to indoor rearing and yielding larger cocoons.

Tasar Silk

Two categories of tasar silk—tropical tasar and temperate tasar—are raised on a large scale throughout much of India. The word tasar is probably derived from the Sanskrit word trasara or tassara, meaning shuttle, and this silk culture is said to date back several centuries in India. Now India exports saris, scarves, neckties, and other clothing made from tasar silk to the United States, Germany, Japan, and other countries. Since the 1960s, this trade has been worth hundreds of thousands of dollars annually.

This map shows where muga and tasar silks are grown.



PHOTOS BY RICK WICKER

India. Muga silk comes from northeastern India. This is a male muga silk moth and empty cocoon, shown with muga silk fabric in the background.

The area of traditional or tropical tasar production, based on the silkworm *Antheraea paphia,* extends along the humid, dense tropical forests of the central and southern plateaus from Bihar down through Karnataka and Tamil Nadu. There are more than twenty-five "eco-races," cultivated in various districts and on different host plants. Several host trees are used, including the crepe myrtle, *Lagerstroemia indica,* a small showy tree commonly planted across the southern United States.

Up to the beginning of this century, most cocoons were gathered in the wild, but today many cultures are "seeded" by placing eggs secured from captive moths on trees outdoors. Larvae are given some aid by deterring predaceous birds, killing arthropod predators, and so forth. The huge cocoon, the size of a hen's egg, suggests a long history of artificial selection.

Tasar fabrics vary considerably in color and texture, depending on whether the silk was reeled or spun, how much it was dyed or bleached, and whether the weft and warp threads are the same or different. Several samples that were sent to me look quite unlike one another. A common yellowish form is glossy and golden and is often made into saris worn by Indian women. Unreelable cocoons are boiled and the silk is spun into thread by pulling loose silk from the cocoons and twisting it across a clay pot or one's thigh; this is called *ghicha* spinning.

The temperate tasar is reared on several species of oak trees in the Himalayan belt from Kashmir to Arunachal Pradesh. It is a new hybrid silkworm that was developed in the 1960s and widely introduced and exploited in the 1970s and 1980s. This created an opportunity for many tribes in the Himalayas to become involved in sericulture, made use of a natural abundance of oaks, and has contributed to the Indian economy. Produced by crossing the native Himalayan *Antheraea roylei* with the Chinese *A. pernyi* (see the next paragraph), this hybrid silkworm has been dubbed *A. proylei.* I was sent samples from Manipur, near Assam.

TUSSAH SILK

Antheraea pernyi is the Chinese oak silk moth or Chinese tussah silk moth. The word tussah, also spelled tusser, is obviously derived from tasar. All over China, thousands of acres of oak trees are cultivated for tussah production. This includes all provinces except Xizang (or Tibet), Qinghai, and Ningxia, but tussah is raised particularly in the northern province of Liaoning.

Tussah silk is grown in many parts of China. For an idiosyncratic tussah source,..

The city of Dandong in Liaoning has been a center of tussah silk production for more than two centuries, and in 1980 provided about 70 percent of China's output. Tussah production fluctuates, as does that of all wild silks; 75,000 metric tons were produced in 1980, and 50,000 metric tons were produced each year from 1987 to 1989.

Undyed tussah silk is usually natural shades of beige, but with improvements in dye techniques the fiber's market is increasing in and out of China. Chinese tussah often appears in international trade, offered for sale in Europe and the United States as finished garments, such as underwear, shirts, and formal wear; as yard goods; and as fiber for handspinners.

Tussah silk has been used in China at least since the Han Dynasty (206 B.C. to A.D. 220). The species was introduced to northern Spain in the last century, and populations persist today on the Balearic Islands off the eastern coast of Spain. It was also introduced and cultivated off and on in Japan and Korea. It is raised in laboratories for insect physiology research in Europe, Japan, and North America. In China, studies are underway to develop uses and markets for byproducts of tussah sericulture in medicine, health foods, and cosmetics, and for biocontrol—tussah eggs are used for rearing beneficial insects to combat forest pests.

TENSAN SILK

Antheraea yamamai is the Japanese oak silk moth, commonly called tensan in Japan. The cocoons are green or yellow, depending on how much light the spinning larvae were exposed to.

This silk has been cultivated in Japan for more than a thousand years. It was introduced into Austria in the 1860s; there the Baron de Bretton reared 16,000 cocoons in 1868. Although not used economically in Europe today, the species became established and spread throughout the oak forests from lower Austria into northern Italy. The range is still expanding, and the species has reached pest status in some districts. In Asia the moth flies throughout Japan, and it is found on Taiwan and on the mainland in parts of Russia and China.

Japan. Tensan silk, from the Japanese oak silk moth, is highly valued in Japan. This picture shows the male and female moths, cocoons, and a necktie with stripes of white tensan silk. The map at the left shows where tensan is grown.

The cynthia moth shown on page 1 is a wild relative of the eri silk moth, cultivated in the Brahmaputra Valley.

Today, tensan silk is cultivated in only a few places in Japan. One firm producing and marketing the finished products is the Shiga Prefectural Tussah Sericultural Cooperative Association. In August 1994, I visited the Ariake Tensan Rearing Farm in Hotaka, Nagano Prefecture. Here the oaks are planted in rows and are covered with arching poles over which nets are stretched during the rearing season. At the Hongo Studio in nearby Matsumoto, spinning and weaving of tensan silk is taught to students. Japan's high cost of labor (as compared with that in other Asian countries) and a much greater demand than supply have allowed this silk to command exorbitantly high prices in Japan.

The silk has great cultural and ritualistic significance. Items produced include small tablecloths, neckties, obis (belts), cloths for Buddhist altars, and family crests in frames. Many of these items cost the equivalent of hundreds or thousands of dollars.

THE AILANTHUS SILK MOTH AND THE ERI SILK MOTH

Probably the most beautiful of all wild silk moths is the ailanthus silk moth, commonly called the cynthia moth, *Samia cynthia.* This insect is native to China, where its cocoons have been used for centuries to produce cloth, sometimes called fagara silk; the practice continues today to a small degree. The closely related, domesticated eri silk moth, *S. ricini,* has been used on a larger scale in the Brahmaputra Valley of India, both historically and in the present day. The cynthia moth feeds on tree-of-heaven, *Ailanthus altissima,* but eri silkworms are usually raised on the big palmate leaves of castor oil plants, Ricinis communis.

Cynthia moths, with their compact gray cocoons, were widely relocated in the 1800s in the hope of founding sericulture industries. In the United States, the big moths were introduced and established in 1861. This species is associated, like its host tree, the ailanthus, with large cities such as Boston, New York, Philadelphia, and Washington, D.C., but populations have declined sharply in recent years. Possible causes for the decline include urban renewal, parasitic wasps, and predation by the European starling.

The Mediterranean region has produced Coan silk, named for the island of Cos, and a small amount of tussah.

The eri silk moth has been domesticated for centuries in India, China, and Japan, and in the last two centuries in Cuba, Uruguay, Egypt, France, and Italy. This domesticated form cannot exist on its own in a wild state. Larvae are raised in open pans, like larvae of the mulberry silk moth. Eri silk moths have large, puffy cocoons, reflecting a long history of artificial selection, that come in snow-white and brick-red forms.

Eri cocoons cannot be reeled, but are spun into thread like cotton, and the weaving is a cottage industry in Assam. A sample of eri cloth sent to me at the Denver Museum of Natural History from Assam Agricultural University looks much like a dull white cotton sheet. Most people who examine it would not suspect it to be silk at all. The fabric is said to be so durable that a garment made from it will last the lifetime of the owner.

During their control of India, the British attempted to enlarge eri silk production to a larger commercial scale, but then, as now, the production was too risky and irregular for most investors. Currently the government of India is attempting to expand ericulture to the states west of Assam, where castor bean plants can be grown even in stressed ecosystems, providing leaves to feed the eri silkworms and beans to yield castor oil.

Coan Silk

Coan silk, presumably from the species Pachypasa otus, was much prized by the ancient Greeks and Romans, but this sericulture disappeared around the second century a.d. when silk from China was brought in by traders. The insect ranges from southern Italy to southeastern Iran. The caterpillars feed on oak, cypress, and juniper trees, and spin white cocoons.

First recorded by Aristotle and later described by the Roman naturalist Pliny the Elder, Coan silk was sometimes dyed purple and worn by dignitaries in Rome. Production of this most precious export centered mainly on the Greek island of Cos (Greek: *Kos*), and many Romans were attracted to the island because of this industry. Although the ancient records leave no doubt that Coan silk came from a moth native to the island (historians agree that the mulberry silkworm from China could not have been reared at that place and time), a few scholars have argued that the Coan silk industry was based instead on the much larger and more common *Saturnia pyri,* the well-known peacock moth that ranges throughout southern Europe into western Asia. Unlike Indian tasar silks, which have been found in tombs dating back more than two millenia, no ancient fabrics of Coan silk have survived, so we may never be certain which moth was used.

Wild Silks of Mexico

Unlike the Asian wild silkworms already discussed, which spin individual cocoons, most of the silk used historically in Mexico comes from two species of wild silkworms that make baglike communal nests. Larvae of Gloveria psidii make a nest from which the silk was used by the Aztecs and the two major indigenous peoples in the state of Oaxaca, the Mixtecs and Zapotecs. Although Aztec attempts to subjugate the Oaxaca area were never successful, the Aztecs adopted some of the art and culture of the Mixtecs. The silk was supposedly an article of commerce during the time of Moctezuma II, whose reign was 1502–1519.

The moth is found today in many areas of Mexico, including the states of Puebla, Veracruz, Guerrero, Oaxaca, San Luis Potosí, and Chiapas. The caterpillars hide in the nest by day and leave it to feed on guava and oak leaves at night. Large nests can be more than three feet (one meter) long, but they average less than half that size. The ones at the Denver Museum of Natural History have a soft, light beige silk.

Eucheira socialis is the only butterfly among the wild silkworms. Its larvae construct a communal nest, the outer surface of which resembles parchment paper in

The wild silks of Mexico, come from communally generated nests, not individual cocoons.

Africa. Anaphe moths and anaphe silk fabric, woven in Nigeria. Anaphe larvae build a baglike communal nest made of reddish-brown fiber which is very strong.

color and texture and has been used historically in Mexico as writing paper. The silk has been processed into fabric in Mexico from ancient times well into this century. It was collected and processed in the Zapotec region of San Bartolo Yautepec as recently as the 1950s.

The Aztecs called the insect xiquipilchiuhpapálotl, which means "butterfly that makes a pouch" (although this name may also have been applied to Gloveria psidii). This species is now widely distributed in Mexico, although recent studies suggest that it originally ranged in north-central Mexico and was spread throughout southern Mexico by humans. Indians of several tribes eat the larvae and pupae, and there is anthropological evidence that this is an ancient practice.

The larvae feed on madrone trees, where they build a communal pouch. They exit the pouch to feed during the night, and eventually pupate in this nest. Long ribbons of silk lead out from the bags, laid down along branches by the caterpillars to guide their return home after feeding.

I observed this species in the field in early March 1992 along a mountain road of Durango state. The white bags were easy to spot from the car (which was moving slowly because of numerous potholes in the road) on sunny days when they were dry, but less so when rainy weather made them a dull gray. Sometimes madrone trees were nearly defoliated. When I attempted to tear open a bag, I found the silk to be extremely strong and resorted to a Swiss army knife.

Africa. These rust-colored **Gonometa rufobrunnea** moths come from Botswana, where the cocoons are gathered and processed into bricks for spinning. These samples were spun, dyed, and knitted by Gail A. Boyd of Denver.

The bag contained 157 full-grown caterpillars, maroon with black heads. Silk from these bags has not been processed in Mexico for several decades.

Larval tents of one other small moth were also used locally to make fabric in Mexico. However, it is interesting to note that two large silk moths, *Antheraea montezuma* and *A. godmani,* closely related to the large muga and tasar silk moths in Asia, occur commonly on oak trees in southern Mexico and produce large cocoons. I have found no record that these were ever exploited by Mexican peoples, but Walter Linsenmaier, in his book *Insects of the World* (New York: McGraw-Hill, 1972), advocated that cocoons of Mexican silk moths must certainly have been used to make cloth in pre-Columbian days.

The mulberry silkworm was introduced into Mexico by the Spanish. Its cultivation was much encouraged during colonial times, and still continues in limited areas.

Wild Silks of Africa

The primary wild silk moths of mainland Africa belong to the genera Anaphe and Epanaphe. Several species have been exploited, and various trees serve as host plants. I have no information pertaining to the historical use of this silk, but it has been much used in the twentieth century and still is today.

Larvae are green or whitish, bear tufts of hair, and are apparently gregarious throughout their life (although one source says that they live separately and then reassemble for pupation). Upon maturity they build a reddish-brown communal nest on the host tree. Only the outer covering of the bag nest is used as a fiber source; the actual cocoons within are of little or no value. Some species, but not all, incorporate stinging hairs from the larvae into the nest, and anyone processing the silk must wear a protective mask and gloves to prevent serious inflammation.

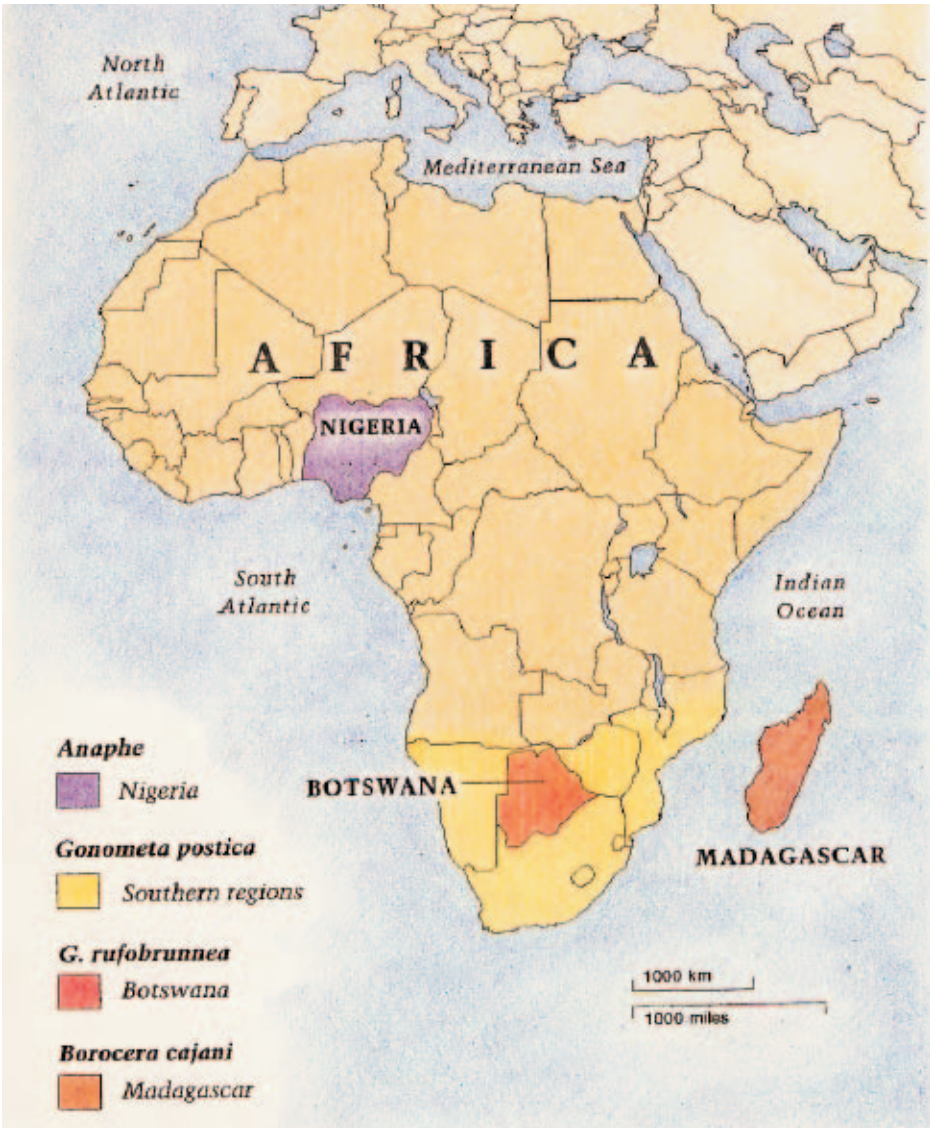
These wild silks are stronger and more elastic than mulberry silk, and have been used in various products including velvets, plush fabrics, neckties, umbrellas, and even balloons. M. O. Ashiru of the Forestry Research Institute of Nigeria wrote to me that anaphe silk is used in Nigeria to produce regalia worn in social ceremonies such as funerals or weddings. These garments have cultural and artistic value and are used by both rich and poor. However, the obeche tree, which is the host tree in that region, is being seriously depleted for its timber value, so a complete costume may cost in excess of $300 to $400; seventeen years ago, the same item cost $30 or less.

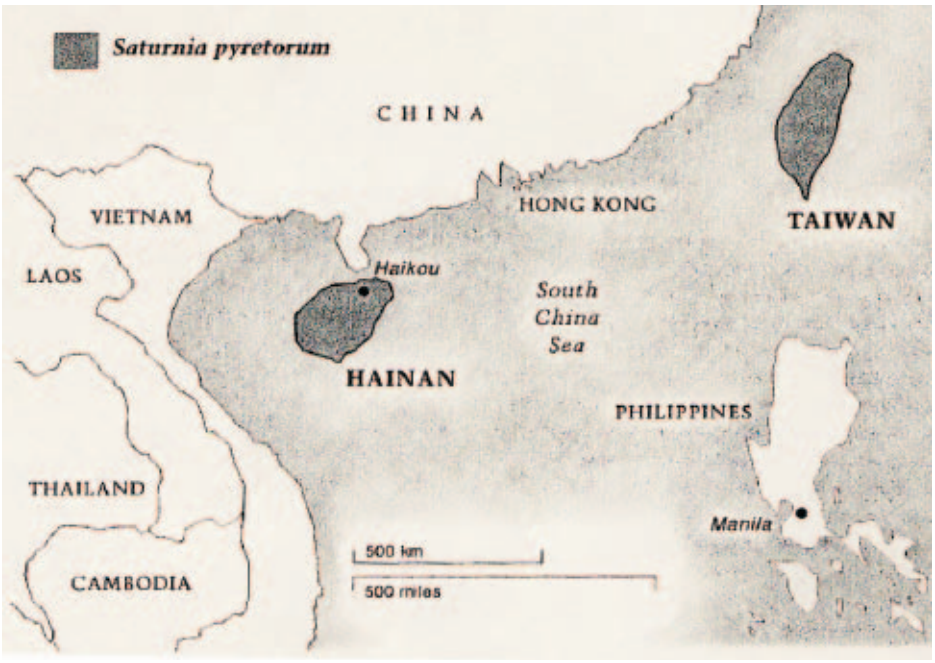
Ashiru managed to obtain a piece of anaphe cloth for me at a fair price. It is dense and heavy, resembling grayish-green canvas but softer, and has bands of gold threads and rows of small holes woven into it. Another Nigerian fabric, called Sanyan cloth, combines anaphe silk with cotton.

A few African silkworms produce useful cocoons. *Gonometa postica* occurs on the African savanna. Its cocoons are up to 2 inches (5 cm) long, and spun silk is processed from them. Workers in Africa and India are studying this species for its sericulture potential.

In Botswana, work with the related species *G. rufobrunnea* shows promising results. These splendid moths have an intense rust coloration. Cocoons are collected on mopane trees in the wild and appear to be more abundant in dry years. The larvae hide on the stems

Several types of wild silks are cultivated and used in Africa.





Centered on the Chinese island of Hainan, the practice of harvesting **Saturnia pyretorum** for use in fishing lines endured for centuries.

by day, and feed on leaves at night. The cocoons are found on twigs and are very hard, presumably containing much sericin. Collecting and processing this silk may offer a viable source of employment and income for the villagers of eastern Botswana. The president of Botswana boasts of a national flag made from his country's native silk.

I received a sample of the unprocessed floss, which had a soft texture and beige color, much like Chinese tussah. At my request, Gail A. Boyd of Denver spun it into thread, dyed it green, and produced an exquisite piece of knitted work.

The cocoons of *Gonometa* have had other uses in Africa. The Denver Museum of Natural History has some ankle rattles made by Bushmen in Botswana; each rattle is a string of numerous cocoons containing tiny chips of stone or ostrich eggshell.

Closely related to the *Gonometa* species on the mainland, *Borocera cajani* and allied species have been utilized for centuries as silk sources in the high plateaus of central Madagascar. The caterpillars feed on various resiniferous plants, including mango trees. They have stinging hairs, which are shed and incorporated into the cocoon when it is constructed. In spite of this, women use the fiber to spin and weave a coarse silk fabric. This sericulture was at its peak at the turn of the century, with many forms and uses of the silk products (including blends with cotton).

These large indigenous silkworms are called *landibe* (distinguished from the mulberry silkworm, called *landikely*, which was introduced to Madagascar in the 1820s), and are still much cultivated today. Although fabrics from the wild silk are coarser and more difficult to dye than those from mulberry silk, they command a much higher price. One particular use is for shrouds. Despite strong encouragement by French workers, this sericulture has hardly advanced beyond an artisan stage and exists at a very low level today.

Other Wild Silks of Asia

A few other wild silks have had interesting specialized or local uses. The following all belong to the saturniid family.

The larvae of *Saturnia boisduvalii* feed on oaks, fruit trees, willows, and other trees across northern China and eastern Siberia, and spin netlike cocoons with a limited amount of silk, doubtfully reelable. The Chinese used this species as a silk source during the Zhou Dynasty (1122–247 B.C.), and considered it a sacred silkworm during the Han Dynasty (206 B.C.– A.D. 220) and the Tang Dynasty (A.D. 618–907).

Attacus atlas, known as the atlas moth, is widely distributed in southeastern Asia and belongs to the genus containing the largest moths in the world. Although its silk is little used today, it may have had occasional significance in the past. The large cocoons contain a considerable amount of brown silk which is not reelable, although it can be made into floss silk and spun silk yarn. In various localities, this silk is called fagara, tagore, or ailanthus silk.

The silk exploitation of *Saturnia pyretorum* was a bizarre deviation from the normal production of fabric from cocoons. For centuries, mature larvae were collected just before pupation and the silk glands were extracted, soaked in vinegar, washed, stretched more than 6½ feet (2 meters) long, and made into what was hailed as very strong leaders for fishing lines. The caterpillars were sometimes fried and eaten after the silk glands were extracted.

This industry existed primarily on the Chinese island of Hainan, where the Loi people collected the larvae from the host trees by knocking them down with bamboo poles, and sold them to the Haka people, who were said to be experts in making the fishing lines. The Japanese introduced the moth onto Taiwan when this island was under their control earlier in this century, successfully securing a portion of the fishing-line market, but the species is not currently used there. I suspect that with the advent of nylon and other synthetics for fishing line the industry is also extinct in China.

The cocoon of this moth bears a striking resemblance to that of the ceanothus silk moth (see the next section), but it has no value in sericulture.

Wild silks in the United States

In the nineteenth century, three saturniid moths native to North America were the subject of attempts to produce silk in the United States. In Massachusetts, a sericulture enthusiast from France actively experimented with native and imported silk moths. This was Étienne Léopold Trouvelot, best known for introducing the pestilent gypsy moth into North America. Trouvelot claimed to have not less than one million larvae of the polyphemus moth, Antheraea polyphemus, on oaks under nets, but for various reasons the project never led to production of fabric. Polyphemus cocoons are similar to those of some Antheraea species that have long been successfully exploited in eastern Asia, so we might assume that this American moth would have been much used commercially if it were Asiatic.

In the 1860s, the state of California promoted sericulture by offering bounties for the establishment of mulberry plantations that could be a food source for mulberry silkworms. Against this backdrop, it is not surprising that the large cocoons of the local and common ceanothus silk moth, *Hyalophora euryalus,* would be noticed and promoted by several people. In 1879, Felix Gillet demonstrated once and for all that these cocoons could not be reeled successfully, so the efforts were abandoned.

Casual references in the older literature also indicate attempts to use the silk from the promethea moth, *Callosamia promethea,* common in eastern North America, but all these efforts evidently failed. Promethea cocoons are familiar sights hanging on sassafras and wild cherry trees, but they are not reelable.

The native ceanothus silk moth and promethea moth were never exploited because American workers apparently never realized that silk from unreelable cocoons could be carded and spun like cotton, even though craftspeople in Asia, Africa, and Mexico have a long and successful history of using wild silk from cocoons or nests that cannot be reeled.

Ironically, the many attempts in North America to raise the easily reelable mulberry silk all eventually failed.

Richard S. Peigler is a biology professor at the University of the Incarnate Word, San Antonio, Texas. As a former curator of entomology at the Denver Museum of Natural History, he developed an extensive collection of wild silks and then donated it to the Anthropology Department at that museum. *A version of this article first appeared in* American Entomologist *39 (Fall 1993): 151–161.*

In the United States, people have attempted to develop wild silk resources, but have never produced significant results.

The Life of a Silkworm

By Karen Selk

All silkworms pass through the same four phases: egg, larva or caterpillar, pupa or chrysalis (the cocoon-forming stage when silk is produced), and moth. Cultural requirements for the three silkworms discussed in this article differ significantly from each other. The phases are represented here by photographs of tasar silkworms, except the final egg-laying moth, which is eri.

Tasar (Antheraea paphia)

1 Eggs, shown in protective cups made of folded leaves secured by toothpick-sized pieces of wood.

2 Larvae, newly hatched and tiny, crawling on the edges of a leaf cup.

3 Larvae, eating leaves on a tree in the forest. Steady eating turns the tiny larvae of photo 2 into the substantial creatures shown in photo 4.

Types of silkworms differ from each other in part according to the number of generations they produce in a year. This can vary between one generation (in silkworms called monovoltine) and five or six (called multivoltine).

Each individual silkworm goes through four phases in its life. The number of days it spends in each phase depends on its variety and on the season, and is also affected by temperature, humidity, sunlight, and rainfall. The four phases require different care, which the tribal peoples accommodate in a variety of ways.

1. Egg. Healthy eggs begin the process of successful silk-rearing. Managing the mating and egg-laying processes are labor-intensive activities for the rearers.

In traditional rearing, the female moths are controlled so they will lay their eggs in places where humans can tend them. Often the rearers use thread to tie the female moths onto bamboo poles or bundles of straw, a laborious job which must be completed in two or three days. The moths lay their eggs on these devices and the rearers are then able to move the eggs without touching them.

Disease can strike silkworm colonies like a plague. Few larvae survive an onslaught of disease. Wherever possible, the Central Silk Board (CSB) provides rearers with disease-free layings *(dfl)*—supplies of guaranteed healthy eggs—in an effort to reduce the devastating risk of disease. The CSB's systematic approach to the production of healthy eggs reduces mortality rates throughout the life cycle, improves the quality of progeny, saves labor, and yields increased income.

The CSB is respectful of tribal customs, which can limit the agency's ability to help. In some villages, traditional beliefs prevent the rearers from beginning a silk crop with eggs they raise themselves. People in these areas begin with seed cocoons, which puts them and their villages at risk of losing an entire crop because of undetected disease in the moths that emerge from the cocoons.

2. Larva or caterpillar. Silkworm larvae shed their skin four times. These molts are almost evenly spaced. Each non-molting period is called an *instar,* and there are five instars in one larval


1


2


3

4 Larva, well fed and ready to make silk.

5 Caterpillar on right; on left, thin envelope of ***cocoon*** in the beginning of the transformation of a second caterpillar into a chrysalis.

6 Cocoons hanging from tree branches. The hanging position, and the attachment device called a **peduncle,** are unique to the tasar. Most silkworms form cocoons within the shelter of a basket or bunch of leaves.

7 Rope of ***cocoons*** hanging inside a mud hut, where they have been collected, with emerging ***moths.***

8 Moths, male and female.

Eri (Samia ricini)

9 Female moth, laying eggs. The cycle starts again.

phase. The larvae grow enormously between the first and last instars, and food consumption varies dramatically at the different instars. The larvae extract amino acids from the leaves they consume and transform them into silk.

3. Pupa or chrysalis. The larva or caterpillar spins the cocoon from which silk is derived. The extruded silk consists of two protein components, *fibroin* and a protective coating called *sericin*. Sericin composes between 20 and 25 percent of the fiber weight, hardens on contact with air, and must be removed when the silk is processed. Sericin can be removed from *Bombyx mori* fiber by simmering the cocoons in soapy water. Removing sericin from wild silk cocoons is more difficult.

Within its cocoon, the larva metamorphoses into a pupa. When it becomes a fully formed moth, with wings and antennae, it releases an enzyme-rich brown juice which dissolves a hole in the cocoon. Silk can only be reeled from undamaged cocoons. To obtain reelable cocoons, the pupae are stifled, or killed, by means of sun drying, steaming, or dry hot air. Pupae in cocoons which will be used for seed (to produce the next generation) are permitted to mature.

4. Moth. Male moths are attracted by pheromones (chemical substances) emitted by the females. After mating, the female lays between two hundred and five hundred eggs. The cycle begins again. Moths have no eating or digestive organs and they die shortly after the completion of mating and egg laying.

BASIC TERMS

CSB: Central Silk Board
degum: remove the sericin coating from silk, so it is soft enough to reel or spin
instar: a stage in the life of an arthropod between two successive molts
molt: to shed an outer layer periodically
monovoltine: having one brood in a season
multivoltine: having several broods in a season
polyphagous: utilizing many types of food
sericin: the natural protective coating on silk fibers

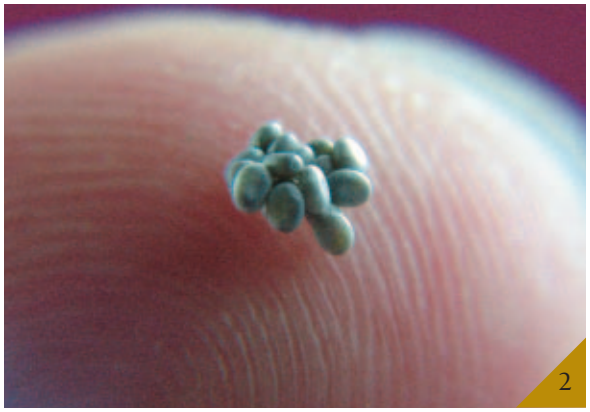
Karen Selk knows more about the spinning of wild silks than most people can imagine. We put this article together between her ongoing explorations. She and her husband, Terry Nelson, founded Treenway Silks, which they have since sold and is now located in Lakewood, Colorado.

PHOTOS BY MICHAEL COOK UNLESS OTHERWISE NOTED

Growing Your Own Silk

BY MICHAEL COOK

There are so many things I love about silk. It's shiny, soft, fine, delicate and, perhaps surprisingly, one of the easiest natural fibers to raise in a home environment. Silkworms thrive in the same temperate conditions as people, and the only care required is feeding and cleaning up. They can't bite or kick, don't make much noise, and only require a small amount of space. I raise silkworms in plastic shoe boxes on a bookshelf and can produce up to a kilogram (2.2 pounds) of cocoons each year with just a little work each day during the growing season.



1. This hatchling is just one day old. The dime behind it is for scale. 2. Silkworm eggs, also called seeds, are tiny and gray. They may be glued down or loose. 3. A toilet paper tube is just the right size for most caterpillars to build a perfect cocoon in.

Silkworms are the caterpillar, or larval form, of Bombyx mori, the China silk moth. It's the world's only truly domesticated insect. In a perfect example of combining human ingenuity with natural wonder, the wild China silk moth, Bombyx mandarina, was selectively bred for centuries to create an amazingly efficient yarn-producing animal. Bombyx mori caterpillars can produce up to 1,500 meters (4,922 feet) of unbroken fiber, which can be wound off (reeled) from the cocoon and used to make a wide variety of yarns. The caterpillars are docile and easy to manage, and the flightless moths are only interested in mating and laying eggs during the five to seven days of their adult lives.

To practice sericulture, or the raising of silk, you will need four basic essentials: a place to put them, appropriate containers, a source of food, and, of course, the tiny, wiggly livestock themselves. And time. Silkworms don't require a huge expenditure of time, but like most livestock animals they need some daily care. I usually budget thirty minutes to an hour a day, depending on where in the life cycle they are. A considerable portion of this time is spent watching them and thinking how cool they are—but probably thirty to forty minutes is a good estimate. It's spread over the day—fifteen or twenty minutes in the evening to feed and clean trays and then five minutes three other times each day for a quick feeding. Every week or so, I take a walk and gather mulberry leaves; it takes about twenty minutes to fill a couple of plastic 1-gallon bags full.

The right place to put silkworms is important. Ideally, they should be in a comfortable, airy room with natural lighting and fairly consistent temperature in the seventies to mideighties. They can't stand direct sunlight, so don't put them in a sunny window. I keep mine on a bookshelf in a spare bedroom, but any counter, cabinet, shelf, or table is fine. I do like to keep them up off the floor so that they're out of the way of the cats. If you have ant problems, you may need to take steps to guard against ants; they can eat the caterpillars, as will mice. Be very careful with any poisons, as they can kill the silkworms just as readily as other insects.

Containers for silkworms should be fairly shallow and easy to handle. Traditionally, a traylike flat basket is used. I like plastic shoe boxes because they're convenient to store and stack and can be run through the dishwasher to sanitize them. I have also used the salad containers from fast-food places, little plastic reusable food tubs (like Rubbermaid), deli trays, and cardboard boxes. The flats that berries come in are great with paper in the bottom. The only furniture that I use for my trays is netting; this is used to separate the caterpillars from their litter. If you use containers not intended for food, be careful—some product packaging uses treated cardboard that is designed to repel or kill insects, and your little insect livestock won't like it. Newspaper is a good liner if you're not sure. If your container is made of something like cardboard, you will need to discard it at the end of the season to prevent carrying germs to the next batch. Plastics can be sanitized in the dishwasher or by washing with a bleach solution. When considering how many silkworms you can raise in a given size of container, the rule of thumb is each silkworm should have a piece of floor three times its size. A silkworm 2 inches long and ½ inch wide is 1 square inch, and so it needs 3 square inches of floor. At that size, thirty-five of them will fill a 13-by-8-inch shoe box. When they're tiny, several hundred will fit in a 4-by-4-inch plastic tub.

The only natural food that silkworms want is mulberry leaf. They want a lot of it, and they want it fresh every day. This sounds tougher than it usually is. Mulberry trees (Morus alba, Morus nigra, etc.) were introduced early on in Europe and then to the Americas by the colonists as food for silkworms and have been distributed by

4. Silkworms come in a variety of sizes and colors. This one from Cambodia makes a small cocoon of bright yellow silk.

5. Bombyx moths are covered with very soft, fine hairs. They are typically quite docile.

6. The hatchlings are tiny—this one is on chopped mulberry leaves.

7. Hatchling silkworms need tender leaves, chopped to ¼" pieces. As they grow, they require larger pieces and eventually whole leaves.

people and birds across much of North America. Where I live in Texas, they're called trash trees or woody weeds, and they spring up anywhere that a lawn isn't tended or a ditch isn't mowed. You may also find them in parks, in neighborhoods, or on school campuses. Just make sure they're not sprayed and ask permission to pick leaves. There are also several varieties, fruited and fruitless, available at plant nurseries. They can range from low bushy shrubs all the way to great spreading trees. For sericulture, it's easier to get more leaves from a shrub-style plant. Despite what you may have read, both white- and black-fruited mulberries will be accepted by silkworms; sometimes the black is a little tougher to chew and the white is preferred, but either will work. Silkworms can also eat a relative of the mulberry tree, called Osage orange (also bois d'arc or hedge apple; the Latin name is Maclura pomifera). These are common throughout much of the central southern part of the United States and can be recognized by their prodigious thorns and their bumpy softball-size green fruits.

Caterpillars in the last stages of growth want to eat four or five times a day. Rumors that they must be fed in the middle of the night are untrue. Like any hungry growing child, if you wake them up, turn on the lights, and offer food, they will eat—but they will also make it through the night with a good supper. I usually feed mine in the morning, sometimes at lunch, after work, and again before bed. The extra-hungry final stage only lasts about a week. Up until that point, usually one or two feedings a day will suffice. Mulberry leaves last two weeks in a plastic bag in the refrigerator. It's much easier to gather them by the bag and feed as needed. For tiny worms, the leaves must be tender and young, and preferably chopped up small (about a quarter-inch dice for the hatchlings, bigger as they grow). As they get older, the worms need more mature leaves and can handle them in clumps or even on small branches. The traditional wisdom is that a worm needs a leaf its same age—so a three-day-old hatchling should eat three-day-old leaves. You don't have to count days, but the general idea is sound. Young caterpillars want young leaves; older caterpillars want older leaves.

If you don't have access to mulberry or Osage orange trees, there is a powdered silkworm chow that you can use. It has its drawbacks and its advantages. On the good side, you can cook it up in the microwave and store it in the refrigerator, and you often don't need as many daily feedings as with mulberry leaves. On the bad side, it is much more expensive, doesn't always produce quite as good a silk crop, and can be a problem with excessive moisture. If you use chow, just be very sure that the silkworms have adequate ventilation and that you feed them small enough amounts at a time that their food doesn't get old and moldy. If you have been feeding them leaves, they won't want to switch to chow, but switching from chow to leaves is easy. I think leaves must taste better. Whatever you choose to feed them, be sure to wash your hands before touching it, and if the leaves are dusty, rinse them off and let them dry.

Once you have the place, the containers, and the food, you need the silkworms. There are a number of companies that can send you silkworms through the mail. Mulberry Farms is one of my favorites, and it has the best customer service I've found. Coastal Silkworms has the widest range of unusual types—if you e-mail and ask, they may even have pink-cocoon worms. I recommend getting eggs, as this allows you to fully experience the life cycle and also is less traumatic for the caterpillars. Eggs are also much cheaper. Live caterpillars can be shipped, but spending two to three

days in the postal system can weaken them. Most of the people in the United States who are buying silkworms use them for lizard food, so they're not concerned about their long-term health. I currently have permits to ship eggs to every state but Hawaii; if I have them in stock, I'm happy to share.

When the silkworm eggs are taken out of cold storage, they start getting ready to hatch. Figure on ten to fourteen days from the time they are shipped to when they hatch out. They usually emerge over the course of three or four days, with a few coming out the first day, then the majority on the second and third days, then a few the last day. Don't put food on top of any eggs that haven't hatched, as it can kill them. When the silkworms hatch, use a feather or a paintbrush to brush them off of the eggs and onto some fresh food, either chow or chopped leaves.

8

The silkworms will eat and grow larger. Replenish the food any time that they eat it up or when it gets moldy or crusty. For the first few days, they will take such tiny bites that the leaves may become wilted before they are eaten up. Keep the small caterpillars covered with a snug lid to avoid loss of moisture. If your air is very dry, you may need to include a piece of barely moistened paper towel in their container to add humidity. After four to five days, they will stop eating and rest. Don't worry—they're fine. They are getting ready to change their skins. They will emerge with a larger, darker face and a new skin that will have more space to grow in. This will happen four times—the five stages are called instars. Each instar lasts four days to a week. The fully matured fifth-instar caterpillars will eat 90 percent of the entire lifetime worth of food—so be prepared! It can be surprising when a tray of silkworms goes from needing five leaves a day to fifty. They also make a slight noise as they eat—it sounds like the pattering of rain, and it's created by their feet moving on the leaves. They are eating so much to build up silk, as well as packing away fat and moisture. The moths don't have mouths and can't eat, so they have to live off of energy supplies stored in the caterpillar stage.

9

8. This plastic netting is wrapped around bottles to keep them from clinking, but it's perfect to separate these black-striped silkworms from their litter. The caterpillars crawl upward through the netting to eat the fresh leaves on top. 9. Left to right: Black mulberry (*Morus nigra*), white mulberry (*Morus alba*), fruitless white mulberry (*Morus alba*), and Osage orange (*Maclura pomifera*).

Michael reels silk from stiffled cocoons to make embroidery thread for weaving.

To clean up after the caterpillars, you need a piece of netting with holes as big around as the caterpillars. I get it at the fabric store and wash it in hot water with bleach but no softener before use. Every couple of days (and daily as they get bigger), put a piece of netting down on top of the caterpillars, and put the food on top of the netting; they will crawl up through the net and onto the food. It's called "netting up." Simply pick up the net along with the caterpillars, discard the frass (caterpillar poop) and bits of leaf and stem, wipe out the tray, and you're done. Hygiene is important, as the worms can get sick if they stay on old or moldy litter.

The fifth-instar caterpillars, after gorging themselves for several days, rest a while and then take a big poop. They are jettisoning any undigested food, as well as some extra moisture, to prepare for pupation. After this, they begin to wander, looking for a place to spin. This is the only time in their lives they actively climb upward. They are also translucent when held up to a bright light. They need to be in an isolated space to spin; I prefer toilet paper tubes placed on end in a shoe box; they look a lot like honeybee comb. You can also make little bundles of twigs or straw—anything that will give the silkworms little spaces in which to spin. If they crawl out of the tubes too much, put a lid on top until they settle down to spinning. Spinning takes about three days. If you're going to use the cocoons for reeling, they should be harvested after about ten days from start of spinning and dried in the oven overnight at the lowest setting to stifle the worm before they hatch. If you're going to let them hatch for breeding, just keep them in a tray and wait—it will take two to three weeks, and the moths will take it from there. Because they have such short lives, their reproduction is very strongly driven; they are little six-legged sex maniacs. They hatch at dawn, and the males will often hook up with a female before she even gets her wings expanded. After ten or twelve hours of breeding, each female will lay 200 to 500 lemon-yellow eggs. The moths usually last four or five days from time of hatching until they die—they have a very short life span. Once the eggs turn dark gray (in about two weeks) put them in the refrigerator in a small sealed container. They need at least two months of "winter" in the refrigerator, after which they're ready to be taken out for the next batch.

Michael Cook has been working with fiber since he was too small for the sharp scissors. He learned to crochet, embroider, and sew from his mother and grandmothers and went on to pick up weaving, spinning, and knitting during college. He has been raising silkworms since 2001. Michael lives in Dallas, Texas, with his partner Chris, three dogs, three cats, and a herd of tiny, six-legged fiber livestock.

Resources

www.wormspit.com. Michael Cook's website, with lots of pictures and detailed rearing information.

www.mulberryfarms.com. An excellent source for silkworms.

www.coastalsilkworms.com. Another excellent source for silkworms; they carry fancier varieties.

http://groups.yahoo.com/group/Catherders. A Yahoo! group for those raising silk moths and working with silk.

Have I Got Worms!

By Jeannine Glaves

Once, a spinner in my neck of the woods (Oklahoma) had more silkworms than she could feed and was looking for homes for them. I said that I would take 50, but when I got home I found I had 150—just a smidgen more than I had bargained for. Sometimes you get more than you ask for. I should have learned.

This year I wanted 50 silk worms again, and a friend brought me some of her silkworm eggs. I didn't count —big mistake! I had 700 worms hatch. It takes about a month for the worms to mature and start spinning their cocoons. When they first hatched, I needed 6 leaves per day per 50 worms—that's 84 leaves a day. By the last week, I needed a 5-gallon bucket of leaves per day to feed the 500 remaining worms. I had a plan though. I had carefully waited for the mulberry leaves in my back yard to grow to the right size and was reassured when the weatherman promised that winter was over. He lied and a frost hit and then hit again. The leaves wilted, and I had 700 hungry mouths to feed—but no pressure! I was climbing ladders and trees, had poison ivy (twice!), an ear infection from allergies, begged leaves from friends and strangers, pulled off highways looking for leaves but found chiggers, and lost sleep worrying if new leaves would grow fast enough.

My friend found silkworm chow from Mulberry Farms in Fallbrook, California, and we spread it like peanut butter on the few leaves we had so the worms would eat it. I found myself cooking for my worms when I hardly cook for my husband, David. I did end up doing some cooking for David, since he had gotten leaves from a buddy after posting a plea at work. I felt that I should at least cook for him in exchange for the worm time that he put in.

One month after the eggs hatched, all the worms were doing was eating. And they were eating a lot—a 5-gallon bucket of mulberry leaves a day! To say that I was looking forward to the day when they stopped eating to spin their silk cocoons was putting it mildly. I started to threaten the worms. I told them I would get out the skillet, butter, and garlic and sauté them into a protein-packed dinner if they didn't start to spin cocoons —it worked! One worm went to work and started a cocoon on my mom's birthday. Since my mom passed away last November, I wondered if this was her way of saving my sanity.

I had lost about 200 worms because I didn't have enough leaves, but there were still about 500 worms to feed. I needed lots of leaves. I found two mulberry trees while at a party and did a happy dance when I was allowed to take all of the "weeds" I wanted. I hauled away a trash bag full.

And then a miracle: 9 pounds of mulberry leaves arrived in time to feed the remaining worms for the last few days before they started spinning cocoons. My desperate pleas had been heard by a fellow guild member. I even had enough that I could share leaves with my friend.

Now I sit itching from the poison ivy and chiggers and watching hundreds of little plastic cups with the bottoms cut off turn into cocoon houses. I had to go with plastic cups because we couldn't finish enough toilet paper for tubes for the job. There are times when I think I'm getting too old for this, but then I reconsider. Next time, though, I'll count.

Jeannine Glaves degums the silk cocoons and stretches them over a frame to make mawata squares to spin from, and also reels her cocoons to create a continuous filament. She uses the cocoons as visual aids when she's demonstrating and teaching about spinning and fibers. She has been a spinner for over thirty years and continues to take classes to add to her knowledge. She has won awards at Convergence and the Midwest Weavers Conference for her spinning. She has taught for many years and feels that passing it on will keep our craft alive.

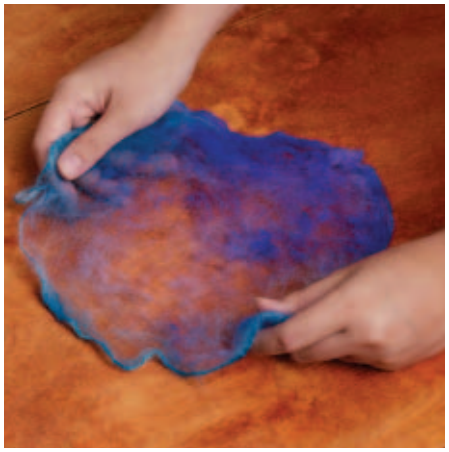
Working with Silk Hankies

By Amy Clarke Moore & Amanda Berka

Chances are you already have a couple of dyed silk hankies tucked away in your stash—perhaps they were too alluring to pass up, even though you weren't quite sure what to do with them.

Silk hankies or mawata are made from silk cocoons that are intact (the transformation of the silk worm into the moth was arrested so that the moth did not break through the cocoon) but not suitable for reeling. The cocoons are soaked in warm, soapy water to remove the sericin that binds the fibers together. The remains of the worm are removed, and the cocoon is stretched out and eased over a small wood frame (or in the case of silk caps and bells, over an arch-shaped mold). Each layer in a hankie is composed of several cocoons. Before you start working with the silk, condition your hands with lotion, or you'll find that the fine silk fibers will stick to cracks and crevices on your hands that you never knew you had.[1]

[1] Treenway Silks provides several suggestions for how to keep your hands smooth while you work with silk at www.treenwaysilks.com



Begin by separating out one translucent, filmy layer from the silk hankie with which to work. If it is too thick, it will be difficult to draft.

Pull outward from the edges of the hankie to begin the drafting process.

Eventually, the layer of silk will become so thin that the center will pull apart.

Now begin attenuating this doughnut shape into a long roving.

Because the silk fibers are so long, they will not slip past one another if you hold your hands too close together as shown. Move your hands farther apart if you are having difficulty drafting the fibers. Snapping the fibers between your hands is another way to draft them apart effectively.

Once you have attenuated the hankie layer to the thickness you desire, break the circle at any point along the edge.

Wind the roving into a nest of fibers to spin from. You're ready to begin spinning.

With this method of drafting, the silk fibers are aligned parallel to each other and so will be spun worsted-style with a short-draw technique. Silk fibers are very strong, so keep a firm grasp on the fibers and start by treadling slowly. You've done all the drafting work ahead of time, so you should be able to focus on introducing the amount of twist you want in your yarn. This yarn will be strong and fine—wonderful for embroidery, weaving, and lace knitting. Ply it to balance the yarn and add strength and diameter. Amanda learned this method of spinning silk hankies in a class with Maggie Casey at Shuttles, Spindles and Skeins in Boulder, Colorado. Maggie advocates spinning silk worsted-style to enhance the natural luster of the silk.

Left: Amy learned this method for drafting for a more woolen-style of yarn with the possibility of slubs (if you want them) from Celia Quinn at SOAR (*Spin·Off* Autumn Retreat) 1998. First dress a swift with a clean tea towel or other cloth to prevent the fibers from sticking to the wood. Middle: Stretch a filmy, translucent layer of the silk hankie over the dressed swift. Right: Pull from the edge of the stretched silk and feed it onto the bobbin of your wheel as you treadle. You'll have to do a bit more work drafting the strong silk fibers as you spin using this method, but the swift will hold the fibers as you work and will help keep them organized.

Unspun silk from silk hankies makes a wonderful knitting yarn—simply follow the directions for drafting the fibers for worsted spinning and cast on using the unspun fiber. To achieve a thicker yarn, attenuate more than one layer of the hankie together. You can also weave with the unspun silk as the weft. The fibers blossom in the fabric and lend a soft and luxurious hand to the fabric.

Wash your silk garments carefully in warm, soapy water. Avoid harsh alkaline detergents that will strip the fiber of its natural oils and make it brittle. Wool-safe detergents will work well with silk as it is a protein fiber. Rinse well and lay flat to dry.

Fiber Sources

Bonkers Handmade Originals
PO Box 442099
Lawrence, KS 66044
www.tracibunkers.com
info@tracibunkers.com

Chasing Rainbows Dyeworks
Nancy Finn
1700 Hilltop Dr.
Willits, CA 95490
(707) 459-8558
crownmountainfarms.com

Paradise Fibers
225 W. Indiana Ave.
Spokane, WA 99202
(888) 320-SPIN (7746)
www.paradisefibers.com

Royale Hare
etsy shop
(707) 579-2344
www.royalehare.com
karen@royalehare.com

Treenway Silks
2060 Miller Ct.
Lakewood, CO 80215
(888) 383-7455
www.treenwaysilks.com
info@treenwaysilks.com

Treetops Colour Harmonies
6 Benwee Rd.
Floreat, Western Australia 6014
61 8 9387 3007
www.treetopscolours.com.au
Distributed in the United States by Outback Fibers at www.outbackfibers.com

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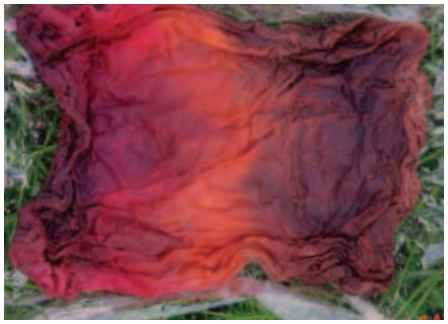


Unwrapped, cool hankie just before rinsing.

Dyeing Silk Hankies

By Kim McKenna

Top: An eighteen-step color progression of pastel- colored silk hankies dyed at a 0.2% DOS. In the center are nine silk hankies dyed at a 0.2% with their 1% DOS wool skein counterparts. These are surrounded by the remaining nine colors in the color progression.

Photos by Kim McKenna.

Silk hankies can serve as a great canvas on which dyers may play and experiment with color without that ever-pressing worry of making a mistake. I started dyeing silk hankies as a way to use up leftover bits of dyestock solutions and have since found many uses for these beautiful splashes of color. I use silk hankies to wrap gifts, embellish felt pieces, make silk paper, spin novelty yarns, or to give as gifts to friends who want to spin these colorful and inspiring silk canvases.

Silk hankies are a form of mawata silk. Mawata silk is made from cultivated or Bombyx mori cocoons deemed unsuitable for the higher quality reeled silk. The cocoons are softened in simmering water, and once the pupae are removed, they are stretched over square frames to make hankies or over arched frames to make caps. Hankies and caps are available through most spinning and weaving

suppliers. I buy mine from Treenway Silks (www.treenwaysilks.com).

Dyeing hankies involves six steps: presoaking, applying dye, curing, steaming, a cooling down period, and rinsing. I have successfully used this direct application method with both Lanaset and Ashford dyes. Hues mixed from Lanaset's base colors are slightly subdued and very pleasing to the eye right out of the jar without color mixing, I prefer, however, to have more control over the colors I create, and for this reason, I gravitate toward the Ashford collection. Using Ashford's selfshade colors (self-shade colors are pure hues without tints or tones—yellow, teal, blue, purple, hot pink, and scarlet) as my base colors I am able to mix a vast array of bright, clean, fully saturated colors, that I can then subdue or tone down as I see fit (see photo on page 22). The simplest way to subdue or tone down a color is to adjust it with Ashford's black or brown dye, or for a more subtle adjustment, one that does not dull or neutralize the color as quickly, use Ashford's green, navy, or rust. For example, I use navy to tone down blues, blue-violets, or violets.

DYESTOCKS

Preparing your dyestock solutions the night before will help to ensure that the dye powder is well-dissolved before use. Dyestock solutions are prepared from a mixture of urea water and dye powder. To prepare a 1% dyestock solution, use the amounts represented in grams, or if you don't have access to a scale, use the amounts represented in teaspoons. Place 1 liter of warm water in a 1½-gallon bucket and add 34 grams (4 teaspoons) of sodium hexametaphosphate (SHM), a water softener containing no additives. Be sure to stir well, as the SHM has a tendency to sink and stick to the bottom of the bucket. SHM can be purchased from most dye suppliers.

You are aiming for a total volume of 4 liters of urea water. With the SHM thoroughly dissolved, add 600 grams (4

Safety notes

Dye smart and use good studio hygiene. When it comes to dyes and chemicals in your home, why take any unnecessary risks—even if the risks are considered to be low. Treat your dyes and auxiliary materials with the same cautious respect you would any paint, stain, or gardening chemicals, and keep them out of the reach of children and pets. Do not use any dyes when you are pregnant or nursing. Do not smoke, eat, or drink in your dye area.

- Work in a well-ventilated area. Avoid inhalation, ingestion, and contact with skin and eyes.
- Wear rubber gloves, an apron, protective eye wear, and, when mixing dye powders, a dust respirator.
- Never dye in your kitchen.
- Never use food utensils or cooking equipment for dyeing—once you use anything for dyeing, reserve it for that use exclusively.
- Use a nonreactive pot to dye in such as stainless steel, glass, or enamel; reactive pots such as copper or brass will change the chemical composition of the dye bath.
- Cover the work area with dampened newspapers. Roll up and discard the newspapers when you have finished dyeing.
- Be sure to clean up spills immediately.
- Label, label, label with contents and date.

Note: Keep urea water and dyestock solutions in a cool, dark place. I have used them up to 6 months after they have been mixed. Dispose of any solutions that develop unusual or noxious odors. (If necessary, neutralize presoak and urea water/vinegar solutions with a bit of baking soda before disposal.) I also store presoak solutions and use them more than once. Even after three uses, I have not experienced any adverse effects on my dyeing.

Project notes

Equipment list

Rubber gloves (dust your hands with baby powder before putting them on to make them easier to take on and off).

Apron.

Protective eyewear.

Dust respirator.

Measuring spoons, cups, and scale (reserved only for dyeing).

One 500 ml airtight, plastic container for each color of dyestock solution.

One 4-liter container for urea water.

One 1-liter container for the urea water/vinegar solution.

Several small containers such as medicine cups that can hold up to 40 ml of diluted dyestock solution.

1½-gallon bucket for presoak solution.

4–5 rinse buckets.

Roll of Saran or Glad Cling Wrap.

Heat source (gas burner or electric hot plate).

Steamer (warm-water-bath canner with three 1-quart jars and shelf).

Wire whisk.

Timer.

Old towels.

Newspapers.

Painter's tape and permanent marker for labeling.

Supplies

100 g of silk hankies.

5 g dye powder per color to dye.

1 kg urea.

100 g sodium hexametaphosphate (SHM).

150 ml vinegar (5%).

Orvus Paste or other neutral detergent.

cups) of urea (½ cup at a time) into the bucket. As it dissolves, urea cools the water temperature. To compensate for this, stir in ¾ cup of very warm water after each addition of urea. Constant stirring and alternating with the addition of very warm water are the keys to a well-dissolved urea water solution. When the volume of urea water solution reaches 4 liters, you're done. Why urea? Urea (46% farm-grade nitrogen) increases the solubility of the dye powders, it causes fibers to swell, it slowly releases acid as it is broken down during the dye process, and it is a humectant, which means it will help your fiber retain moisture during curing. Curing is the stage in the direct dye application process where the fiber or yarn is allowed to sit undisturbed for a period of time, allowing the dye to more fully penetrate and bond with the fiber. A warm environment assists the process.

While the urea water is still warm, prepare a 1% dyestock solution. If the urea water is too cool, simply place the container of urea water in a bucket of very warm water to bring it back up to a lukewarm temperature. You will be dissolving 5 grams (about 1 teaspoon) of dye powder with 500 milliliters of warm urea water. First pour 200 milliliters of the lukewarm urea water into a container (I find plastic containers work better than glass ones because the dye powder is not as inclined to stick to the sides or the bottom of the container), and then add the 5 grams of dye powder a little at a time, stirring with a wire whisk all the while. I wear a dust respirator, apron, and gloves when working with dye powders. As an added precaution, I also cover the mixing container with a damp piece of cotton cloth while stirring in the dye powder. The damp cotton serves to wick up any dye powder that may waft up the shaft of my mixing container. Once the dye powder is well dissolved, gradually stir in more warm urea water until you have added the full 500 milliliters. Dyestock solution in this form may be used for either direct application, as outlined here, or for immersion dyeing. For direct application, dilute the dyestock solution before applying directly onto the hankies.

The hankies I purchase come in a 100-gram bundle. Soak the bundle in enough presoak solution so as to thoroughly wet out all the fiber, allowing it just a bit of room for expansion as it soaks. If the bundle is too crowded, you create folds and, in turn, resist spots. The recipe provided is enough solution to wet out about two 100-gram bundles. If you are presoaking a smaller batch, any excess presoak solution may be stored for a later date. I have successfully reused the presoak solution up to 2 weeks after the first use. To prepare presoak solution, dissolve 5 teaspoons of SHM and ½ teaspoon of a neutral detergent (I use Orvus Paste or Eucalan as I find these products to be the gentlest on silk fiber) in 5 liters of warm water. Once the SHM and Orvus are dissolved, add 90 milliliters of household vinegar (which is usually 5% acid) to the solution and stir. Presoaking can be carried out in one plastic bucket or, if you strip the bundle into ten smaller sections, in ten margarine or yogurt containers, jars, or even baggies. If you use baggies, place the baggies in a plastic tub just in case one should accidentally leak. Let the hankies soak for at least 1½ hours. Dye penetration is optimized if you

1% dyestock solution

5 g dye powder (about 1 tsp).
500 ml lukewarm urea water.

Extra hints regarding your dyestock solution

1. Some base colors (i.e., rust, scarlet, purple, and black) are more prone to forming sediment at the bottom of the dyestock bottles if they have been sitting for a week or more. Simply soaking your dyestock solution bottle in a hot-water bath and swishing the warm dyestock solution around before use helps to coax the heavier dye particles back into suspension. Measuring out your dyestock solution with the particles well-dissolved and in suspension is important if you want to achieve even and consistent color results.

2. Some dyers prefer to boil their dyestock solutions for 5 minutes to help dissolve the dye pigments. This does not seem necessary with this dyeing method.

Urea water

For 4 liters of urea water:
1 liter warm water.
34 g (4 tsp) SHM.
600 g (4 c) urea.
More very warm water.

Presoak solution

5 liters warm water.
5 tsp SHM (42 g).
90 ml household vinegar.
½ tsp neutral detergent.


A 10-gram hankie before dyeing.


Presoaking a silk hankie.

Dye application hints

1. Darker values may be achieved in a variety of ways. The most straightforward method is to squeeze out more presoak solution from the hankie before applying the dye. This will help the hankie to absorb more than 20 milliliters of diluted dyestock solution.

2. Always apply lighter colors first and darker colors last.

3. If you don't like white spots showing through, try squeezing out as much of the presoak solution from the hankie as you can into a shallow pan, add a few drops of a ground color, and then apply this to the hankie before your other colors. Note: A few drops of black or brown can make an intriguing ground color.

4. Until you have developed experience in color mixing, stick to applying analogous colors to your hankies; avoid the use of triadic or complementary color schemes in the same hankie. (See Deb Menz's book, *Color Works* [Interweave Press, 2004] for more information about working with color.)

allow the hankies to soak overnight.

I know vinegar and SHM are not normally used in presoak solutions. Keep in mind, however, that silk can hold up to 20% of its weight in water and still feel dry to the touch. Using vinegar in the presoak solution helps ensure that once the dyestock solution combines with the water retained in the hankie you will still be well within the pH range needed for maximum dye exhaustion. SHM helps ensure that any minerals that might otherwise interfere with the dye run are sequestered and not running amok.

When removing the bundle from the presoak solution, gently squeeze the bundle while it is still underwater. Keeping it cupped between your gloved hands as you lift will help keep the fibers intact. Once removed from the solution, strip the bundle into ten smaller units and set them aside.

Lay one or two cotton towels out on your work surface. To make it easier to press the dye into the hankie, the cotton towel layer should be thick and cushiony. The hankies I purchase roughly measure 10 inches square. Lay a 2-foot strip of plastic wrap (such as Glad Cling Wrap or Saran Wrap) on top of the towels. Gently stretch one of the ten hankie strips back into a square shape and center it on the plastic wrap, pushing the top and bottom edges in about 2" from the edge of the plastic. Now you are ready to apply the dye. The concentration of your dyestock solution is diluted at this point. Your presoaked hankie strip should have had just enough of the presoak solution gently squeezed from it so as to allow the absorbtion of about 20 milliliters more liquid. To achieve a medium value, or about a 1% DOS, dilute 10 milliliters of the dyestock solution with 10 milliliters of a urea water/vinegar solution. The pastel-colored hankies in the photo are a .2% DOS. Each weighs roughly 10 grams and was dyed with a diluted dyestock solution of just 2 milliliters of dyestock solution added to 20 milliliters of the urea water/vinegar solution.

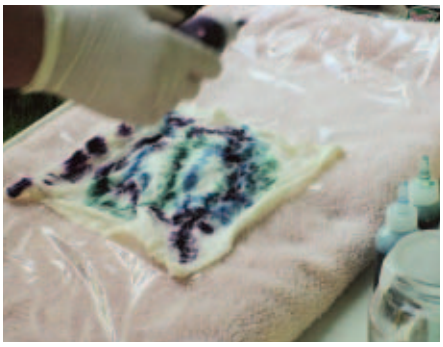
Urea water/vinegar solution used to dilute dyestock solution

1 liter urea water.

20 ml household vinegar.

Pour the diluted dyestock solution onto the hankie, gently pressing the dye into the hankie until you are satisfied with dye penetration. Your aim is for the fiber to hold the dye. Do not add so much that it seeps out and away from the fiber. Don't forget to take a peek at the reverse side of the hankie, adding dye where deemed necessary. After the dye has been applied, take the excess plastic wrap to the left and right of the hankie and fold both ends toward the center so that they overlap a bit on top of the hankie. Then fold about 2 inches of the top and bottom edges of the plastic wrap toward the center of the hankie. Roll up the hankie jellyroll-style and allow it to cure in a warm place for 3 hours.

Place your hankies in a steamer (see Steamers) while the steamer water is still cool, and turn on your heat source. As soon as you see steam starting to develop, turn off the heat source allowing



Worktable set up for dye application and dye poured onto the hankie.

Pressing dye into the hankie.

Ground color has just been applied to this silk hankie.

The steamed jars upon removal from the canner.

Saran-wrapped hankies curing before steaming.

the hankies to sit in this moist, warm environment for about 15 minutes. After 15 minutes, turn the temperature back on and slowly, over a 30-minute period, bring the steamer (or canner) up to a full steam. Steam the hankies for 20 minutes. Remove the steamer from its heat source and let the hankies cool down in the steamer with the lid on. It is important not to shock the fiber. This can be prevented by ensuring that your rinse water is about the same temperature as your hankies. To rinse, set up four to five rinse buckets. Unwrap the hankies from the plastic wrap, squeeze out any excess liquid, and rinse. There should hardly be any color in the liquid squeezed from the hankies. (If there is color in the liquid, you probably added more dye than the fiber could absorb, so you might want to use a mild detergent in the second rinse bucket to help strip off the excess dye.) Continue rinsing in successive buckets until the rinse water is clear.

Once you have tried this technique a few times, the sky is the limit. You can also dye silk ribbon, yarns, roving, top, and what I call "Mad Caps" or mawata silk caps.

Hints for Spinning Preparation

Drafting a roving from hankies is easier if you carefully maintain a drafting triangle while attenuating the fibers. See "Spinning Basics" in the Spring 2007 issue of *Spin-Off* or online at spinoffmagazine.com for tips on how to spin from a silk hankie or cap. Attenuated rovings are easier to spin from if you place a bobbin on your lazy kate that has been loaded with the attenuated roving.

Passionate about fiber and color, Kim shares her knowledge of spinning and dyeing through lectures, demonstrations, workshops and, her latest venture, www.claddaghfibrearts.com. Her website provides useful information on spinning and dyeing through both free downloads and online modules for which there is a modest fee. Each module contains the same information presented in her workshops and is well researched, tested and easy to follow.

Resources

Knutson, Linda. *Synthetic Dyes for Natural Fibers*. Seattle, Washington: Madrona Publishers, 1982. Revised edition by Interweave Press, 1986.

Milner, Ann. *The Ashford Book of Dyeing. Christchurch*, New Zealand: Shoal Bay Press, 1998.

Steamers

Steamers can take many forms.

1. I use a warm-bath canner partially filled with water in which I place three water-filled jars. I then balance a screen or vented pizza pan on top of the jars to act as a steam shelf. I protect my silk from scorching by placing a damp towel on the steaming shelf, laying my hankie packages on top, and then covering them with another damp towel.

2. Use an old vegetable or bamboo steamer.

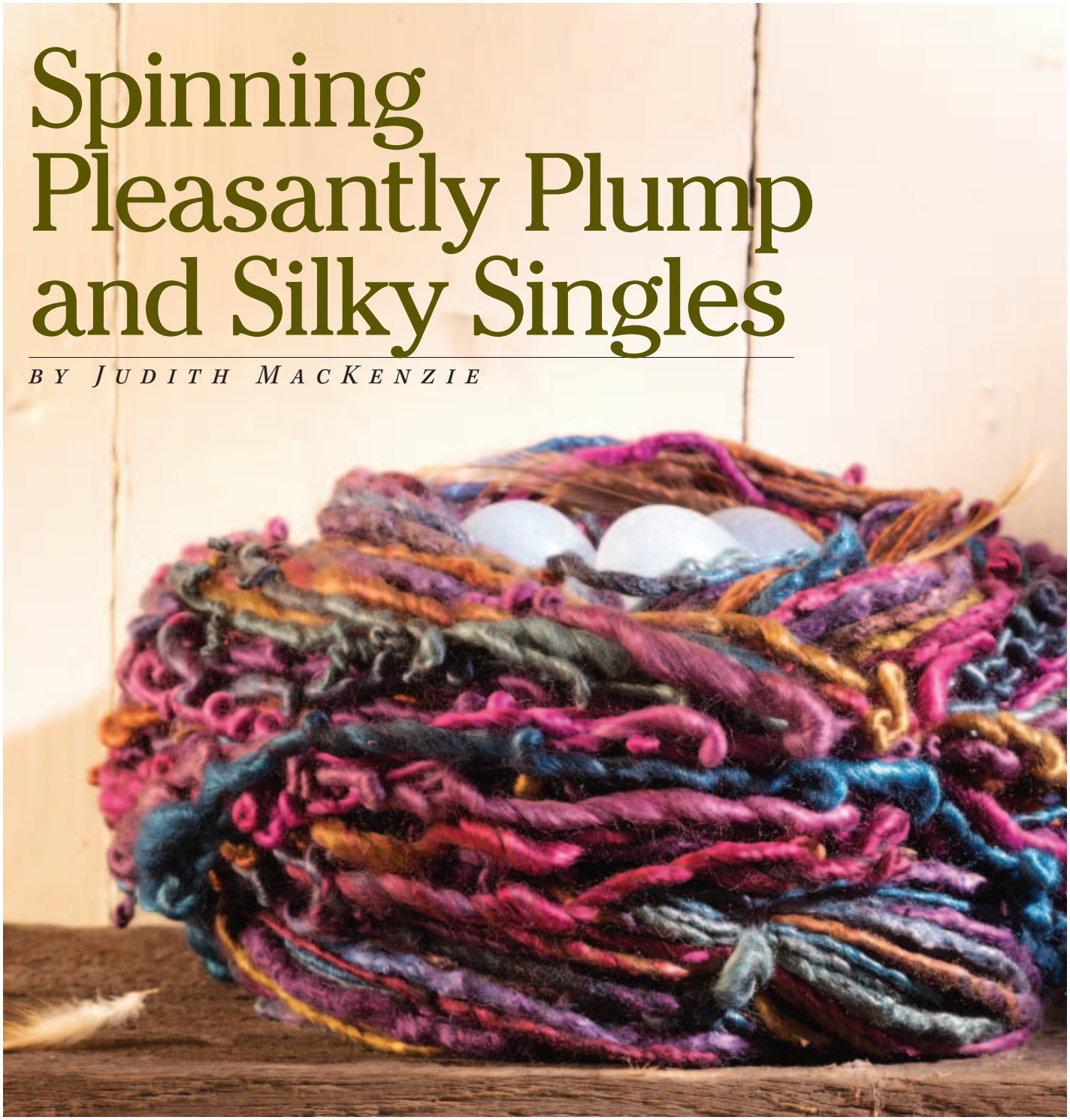
3. If you want to prevent any and all dye from leaking into other packages of hankies, you can put the wrapped hankies in canning jars, place them on a steaming shelf, and process as described in the text. (This last hint was suggested by friend Diana Twiss, and it works like a charm. I just love the innovativeness of spinners, weavers, and dyers.)

Left: The warm-water-bath steamer set up. Please note the protective layer of towels under and over the hankie packages to help prevent scorching.

Right: Another option—heat set the dyes by steaming them in canning jars.

Spinning Pleasantly Plump and Silky Singles

BY JUDITH MACKENZIE



Silky singles, spun once tightly, then spun in the reverse direction to release and level the twist. Full a thick, silky singles to stabilize it for weaving.

Madelyn van der Hoogt, the marvelous weaver, teacher, and former editor of *Spin·Off*'s sister publication *Handwoven,* often talks about how weavers can be separated into two main groups: those who love the structure of cloth, and the more complex the better, and those who love color and texture. I'm quite sure I fall in the second category and usually choose both my weaving structure and my knitting pattern to enhance my yarn. I love yarn; like every spinner, I love that magic moment when fluff takes form in my hands, taking on new shapes and purposes.

Space-dyed commercial silk and wool top, blended 50/50.

Space-dyed top stripped for spinning.

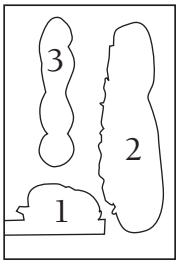
Nothing shows that moment better than a singles yarn. Fresh from the wheel, unlike their tamer cousins the plied and cabled yarns, singles have a wild, untamed energy, still showing very much the qualities of the fiber they came from. Are they easy to work with? Are they stable and long lasting? Sadly, not always. That very wildness can be their downfall. One of the first principles that govern textiles says that all fiber will return to its original shape. Singles do this by trying to either untwist or reach out to other surfaces to balance their own twist. When used in cloth, either knitted or woven, this movement can make the cloth ripple and twist. While both weavers and knitters use this as a design tool to create wonderful fabrics that have buckled and contorted surfaces, it is, perhaps, better when it is not a surprise.

There is also that pesky question about the ability of singles to make stable cloth. The same untwisting and attraction for other surfaces cause singles not to wear as well as plied yarns. The twist energy reaches out for any other surface, just like a bindweed plant, and, in that process, deconstructs the yarn, causing it to fray and pill. When yarns are plied, the twist energy reaches a balancing point, and the yarns become still and therefore much more stable.

But what about that wild and wonderful movement of a singles, especially a plump singles and especially with a fiber such as silk that lacks any mechanical ability to hold itself together? It's a yarn puzzle that I've thought about off and on over my spinning life, and I have had some true wrecks along the way as I happily ignored the basics of structure in the pursuit of wild beauty.

One of the best examples of my wishing that physics would simply ignore my projects is 3 pounds of stunning, rich honey-colored tussah silk, handspun on an old Indian-head spinner into luscious singles the size of my little finger. It's been wound into a warp for a doubleweave queen-size bedspread intended as a wedding present. One inch is woven; the remaining warp has the consistency of old tissues. It has been drug out from under my bed during many moves over the years. Not a pretty sight, but I don't give up easily. I tried support threads, made new heddles, even made a special reed, but there it lies, under the bed. It simply came apart during the weaving process. But that woven inch looks magical, very textured, and so much like the fiber before it was spun. How could I capture that beauty and still have a workable thread?

Wool and silk top blended 50/50.



Judith MacKenzie discovered through a happy accident that when her 50/50 silk/Merino plump singles was fulled, the twist energy that made the skein bunch up like a scrunchy, was discharged into the water. 1) The 50/50 silk/Merino fiber before dyeing and spinning, 2) after dyeing and spinning, and 3) after fulling.

Fiber and dye mixed into stock solution.

As I said, I don't give up easily. I tried many different types of structures and blends in an effort to produce a heavy, silky singles yarn that would weave or knit the cloth of my dreams. I would love to be able to tell you that because of my understanding of fiber and yarn structure, I finally came up with a perfect solution. But I didn't—instead, I came up with the perfect accident.

I had been making some silk blends with a fine Merino and cultivated silk. After carding together 75 percent cultivated silk and 25 percent fine Merino, I spun a lovely, uneven thick singles at about 11 wraps per inch. I tried varying amounts of twist. I could make a stable yarn if I overtwisted it, but when I did this, I lost both the sheen and the hand of the silk, and it was very difficult to work with. Spun loosely, between 5 and 6 twists per inch, it was lovely, but when passing it through my hands I could see how quickly it would abrade. When I knitted a sample, the low-twist yarn did not hold its shape in washing, stretching more than 15 percent; the high-twist yarn had all the appeal of an expensive

Twists per inch

No matter what fiber you are spinning, the twists per inch measurement for a balanced yarn changes with diameter. The larger the diameter of the yarn, the less twist it takes to make it overtwisted.

Silk and wool blend is placed in the dye pan.

Dye is added in solid bands.

but colorful pot scrubber. Discouraged, I shoved a little spun skein of the low-twist yarn in my jeans pocket and went back to work on other projects. The jeans went through a wash cycle for work clothes—definitely not delicate—and then through the dryer. Imagine my surprise several days later when I put my hand in my pocket and pulled out an exquisite yarn! It was silky with lots of luster and a beautiful hand, and it was amazingly stable with a quiet relaxed twist. Instead of finding the necessary structure in either the fiber or the spinning, I had found it in the finishing.

What makes this yarn work? When you apply soap, agitation, and a cold rinse to the yarn it does exactly what you think it should do—it felts. The wool in the silk blend forms a web that locks the silk in place. The silk, an extruded fiber, does not have any crimp or scales and is unable to felt. Instead, it remains soft and lustrous. If you try this, be careful not to overdo the agitation; I found that an extreme agitation, especially on a very loosely spun singles, causes the wool to felt quite firmly.When this happens, the yarn loses both its softness and its sheen. It becomes prickly and dull instead. Remember, also, to use a worsted method to spin this yarn; worsted both decreases the likelihood of overfelting the yarn and enhances luster.

I've used this yarn and several variations for the last few years. I've used it to knit with, and I've used it as both the warp and weft in weaving projects. It has been easy to handle, and as long as I give it enough space, it has a lovely drape. It is very lustrous, much more so than before it is finished, and it has a wonderful hand that is very silky with, as they say of a fine wine, overtones of cashmere. And it has the added bonus of being very simple to make.

Preparing the Fiber

The wool/silk blend can be made by either combing the fibers together on a pair of fine minicombs or by using a drumcarder that can process silk easily. Usually, I feed all my fibers into the carder sideways; it speeds up the carding process and puts less stress on the fibers, but for this project, I'm using fine Merino combed top and cultivated silk top. I want to keep the alignment as worsted-friendly as possible; the carder is used to mix the fibers together but not to produce a true carded batt. Depending on the equipment, you may have to run the fiber through the carder several times. Don't worry if it isn't completely blended.

When combing, use a diz with a large opening to draw the fiber off the combs; you can also use a diz to draw the fiber off the carder. A diz is a great help to maintain yarn diameter. Remember, you can always spin finer than the hole on the diz but you won't be able to spin thicker.

Another alternative is to use one of the commercially produced silk and wool blends. For the photos in this article, all my samples were made from a commercial blend of 50/50 Merino and cultivated silk that is easily available.

Dyeing Safety

Follow the safety precautions on the labels for handling dye powder and dye solutions. Always wear a dust mask and gloves when handling dye powder and work in a well-ventilated area. Protect your skin and eyes from dye solutions. Never use your dye equipment for food preparation.

Dyeing the Fiber

If you decide to dye the fiber before you spin it as I did, it is a fairly simple process. You'll need, ideally, a big rectangular pan. I use a dedicated commercial stainless steel steam tray for this type of dyeing. These are readily available from restaurant supply stores; be sure to check their used department.

Choose a simple weak acid dye that dyes wool and silk. Follow the instructions on how to mix up a stock solution or mix a bit of dye powder and warm water in a plastic disposable container. You'll need vinegar or citric acid to set the dye.

Combine about 3 inches of warm water and the acid that the manufacturer suggests. Place the dry fiber in the pot in lengthwise loops; for this type of dyeing, I don't soak the fiber beforehand. You want to have enough fiber in the pot that the water can't move easily through it. The fiber will become its own dye resist.

Use a wooden spoon to gently press the fiber into the water. For a painted effect, add the liquid dye in strong, bold bands of color. I like to mix and match three or four colorways—just treat them like paint—to create a color system that is uniquely mine. For a single color, add the dye to the water before you add the fiber. Use the spoon to gently move the loops apart so the dye can penetrate easily. Be careful not to disturb the pot too

Top being spun into singles.

much, especially if you want distinct color changes. The dry fiber will absorb a great deal of water; you may have to add extra to keep the fiber just barely covered with water.

Heat the pan until the water comes to a simmer; don't let it boil because the motion will cause the fiber to felt. Follow the dye manufacturer's instructions for time and temperature. Let the fiber cool in the dyebath to ensure a good dye strike. If possible, spin the excess water out—a dedicated salad spinner works great—and hang the fiber up to dry. If possible, don't rinse until you have spun the fiber into yarn. The finishing process will easily remove any unattached dye, and the yarn will be much easier to handle in the rinse bath than the unspun fiber.

Not up to taking on a dye project? There are many independent dyers that have beautiful colorways using this fiber combination; check them out at fiber shows and on the Internet.

Consistency

I don't always want a consistent diameter in this type of yarn, but if you want your yarn to be more consistent, spin it firmly to the right. The more even you make it, the more extreme the overtwist will be. Then remove the excess twist by using a trick I learned from the Coast Salish spinners in British Columbia. Simply take the bobbin of overtwisted yarn, put it on a lazy kate, and run it back through the wheel in the opposite direction—if you spun it to the right, send it back through the wheel to the left. Remove as much twist as you wish from the yarn.

Spin a Silky Singles

Once the fiber is dry, strip it into lengths about the size you want your singles to be. If you are working with your own roving that has been drawn through a diz, you are ready to spin. Choose the largest size whorl you have for your wheel. If you have a bobbin-driven wheel such as a Louet S10, this is a good time to use it. With its strong drafting-in speed, it is perfect for spinning this weight of yarn. Keep a low twist on the yarn; correct the drafting-in speed by increasing the brake tension so that you have a 55- to 60-degree angle of twist. The yarn will inevitably have a serious overtwist, especially if you want an even diameter. Remember that at least 30 percent of the twist will be removed in the finishing. Remove some overtwist by running the yarn through the wheel in the opposite direction. It is a good idea to spin and finish a few small test skeins to make sure that your yarn has the amount of twist and the finished diameter that you need.

Skein the yarn and tie it loosely. It will look like a scrunchie; be calm and take the next step.

Finishing the Yarn

The finishing process for this yarn is fairly simple; you need to give it a vigorous wash in hot, soapy water, followed by a rinse in cold water. I use a little sink plunger to agitate the yarn. You may have to do this several times until the yarn becomes stable. Move the fiber between your fingers and feel the amount of slippage. When it feels firmer, stop and spin dry your skein. Check to see if it is stable, nearly balanced, and firm enough to not abrade when you rub it. It is much like making good bread; you'll feel the yarn take shape under your fingers, and once you know how much movement the fibers should have, you'll remember next time, too. You can full this yarn too much; if you do so, it will become harsh and prickly. Do use several small samples to learn what the finished yarn should feel like. It won't look terribly promising when it is wet. Give the yarn a final spin and hang it up to dry. When it is dry, the yarn will be lustrous, soft, and stable. Even at this stage, if you think your yarn still has too much twist for your project, you can run it back through the wheel in the reverse direction to remove as much twist as is necessary (see the box at left).

Judith MacKenzie of Forks, Washington, has been a textile artist for over thirty years. She is the author of *The Intentional Spinner* (Interweave, 2008) and featured in the DVD set, *Popular Wheel Mechanics* (Interweave, 2010).

Spinning Silk for Weaving

Use two-ply yarns that emulate reeled silk to make glorious warp-faced fabrics

By Sara Lamb

PHOTO BY SHIRLEY BORBA

Sara says that while this is the way she actually sits while she's spinning, she doesn't recommend it since it causes her feet to fall asleep.

Silk! The mere mention of the word conjures images of luxury. Silk has been the fabric of royalty and nobility for centuries, with its luster, drape, and soft hand.

Until the mid-eighteenth century, all silk fabric was woven of reeled silk, a particularly smooth yarn made from only the longest, strongest threads in the cocoon. Waste from the reeling process was originally used only for stuffing or batting. Then someone, somewhere (probably in France, Britain, or China) figured out that all the waste from the reeling process could be combed or carded and spun on machines. The "waste silk" that was spun this way was used for weaving second-quality fabrics and for machine knitting and needlework. Interest in and need for handspinning declined at the same time this machinery was developed, so there is no real tradition of handspinning silk in the west.

Spinning silk has become popular in recent years, and the fiber is available today for handspinners in unprecedented varieties and quantities. We may just be the first generation to have access to processed silk fibers and the interest to spin them. My goal is to spin a yarn suitable for weaving smooth, lustrous fabrics, and the key I've discovered is to emulate reeled silk as closely as possible.

Spinning Specifications

Fibers in yarn are held together by twist. The amount of twist and the finished grist[1] of yarns vary according to the intended use of the yarn. Weaving, knitting, crochet, and needlework yarns all require different levels of twist. Once the basic yarn is understood, the spinner is then free to push the limits of twist and grist to obtain special effects.

[1] Grist refers to the yarn size—the yards per pound.

Pilling can be a problem with silk yarns and fabrics. Tiny fibers work their way out of the twist and are abraded and rolled into pills on the surface of the fabric. Tighter twist helps control this, and in weaving, a close sett and a weave structure without large floats or gaps will help as well.

To emulate reeled yarn for weaving, I use only the finest top, sliver, or bricks I can find. The silk top I work with is either tussah (golden brown) or bombyx (pure white). Tussah is also called wild silk, and bombyx is often referred to as domesticated silk. Tussah is generally coarser and has less luster, while bombyx seems smoother, finer, and softer.

Caps, cocoons, and mawata are useful for making novelty or weft yarns but are too fuzzy and unaligned to make a yarn useful for warp. If you do wish to use yarns made from caps for warp, consider creating a loose weave, combining the yarn from caps with smooth yarns, or using a warp sizing to minimize the effect of the hairy yarn.

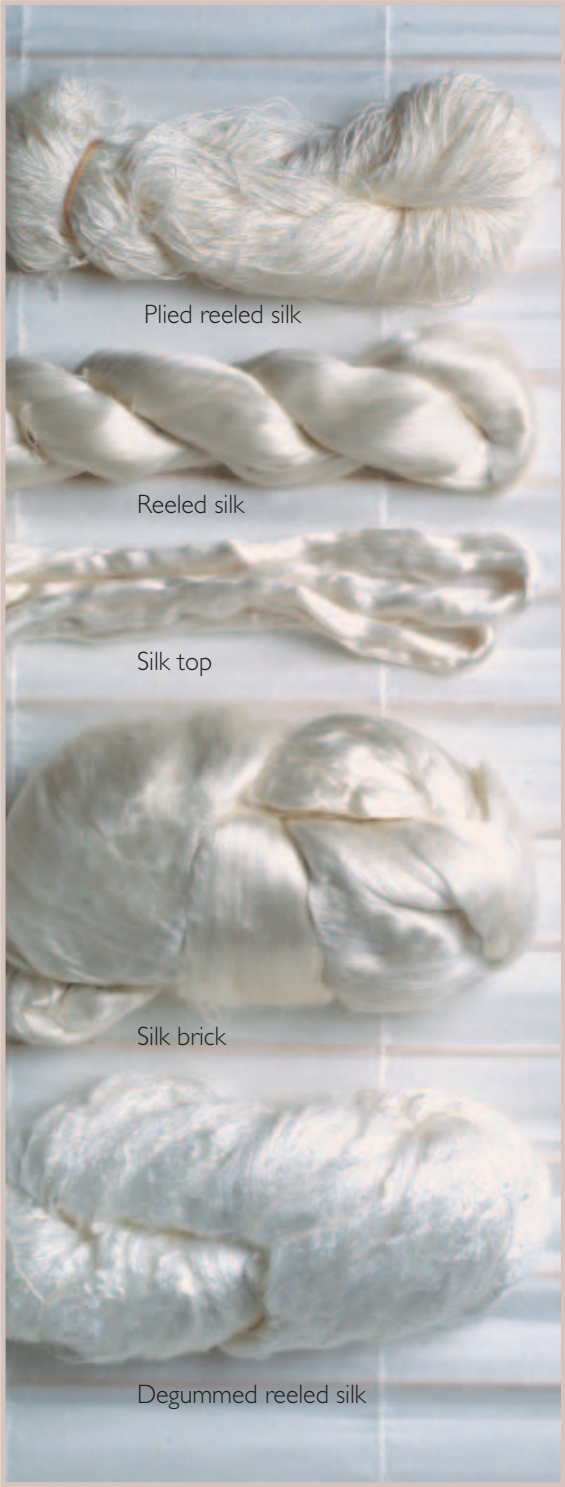
Qualities of silk

The qualities that make silk so prized include luster, softness, elasticity and strength, as well as an ability to absorb moisture. But silk must be handled carefully to enhance and retain these qualities.

Luster is enhanced by a balanced twist in the yarn. The fibers that are most parallel to the length of yarn catch and reflect the most light. Under a microscope, silk is a long continuous filament with few, if any, breaks along its length. It is a triangular shaped fiber in cross section. These factors enhance silk's luster and hand while spinning, and carry through to the finished fabric.

The moisture absorption of silk is about 30 percent. This greatly aids the fiber's ability to absorb dyes, making it one of the more pleasing fibers to dye. Silk also absorbs impurities, such as metal salts, that tend to damage the fibers. "Weighted silk" refers to fibers that have been subjected to a process that adds metal salts, thereby changing the hand of the fabric, but also decreasing the durability of the fabric.

The elasticity of silk is good, but silk is less elastic than wool. Silk fibers can stretch as much as 10 to 20 percent when dry and 30 to 35 percent when wet. Silk has a breaking elongation of 20 percent (dry), and since there are no cross-linkages in the molecular structure, it does not regain its original length. Silk's ability to stretch has made it a high demand fiber for industry and in such uses as parachutes. Different silks stretch at different rates. Bombyx stretches differently than tussah and even different batches of bombyx stretch differently from each other. For a large project, buy enough silk from one source to complete the whole piece.



Temperatures over 300°F begin to damage the molecular structure of silk fiber, and it may begin to discolor, turning yellowish. Iron silk cloth on a medium setting, or use a damp press cloth. Silk burns with a sputtering flame, leaves a crisp brittle ash, and tends to smell like burning hair or feathers.

Chemically, silk is a protein fiber, and as such, it accepts dyes formulated for wool. An acid environment damages silk fibers the least, and organic acids (such as those used by home dyers) are the safest for the fiber. Silk also accepts dyes formulated for cellulose fibers, which require an alkaline bath. Alkaline, however, damages the fibers, so use only a weak (2 percent) solution of soda ash when dyeing and be sure to wash it out afterwards. Chlorine bleach will dissolve silk. Silk is damaged by perspiration, which will weaken and discolor the fibers. It is also harmed by aluminum chloride, a chemical commonly used in antiperspirants. Ultraviolet rays from the sun destroy silk fibers. As little as six hours direct exposure may damage the fibers as much as 60 percent. Even oxygen is harmful to silk fibers and unless kept in sealed containers, silk will eventually break down. Silk is resistant to mildew and moths, but the carpet beetle will damage silk.

Spinning silk

PHOTOS BY SHIRLEY BORBA

I spin "off the fold," holding the fiber over the index finger of my drafting hand. I pull off a comfortable length of top—about 6 inches—by holding a bit of top between my two hands and moving them gently apart until a section slips away.

If I am using a brick, I usually go further and split this 6-inch section lengthwise into three strips. Bricks and tops typically contain fibers of many lengths, all combed together.

I hold the 6-inch section loosely over my finger and spin off the fold. The first part of the top spins off the fold easily.

As I continue, the bundle of fibers becomes less organized, and I gradually hold the end of the bundle in the palm of my hand and control the drafting triangle with my thumb, index finger, and middle finger.

Because I am right-handed, I hold the bundle of fibers in my right hand and draft and control the twist with my left hand. I draft toward the orifice with my left hand (the right hand almost serves as a distaff, except those fingers are also controlling the fibers).

I move my hands around a lot as I am spinning. Because I am spinning for months on a project, I cannot hold my hands in one static position or I'd get repetitive-motion injuries. So I flip my fingers around, switch dominant hands, and generally fool around, all the while watching the drafting triangle and trying to maintain a consistent grist range and amount of twist.

When I get to the end of a tuft, I join the next 6-inch section by overlapping the fluffy ends. I control the twist in the yarn by starting with a pinch, and holding the developing yarn in my left hand between my thumb and index finger. It usually ends up that I am using only one finger to draft towards the orifice and control the twist. With yarn this fine, one finger is enough to pull fibers out of the bundle and stop twist from entering. Some spinners maintain that spinning from the fold creates a "hairy yarn" but I find it the most efficient method to spin the large amounts of fine yarn needed for a project.

I control the drafting triangle with the fingers of my right hand to ensure the fibers are feeding smoothly and as close to parallel as possible. This is the most important point to watch. There are occasional irregularities (such as variations in thickness and tufts of short fibers that need to be pulled off) with this method of drafting, but they do not seem to adversely affect the weaving process or finished fabric. In fact, I think that spinning from the fold works wonderfully.

Spinning Notes

I often spin lounging in an easy chair, the wheel to my left and my legs crossed, with my right foot treadling and my left foot slung over. This occasionally results in both legs going to sleep, and usually at that point the phone rings and I hobble over to it, if I don't fall flat on my face. I bought a double-treadle Lendrum to force myself to sit "properly" which has helped —but I find that I get antsy and I tend to spin longer on my other wheel. Mostly I keep my right hand stationary, and my left hand moves toward the orifice. When I get tired of this I switch hands. I go back and forth between watching the drafting triangle and spinning by feel. I can spin for hours if there's a good disaster on TV. O. J. Simpson's trial was a kimono in itself. So were the floods a few years ago. I also create spinning time by listening to books on tape, and we have a great community radio station here with several shows that I listen to faithfully.

Other spinners emphasize how smooth your hands must be when working with silk. I think this is less important with tops than with caps, but I do keep hand lotion and an emery board nearby.

I have two wheels—an Alden Amos Canadian Saxony and a Lendrum DT with the super-fast head. I use them, and the yarn from them, interchangeably. When I first got the Lendrum I had to adjust to its faster speed, but I can keep up with it now. For plying, I use Alden Amos's lazy kate—it has upright spokes that provide enough tension so that the bobbins don't spin too fast.

I spin the yarn for one project at a time. When I have spun and plied two bobbins, I run it directly onto the warping board, sit down, and spin two more, until I have enough yarn to warp the loom. When I have spun and plied enough yarn to prepare all the warp chains I need, I usually degum and dye them, but you may want to just wash them prior to dressing the loom.

Kimono #1, January 1997. This kimono includes two fabrics woven on different warps, both handspun bombyx two-ply silk yarns sett at 48 ends per inch. One warp was 11 yards long and 750 ends wide, the other was 3 1/2 yards long and 367 ends wide. The cardwoven and Peruvian pick-up bands used as trim were also woven on handspun two-ply warps. All used fine millspun silk weft. Sara thought this kimono would be her masterpiece, but when it was done, it was too busy for her taste. So she decided to make another—*Kimono #2*.

Degumming Silk

Silk occasionally smells "fishy" or seems stiff and unyielding, especially after wetting or dyeing. This is caused by sericin left on the surface of the fibers. This substance, extruded with the fiber by the silk worm, can be removed in a warm, mildly alkaline soap and water bath by a process called degumming. Sericin may inhibit the take-up of color so it's best to remove it before dyeing. Degumming the fibers in staple form is difficult, so I usually do not dye silk top or bricks prior to spinning. I spin and ply first, then degum and dye the yarn.

Kimono #2, August 1997. The colors and foiling for this fabric came to Sara in a dream. This kimono is one of Sara's favorites and she wore it at her wedding. For the main fabric, she made a handspun bombyx silk warp 13 inches wide and 11 yards long, using 624 warp ends at 48 ends per inch. A fine millspun silk was used for the weft. The warp for the band was 4¼ inches wide and 3½ yards long. The foiling was added as a surface design treatment after finishing the fabric.

I always degum the warp before I dye it—even well prepared bombyx top has sericin still in it. I use Dawn dishwashing soap or Orvus paste and a good amount of hot water, adding just enough washing soda to bring the pH slightly alkaline (I test the pH with litmus paper). I heat and soak the silk in this solution in a crockpot set on low at least overnight. If the water is very yellow and smells of sericin the next day, I repeat the process again before dyeing the warp. Since I work with my warp yarns in chains, the small size of the crockpot isn't a problem.

Dyeing

I dye some of the yarns as top, and some I paint or dye as yarn. The painted top gives a "tweedy" look to the colors, while painting the yarn keeps colors more distinct. I use Sabraset dyes and mix them to a 1-percent solution. Then I either paint the top or paint the yarn. Occasionally I will dye the yarns in an immersion dyebath. I try to dye a 3-percent depth of shade, to matchthe intensity of the 1-percent direct application of the painted yarns.

Warping, Weaving, and Finishing

All my fabrics are warp-faced plain weave—allowing the dyed, handspun warp to shimmer. I sett the warp at 48 ends per inch, with 4 ends per dent in a 12-dent reed. I determine the sett by wrapping the yarn loosely around a ruler, and pushing the yarns together so they just touch. I make a yarn that is 40 wraps per inch. If I sett the warp at 20 ends per inch, this yarn would make a balanced plain weave using itself as weft. I use a finer weft, and so I want the warp sett closer to cover it. As I measure a warp, I allow about 5 percent extra for shrinkage.

Some people size their silk warps. I don't because I use a smooth, plied yarn. If you're using a fuzzy, singles yarn I recommend hair spray. After you've warped the loom, spray cheap hair spray on the yarns while the shed is open, between the reed and breast beam. Let it dry and then continue to weave. Since I warp front to back, occasionally static electricity will build up in the warp yarns as they are wound on. I simply spritz them with a little water, and tie on. I have found that static electricity isn't a problem with the yarns once they are under tension.

For weft, I use a very fine commercial silk (Lunasea's 140/2). It doesn't show in the finished fabric. Because the weft yarn is so fine and the warps are under tension, the fabric hardly draws in as I weave it and I don't need to use a temple.[2]

Sara dyed the red warp chain as top and then spun the yarn. She painted the pink chain after it was spun and the warp was wound off.

After the fabric is woven, I machine stitch a basting line at each end to secure the warps before I finish the fabric. I then wash the fabric in a regular cycle in the machine, using hot water for both the wash and rinse cycles (and pace nervously until it's done). Then I partially dry it in the dryer (pacing again). I finish the drying with my old 1950s rolling mangle, but you could use an iron. After the garment is constructed, I hand wash it and hang it to dry, then finish the drying with my iron.

The Motivation Behind the Art

I wear my garments all the time. When I started, I was interested in creating a wardrobe of my handspun garments, but by the time I had thirty or so cotton kimonos and about twenty shirts and a few dresses I lost interest in quantity. Now, I aim for one handspun silk kimono a year, plus a few commercial silk ones.

I work on some part of the process every day. Sometimes I think that the dyeing is my favorite part because it is the most dramatic and you can see the results so quickly. But when I think about it, I really love the whole thing. I love warping because that is when I start to see if my planning will all work out. Weaving the fabric is meditative like spinning. Sometimes, though, I have to set goals for myself, like "weave for an hour, then you can have tea." After I wash the fabric, I have to force myself to sew the garment. By this time, any shortcomings in the project are evident, and I'm already planning the next and thinking things like "next time the stripes will be bigger, next time the weft will be heavier so the fabric is more sturdy," or "now I need a green one."

Many years ago, when I wanted to learn to spin, it took me a year to find a teacher, buy a wheel (an Ashford kit

[2] A weaving tool that is used to maintain selvedges—it has two bars with teeth that hold the edges out.

Kimono #3, January 1999. Sara likes this heavier fabric because the cotton weft gives the garment more body. She can wear this kimono as everyday wear, as it is sturdy and not quite as fancy as her other garments. Body of fabric: Handspun two-ply bombyx silk sett at 48 ends per inch, 11 yards long. Band: Handspun two-ply bombyx silk, sett at 48 ends per inch, 3⅜ inches wide and 3½ yards long. Peruvian band: 20 warp ends, 60 inches long. The weft for the body fabric and both bands is 20/2 millspun cotton.

via mail order) and learn to spin. I vowed then that I didn't want to see others so frustrated as they tried to learn to spin, and I have been teaching ever since. I love teaching best of all—and while I'm making things, I'm thinking of ways to communicate what I have learned. There are many resources available now that weren't available when I was learning. When I couldn't find the information I wanted on spinning silk, I started a process of exploration that has brought me here. I think the next avenue I explore will be carpet weaving.

Sara Lamb is a spinner, dyer, and weaver from the foothills of the Sierra Nevada Mountains.

Resources

Hochberg, Bette. Fibre Facts. Santa Cruz, California: Bette and Bernard Hochberg, 1981.

———. Handspinner's Handbook. Santa Cruz, California: Bette and Bernard Hochberg, 1978.

———. *Spin, Span, Spun: Fact and Folklore for Spinners.* Santa Cruz, California: Bette and Bernard Hochberg, 1979.

Kolander, Cheryl. *A Silk Worker's Notebook.* Loveland, Colorado: Interweave Press, Inc., 1985.

Vest, March 1998. Sara made this vest so she'd have something to wear to the summer conferences she attends in hot climates. It was woven on two warps, both handspun two-ply bombyx silk sett at 48 ends per inch, and both woven with fine, millspun silk weft.

Silk Embroidery Threads

By Carol Huebscher Rhoades

Spinning small amounts of luxury

Millspun, silk Pearl Cord 20/3 (spearmint green); millspun silk floss (blue); millspun silk floss (Silk Mori pale green).

Silk embroidery brings to mind fanciful antique textiles with intricate designs worked in tiny stitches by Eastern and Western cultures. However, silk embroidery needn't be elaborate. A small motif stitched in silk can make a dress, shawl, or other wearables luxurious and special. Even if you haven't spun silk previously, you can, with a little time and effort, produce a variety of threads for sampling stitches.

Although I have a number of embroidery books, virtually none offers information about the qualities of silk embroidery threads, so I went to a needlework shop where I found several types of silk embroidery threads to use as models. Next, I consulted *A Silk Worker's Notebook,* by Cheryl Kolander for advice. Kolander divides silk embroidery threads into two categories: floss and cord. Her definitions help determine which silk to use and how to spin it. "Soft, loosely twisted *floss* displays silk's luster, especially in large areas of satin stitch. . . . It forms a flat surface; it spreads out and covers well. Almost any loosely twisted two-ply or even a single can be used in this way."[1] Because tussah silk is coarser than bombyx, it tends to spread more and is a good choice for floss.

"Tightly twisted and plied *cord,* also called cordonnet and twist, is especially good for chain stitch, buttonhole stitch, and any looped or feathered stitch. The cabled texture of the cord is important to these."[2] Cord can be either fine or heavy, depending on the effect desired in a design. Bombyx, finer and more lustrous than tussah, makes excellent cord.

[1] Cheryl Kolander. *A Silk Worker's Notebook.* Loveland, Colorado: Interweave Press, Inc., 1985, p. 66.

[2] Ibid.

Couching thread

If your design involves a grid or long lines of cord, you may also want to spin a fine couching thread the same color as the cord to stitch down the cord. On the other hand, you may want the couching thread to form its own design, in which case it should be heavier and of a color that contrasts with the cord. Kolander suggests a "fine, medium-twist two-ply" for couching. Bombyx is a good choice for a fine couching thread and either bombyx or tussah can serve for a heavy couching thread.

Reeled silk, taken directly from the cocoons, is the longest and strongest form of silk. However, since it is rarely offered in fiber catalogs, you will have to reel and dye the silk yourself.[3] Not being one for either reeling or dyeing, I take the easy route and spin space-dyed tussah and bombyx silk top for my embroidery threads. If you are going to do much silk spinning, I suggest that you buy silk fibers from several vendors and sample to determine which works best for you. The handle can vary depending on the quality of the silk cocoons, the degree of degumming, the form (handkerchiefs, also called mawata, caps, top, roving, or brick), and the effects of dyeing.

Preparing for spinning

Since, for most embroidery designs, smooth, even threads are desirable, it is best to spin silk in a well-lighted space. I place a square of cloth (black for light threads and white for dark threads) on my lap so that I can see the drafting zone clearly as I work.

To prepare the silk for fine spinning, I first check the fiber length by pulling out a few strands from the mass. Then, I "pop" the fiber open by holding the top or roving between my hands extended slightly more than the fiber length apart and pulling quickly. You will feel the fiber give a little, and it will open up. If the strand is very wide, I start by dividing it lengthwise into more manageable segments. I pop open one segment and then move my hands down to work the next segment until the entire strand is opened without being drafted apart. To spin the silk, I further divide the strands into very thin lengths. The width of the lengths should be proportionate to the yarn size desired. Test-spin a bit. If you have to manipulate the strand back and forth or draft in several steps to get to the desired yarn size, make the strips of fiber narrower. (On the other hand, if you aren't drafting at all to get the yarn size, make the strands just a little wider.) Drafting adds loft to the yarn and overlaps the fibers for stronger, more even yarn. As you draft, keep your hands slightly more than the fiber length apart and work with a light touch to avoid ending up with fiber wadded up in your hand behind the drafting zone.

Take time to sample extensively before you start on a project. Sampling won't take much time because most small projects require only short lengths of yarn, sometimes ½ yard is all that's needed.

Adding enough twist

Silk can take a high amount of twist. Spinning silk is easier if you oil the wheel well and, if possible, have a high-ratio whorl and a lighter drive band on your wheel. Lower the tension until there is just enough to keep the yarn feeding onto the bobbin. Work slowly at first until you feel comfortable drafting the yarn size you want. Then adjust the wheel tension and your treadling speed. With a high-ratio whorl, your feet shouldn't have to move too fast.

When you've determined the yarn size you want, keep an eye on the drafting zone as you spin. If you have about the same amount of fiber in each drafting zone, then your yarns will be even. Watch for little bunches or slubs of short fibers that can sometimes occur in silk processing. Eliminate these as you work so that your yarn doesn't have weak, lumpy spots that will impede embroidery.

[3] For information on dyeing silk embroidery threads, see Jean Sherman's article cited in Resources.

Here we have two strips of blue tussah top ready for spinning—(A) is unpopped fiber and (B) is popped and ready to spin.

By spinning sample lengths of floss, cord, and couching threads, you can learn how to control yarn size and density. By adjusting the amount of fiber in the drafting zone, you can change the size of the yarn. If you add more twist to the zone, you will make the yarn denser. I suggest that you spin some generic silk embroidery threads before you start spinning for a specific project.

For a two-ply floss, choose tussah silk that has been degummed well. If the fiber is short (3 inches or less), you may want to card the fiber into small-diameter rolags and spin it long-draw style (see page 43). For longer tussah, work from narrow strips of roving or top and spin short draw (see page 43). The commercial floss I checked had six strands of two-ply threads. The singles were about the same diameter as cotton sewing thread. The two-ply threads were firmly but not tightly twisted (about 14 to 15 twists per inch) while the six-strand yarn had almost no twist. Unless you are determined to reproduce the commercial yarns exactly, aim for a two-ply handspun silk that approximates the grist of two to three strands of commercial floss.

My experience with tussah has shown that it tends to lose the twist a bit and to spread out after it has been spun and plied. I usually realize that I could have spun the fiber a bit finer, with a little more twist, than I did. Experiment with lower and higher twists on yarns with more and then fewer fibers in the drafting zone.

Wind the singles onto a small piece of matt board or onto separate bobbins to ply. Keep the singles well tensioned and watch out for snarls. Ply the samples and steam-set the twist (be careful not to burn either yourself or the yarns). Try each sample with a little satin stitch and then spin what you need for your project based on the sample that worked best. Just make sure that the floss is loosely spun and plied but is not so loose that it shreds during the stitching.

Spinning a Silk Cord

Silk cord needs a lot of twist in the singles and the ply. Select a lustrous and fine bombyx fiber and spin it short draw from the ends of the fiber or folded over your finger (see page 43). Using a higher-speed whorl makes treadling easier. The commercial pearl cord I checked, consisting of three fine singles plied together, was about the same diameter as two strands of the two-ply for the floss but it had 28 twists per inch (about double the amount of twist in the floss).

Try both bombyx and tussah for couching threads. Depending on your design, you can spin a very fine singles for almost invisibly tacking down long cords or a two-ply with about 20 twists per inch for cross-stitching at the intersections of a grid.

One of the nice benefits of spinning your own silk embroidery threads is that you can easily shade your strands for color nuances. Spinning a singles from space-dyed fibers can yield subtle

or dramatic color shifts depending on the colors in the strand. You can also spin two strands from a space-dyed yarn with several shades of the same color but ply them so that the same shades don't quite meet. Another choice is to select one color from the sequence, spin a singles of that color, and ply it with a strand with multiple shades or colors. Of course, working with three or more plies can give you even more color choices.

Another way to extend the color range for embroidery is to soften a strong color with white. I made the three shades of rose for a floral design by carding some dyed tussah top with varying percentages of Sea Island cotton.

Another way to extend the color range for embroidery is to soften a strong color with white. I made the three shades of rose for a floral design by carding some dyed tussah top with varying percentages of Sea Island cotton. The cotton, about one inch long, was considerably shorter than the tussah. However, spinning the rolags long draw meant that the fibers remained more mixed during drafting than they would have been with a short draw. A similar blend with very short-stapled brown cotton to deepen some green wasn't quite as successful. Because the cotton was a bit nubbly, it was hard to spin smoothly. However, the finished yarn worked nicely for the cross-stitch pattern. I even made a few stitches with two-ply 100 percent brown cotton and had no problem with abrasion.

Once you see that it isn't difficult to spin a useable silk embroidery thread in several qualities, it is easy to produce exactly the threads you need for a given design. Think about the stitches and whether they need to cover the fabric well or to sharply define a motif. You may need a mixture with one, two, three, or more plies.

Carol stores her handspun thread on small pieces of matt board to keep it organized for embroidery. Examples of (A) cord and (B) floss in curry yellow.

Spinning a Singles Yarn for Embroidery

For a singles yarn, try different grists to see which works with your chosen stitches and fabric. If the singles tend to come apart, either try spinning them with more twist or spin in the opposite direction. For the way I embroider (right-handed and working from top to bottom), I've found that a medium Z-twist singles works better than a highly twisted S singles. You may need to protect your fingers when you're plying highly twisted singles—silk can be as strong as steel. I often put a bandage or some tape over my left index and middle fingers so the strands don't cut me as I ply.

The yardages you will need for silk embroidery will, of course, depend on how extensive your pattern is. I needed about half a yard each of six colors to cross-stitch a 1¾-by-1¾ inch floral design on 14-count Aida.

Handspun silk embroidery threads can be made without much investment in either time or money, but they will give you many hours of luxurious embroidering. Perhaps your work will invite wonder and inspire a future embroiderer.

Carol Huebscher Rhoades *dreams of Silk Road adventures while she spins and embroiders in Austin, Texas.*

Resources

100 Stitches: Embroidery. Greer, South Carolina: Coats & Clark, 1979.

A Stitcher's Guide to Silk Threads. Baltimore, Maryland: Kreinik Manufacturing Co., Inc., 2001. See Kreinik's website, www.kreinik.com, for more on embroidering with silk and caring for silk embroideries.

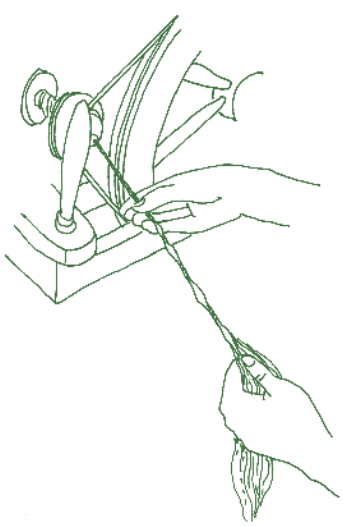
Kolander, Cheryl. ***A Silk Worker's Notebook.*** Revised edition. Loveland, Colorado: Interweave Press, Inc., 1985.

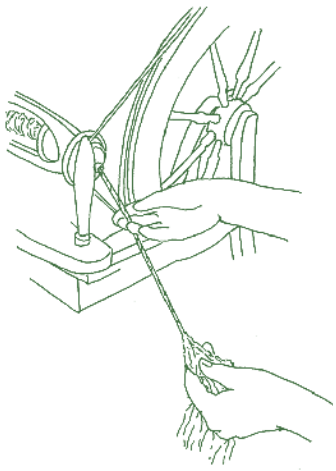
O'Donnell, Louise. ***"The Wonders of Wild Silk."*** ***Spin.Off,*** 24, 1 (Spring 2000), 52–55.

Sherman, Jean. ***"Spinning Silk Threads for Embroidery."*** ***Spin.Off,*** 18, 2 (Summer 1994), 78–80.

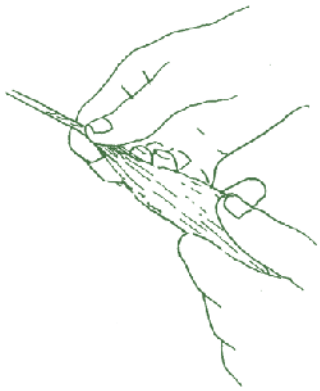
Long draw: With long draw the drafting zone is much longer than the fiber length. Draw back with fiber supply hand to attenuate the fiber, while controlling the twist with the other hand. Feed entire length onto bobbin in one motion.[1]

[1] See The Spinner's Connection by Bobbie Irwin (Loveland, Colorado: Interweave Press, Inc., 2002) for more information.



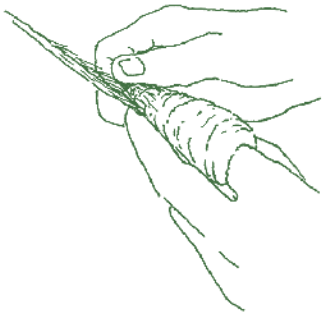


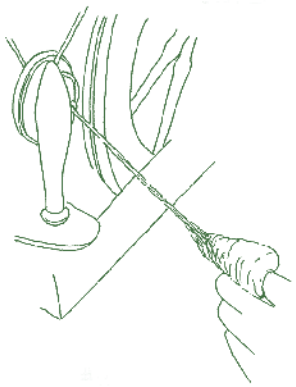
Short draw: Draft yarn using a short-draw technique by keeping your hands close together and allowing the drafting triangle to be a little longer than the staple length.



Spinning from the fold: Spinning from the fold works best for long (at least 4-inch), supple fiber. This drafting method is useful for controlling slick fibers such as silk.

Fold a length of combed roving or a lock of fleece over the forefinger of your away hand and draft from the center of the staple, or hold folded fiber lightly between your thumb and forefinger. Use any short-draw technique; spinning from the fold is especially good for point-of-contact spinning.





ILLUSTRATIONS BY MARJORIE LEGGITT