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Signed: Patricia Elaine Duncan

Date: July 11, 2019
A comparison of lusters in low to high twist silks commonly used by the handspinner

By Elaine Duncan
Abstract: A comparison of lusters in low to high twist silks commonly used by the handspinner.

It is obvious that reeled silk is more lustrous than noil but the attempt to present scientific results inspired this study. The samples of Bombyx, Tussah, Eri and Muga silks spun for this study were chosen because they are easily accessible to the handspinner. Two machines were used to test the results in this study. One was an illuminance meter often used by photographers to measure reflective light for successful photographs. The second machine was a commercial gloss meter which is an instrument used to measure specular reflection gloss of a surface.

In my testing most of the samples proved my theory that less twist created more luster. There were two exceptions. The Bombyx hankies and the Tussah noil did not follow the trend. Several factors can effect luster in silk. Excess temperature and sericin not completely removed will make the yarns less shiny. The Bombyx hankies were from my processing the cocoons and may have been over heated or not had all the sericin removed. With the noil, the sparkle of the tighter twist may have played a factor that came from spinning fibers that were placed in many directions. The noil was carded into punis in order to be spun therefore having ends sticking out everywhere reflecting light. All other samples tested indicated that less twist creates more luster. The variance in twist did not have to be great to make a difference in the luster of the yarn.
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In-Depth Study: A comparison of lusters in low to high twist silks commonly available for use by the handspinner.

Fibers to be used: Bombyx mori, reeled, hankies, brick, top, roving and thrown; tussah top, noil, roving; white eri roving; muga roving

Preparation methods: Reeled, hankies, brick, top, roving, and throwsters silk

Spinning methods: Reeled and worsted spun silks

Finishing method: Wet finishing of yarns and degumming when necessary

Samples or end products, how many and what they will be: Two samples of each fiber preparation, one low twist and one high twist (24 samples)

How will the objective be accomplished: Samples will be reeled or spun silks in the most commonly attainable forms for the handspinner. These samples will be spun into low and high twist yarns wound on display cards. The samples will be tested by a digital illuminance meter (photo light meter) and measured in lumens. Samples will then be sent to a testing laboratory of a film and coating company in Kansas City and tested again using a commercial gloss meter. The samples will be wrapped onto cards to give more accurate results from the light reflected without the interference of adding more
texture that knitted or woven samples would produce. Samples will be of natural or bleached silk to prevent color playing a factor in the measuring of the lumens. The results will be charted and analyzed to help the handspinner determine desired luster of silk yarns.

This discussion of luster will help the handspinner choose appropriate silk fibers for spinning with consideration of appearance and cost. The different types of silk listed in this study along with the availability, cost, origin, breeds, different commercial preparations and appropriate use of the yarns will be discussed.
Introduction

I have always loved silk fabrics and fibers. Before being introduced to handspinning I was an avid seamstress and tailor. As I think back over the years, I remember silk garments I constructed or purchased that I wore many times with pleasure. Silk garments of douppioni, noil and organza always had an elegance about them with their unique qualities. The hand and luster of the silk fibers were like no other.

A strange link to the silk industry was found while researching my family history a few years ago. My great-great-grandfather, John Baxter, born in Manchester, England, in 1815, worked in the silk industry there for some thirty years. He then immigrated to the United States in 1867, settling in Connecticut and once again worked in the silk factories another eight years. I wish I could sit down with him and visit about the silk industry of the day and what he did in that industry. Maybe there is more to this interest than curiosity; maybe it is genetic!

According to Webster’s Dictionary (1991), “luster is the quality, condition, or fact of shining by reflected light: gloss: sheen”. In the Olds College Master Spinners Level 3 manual the characteristics are described as:

“Silk is the lightest, strongest fiber known, although it is the luster that makes it so desirable. The fiber is somewhat translucent and reflects light. Irregularities on the surface break up the reflected light, giving the fiber a unique sparkle in addition to its luster” (Murray, 2012, p. B-8).

Little irregular ends sticking out of yarns can add sparkle to the fiber but the proof of the effect of twist on the luster is my focus in this study.
Since learning to spin I have become more familiar with the silk fibers and their sources, leading to a more curious study of fibers in the marketplace. While researching silk fibers I discovered the contradiction in theory of the effect of twist on silk. Some experts state that the more twist the higher the luster in the yarns. Other sources state the less twist the higher the luster. What is the true effect? Here inspired my study of luster.

This study evolved while visiting with a friend who worked for a company that owned and used a gloss meter to test light reflection. The friend volunteered to take a couple of samples and see if the gloss meter could pick up the differences in the luster of the differing twists in two samples of the same silk preparation. It worked! I then had a nephew suggest the use of a photo light meter as well. He is a professional filmmaker and helped me select a suitable light meter to purchase. After the confirmation that these testing tools would be able to give the desired results, I proceeded to choose the types of silk to be spun.

While attending Olds College Fiber Week I checked out the types of silks I could purchase and what seemed to be the most common preparations. I came home with a wide variety of silks from which I could make my samples. I would spin high and low twist samples of:

Bombyx mori (reeled, hankies, brick, top, roving and throwsters), tussah (top, noil and roving), white eri roving, and muga roving.

This study is designed to compare luster of each silk type and preparation, spun in two different twist-per-inch samples. Samples would be spun using a 6:1 ratio and a 17:1 ratio on my Lendrum wheel. They would be treated in the same manner for finishing on all samples to try to keep everything consistent except twist. The objective was not to compare different types of
silk but to liken each type of silk against itself. This objective was to compare low twist reeled bombyx to higher twist reeled bombyx, not reeled bombyx to bombyx noil, for example. This comparison, hopefully, would determine if twist really does make a big difference in the lustrous effects on handspun silk yarns. It was hopeful the study would help dispel the theory that the tighter the twist the more luster is produced in a handspun silk.
Background Information

The history of silk is long and filled with stories of intrigue and mystery. According to Sara Lamb in her book, *The practical spinner's guide Silk* (Lamb, 2014) the history of sericulture, or the cultivation and reeling of silkworms, can be traced back to the Chinese some 5,000 years ago. The secret of raising and reeling silk was highly protected and had a penalty of death to those who attempted to steal this knowledge. Legend has it that a Chinese princess smuggled the silkworm eggs out of China in her headdress when she wed and moved to Kho tan (modern Xinjiang, China) in A.D. 419. Legend also claims that Nestorian monks smuggled silkworms and mulberry seeds into Constantinople where the Byzantium Empire unsuccessfully tried to keep the secrets of silk production. Cultivation spread around the Mediterranean during the Moorish invasions. There were many stories written about the famous Silk Road where trading of silk was a major economic export of the Orient.

Today China, Japan, France, Italy, the Philippines, Thailand and India are all bombyx silk producing nations. Bombyx mori silkworms are the leading source of silk in the world today. The parent silkworm, bombyx mandarina, from which the bombyx mori was bred (Cook, 2014) is still found in the wild in Asia.

Silk has not only been used as a luxury fiber but it has many other uses today. In the July 30, 2010 issue of the journal *Science*, Tufts University biomedical engineering scientists Fiorenzo Omenetto, Ph.D. and David Kaplan, Ph.D. reported “Silk-based
materials have been transformed in just the past decade from the commodity textile
world to a growing web of applications in more high technology directions." The paper
continues to note the development of silk hydrogels, films, fiber, sponges, adhesives
and microfluidics as well as the engineering of bone and ligaments are making great
advances in medical technology. Because silk is biologically and environmentally friendly
it can be integrated with living systems. These products are capable of being used as
implantable optical systems for varied diagnoses and treatments (TuftsNow, 2015).

Narendra Reddy and Yiqi Yang, researchers at the University of Nebraska-Lincoln,
published a paper (Journal of Materials Science, 2010) discussing their research on the
species of silk moth, Hyalophora cecropia, found in North America. This silkworm feeds
on native crab, elder, sugar maple, wild cherry, birch and dogwood trees and has anti-
microbial and anti-cancer properties. Until this research was conducted, the moth has
been considered a pest. More research continues on this strong, fine fiber with the
hope that it will prove to be a viable source of silk that can easily be produced in large
quantities, inexpensively, in North America.
Methods and Materials

Silk is a very strong, warm and absorbent fiber. Of silk’s many great qualities one of the most endearing is its luster. The debate of the effects of twist on luster for the handspinner has been argued for a long time. Some spinners believed the tighter the twist the more luster is produced. After studies conducted, under a microscope, this thesis has been questioned. Is what the eye sees really luster or is it sparkle?

The long smooth outer portion of the silk fibers catch the light, making it reflect off the fiber, creating luster. Sparkle is created in a much different way in that it is the little ends that stick out in yarns that catch the light and make the light rays bend and bounce to give the effect of more reflected light (Kolander, 1985).

It is obvious that reeled silk is more lustrous than silk noil but the attempt to present scientific results was the inspiration for this study. In this study samples of bombyx, tussah, eri and muga silks were chosen because they are easily accessible to the handspinner. The color of the samples was to be white or a natural white, if possible, as colored fibers like red eri, which loses its color once washed, would skew the results of luster measurements.

There were two machines used to test the results of the samples in this study. One was an illuminance meter, which is often used by photographers to measure reflective light in photographs. The second machine was a commercial gloss meter, an instrument used
to measure the specular reflection gloss of a surface. Gloss is determined by projecting a beam of light at a fixed intensity and angle onto a surface and measuring the amount of reflected light at an equal but opposite angle. This instrument is often used in the ink and paint industry.

Samples in this study were reeled on a zakuri or spun on a Lendrum flyer-lead scotch tension wheel using flyers with ratios of 6:1 and 17:1. All samples were spun as two-ply yarns spun Z or clockwise and plied S or counterclockwise. All samples were wet finished by being immersed in very warm tap water and hung to air dry. The samples were then wrapped on white weaving cards in an appropriate size to fit the gloss meter. Wrapping the yarn around the cards in a single layer minimized texture to give a more accurate reading of the measured light reflected. Knitted or woven yarn samples would have produced more texture and skewed the results. Samples were of natural silk to prevent color playing a factor in the measuring of the lumens. Results were charted and analyzed to help the handspinner determine desired luster of silk yarns.

In the comparison of samples prepared, the breed, preparation, luster and twist were compared and analyzed. The preparation of fibers for spinning and cost were analyzed to help the handspinner determine the best silk preparation for any given project.
What is silk?

Silk is an extruded protein fiber produced by silkworms and the only natural fiber which is found in filament form. There are four main amino acids; glycine, alanine, serine, and tyrosine that make up this fibroin structure. Silk’s molecular structure is highly organized and strong. This semi-crystalline material has 62-65% crystallinity in Bombyx mori and 50-63% in wild-type silk cocoons (Winegardner, 2016).

Silk is a very smooth, slippery, shiny fiber. The molecules of silk are very organized and this smooth surface is the reason silk fibers have such beautiful luster. The light passes through the silk as two refracted rays in different directions and at different speeds, contributing to the luster (Winegardner, 2016). Minus the scales that wool fibers exhibit, the twist is the only thing holding silk fibers together to form yarn.

Silk fibers are very long. The bombyx mori silk can have a cocoon filament length of up to 1200 meters while muga and eri have only about 450 meters per cocoon. Tussah fits in the middle with about 700 meters per cocoon. The length as well as other characteristics can vary depending on the health of the silkworm and the environment in which it lives (Winegardner, 2016).
Types of silk

Bombyx mori silk is found in the domestic silk market and known as cultivated or mulberry silk. The filaments can be reeled or spun from long lengths of fiber harvested from these whitish colored cocoons. The filaments are very strong and fine.

Photo 1. Bombyx mori silk cocoons can be reeled into very lustrous threads or yarns. Photo by P. E. Duncan

Bombyx mori silkworms have been domesticated and are raised on farms where a safe and healthy environment can be created and a continuous supply of mulberry leaves can be provided for food. The finest blue-white colored silk comes from bombyx mori silkworms that are fed a diet of white mulberry leaves. Lesser grades of bombyx mori are fed fruitless black mulberry and fruiting black mulberry leaves respectively (Lamb, 2014). Other varieties of mulberry leaves found in India and North America can be used to feed silkworms. The difference in the silkworm's diet will make a difference in quality and color of the silk fibers.
Tussah silks (also referred to as tussar or tasar) are basically wild silks. They are more durable than bombyx silks and the coarser filaments are more resistant to acids, alkali and sunlight. The most plentiful wild silks are found in the Antheraea family with Antheraea pernyi, found in China, being the only true tussah silk. Antheraea mylitta found in India and Antheraea yama-mai from Japan are similar to the A. pernyi, but are rarely found outside their country of origin. Tussah wild silks are allowed to grow in their natural environments and some of them can be harvested at the cocoon stage where they can be reeled, much like bombyx mori (Lamb, 2014). The process for growing and gathering has become more sophisticated as demand grows for these silks. Tussah silk farmers gather wild cocoons but often prefer to grow them in controlled areas. The farmers fend off predators by standing watch twenty-four hours a day during the silkworm’s instar stages. Sometimes cocoon-loaded branches are cut and taken into protected areas to develop. Food has to be provided to them in this situation (Selk, 2013).
Tussah silks range in color from an off-white honey color to gray or brown, all depending on the diet of the silkworm. Tussah silk is a coarser fiber and because it requires less manual labor to produce it is considerably cheaper than bombyx mori.

There are two types of tasar silk moths, tropical and temperate, both found in India. The name is thought to be derived from the Sanskrit word tassara, meaning shuttle. The temperate tasar is a hybrid silkworm developed in the 1960s and grown in oak trees in the Himalayas. This tasar silk has greatly added to the Indian economy (Peigler, 1999).

Female tropical tasar moths are tethered to bamboo poles with thread so they will lay their eggs in a controlled environment. These captive moths are moved outdoors at night to attract wild males with which to mate. The females, after mating, are then taken indoors where they lay their eggs in bamboo baskets for the next six to seven days. Raising silkworms in this manner helps keep them from falling victim to predators which include birds, ants and diseases. Leaf baskets are made by folding leaves that
encompass the eggs, before men using long hooks, hang the small caterpillar baskets in food trees. When the silkworms start to spin their cocoons they spin a peduncle that tethers them to a twig in a cradle-like hammock sling (Selk, 2000).

The recent trend to advertise tussah silks as Peace Silks implies the silkworm is allowed to complete its metamorphosis and fly away. This is met with skepticism. Most tussah producers still kill the pupae and remove them before they reach that stage of development. All reeled silks stifle or heat the pupae to kill it in the cocoon (Selk, 2013).

Eri silk comes from the Samia ricini silkworm mostly found in India (Cook, 2014). It is often referred to as poor man’s silk or erendi silk. These prolific silkworms produce up to seven life cycles per year. They feed on castor or tapioca leaves with their large cocoons ranging from white or cream to red in color. Unfortunately, much of the red color washes out during the degumming process. Eri cocoons are loosely formed and cannot be reeled. This silk has a fine, cottony texture, not glossy and is warmer than most other silks. The silkworms attach
themselves to tree branches to spin their cocoons. The silk farmers cut the branches and bring them indoors where the silkworms can be protected from predators while making their cocoons. These cocoons are most often stifled and not allowed to mature. The pupae from these cocoons are part of the diet of some cultures in India.

Muga or munga silk is produced mainly in the Assam region of India. It is a beautiful, very desirable silk from which fancy wedding sarees are made. The Antheraea assama moth is closely related to the tussah moth. Muga is a glossy fiber and golden in color.

The best cocoons are hand reeled and the waste is used for spinning fiber. The reeled silk fabrics are typically not degummed, therefore, have a crisp body to them. The spinning fibers, however, are degummed and have less sheen and metallic appearance. This silk is not easily bleached but takes dye very well (Cook, 2014).

There are many other types of silk too numerous to investigate in this study. They are found anywhere cocoon-producing moths live. The silks that have been discussed here are the most common silks that the handspinner will find in the marketplace.
How silkworms grow and produce silk?

Silk is produced by insects that all pass through the same four stages of development. Those stages are egg, larva or caterpillar, pupa or chrysalis and moth. Whether wild or cultivated they all produce silk in the same way.

The female silkworm has two glands that release chemical substances produced in her abdomen known as pheromones. This substance can send out different messages such as danger or that a female is present. The male does not have a nose to smell this alluring substance but feathery antennae that react to the chemicals released into the air. These chemicals tell him there is a female in the area and she is ready to mate. Mating occurs when the moths put the tips of their abdomens together and sperm cells pass from the male to the female’s body. The sperm is stored in the female’s body in a sack where it is kept until the time when her eggs will be fertilized.

The female lays her eggs and then dies shortly after because she has no mouth or digestive system to enable her to sustain life for any length of time. She will lay about 500 yellow eggs that each weigh only about 1/30,000 of an ounce and are no bigger than the head of a pin but so strong a person could step on them and not crush them. The eggs hatch into tiny caterpillars in about 10 days.
In their second, or larval stage, silkworms, as they will be referred to from here on, molt four times. These stages are called instars where the silkworms eat and grow then rest before molting to the next instar.

The silkworms go through five instars with the last being where they consume over 80% of all their food. They weigh over 10,000 times more than when they hatched. As they reach these resting periods, or instars, they raise their heads and stop moving for about a day. The new, inner skin completely develops and the old outer skin becomes thin and loose. As they awaken from their instar state, the silkworm starts moving and sheds the old skin. The new, wrinkled skin soon becomes smooth and tight. At the end of the fifth instar the two silk glands weigh 25-50% of the total body weight.

On the worm’s head are twelve eyes that can only see light and dark and eighteen spiracles, or breathing holes. There are two silk glands that are immature during the first four instars and produce only enough silk to help tether worms to leaves or other surfaces, especially useful while wiggling out of their old skins.
At the end of the fifth instar, the silkworm extrudes two proteins. Fibroin is the actual silk structure from the two silk glands and sericin acts as a glue to hold the two strands of silk together. These two glands meet just below the silkworm's lower lip and two strands of liquid silk are extruded as the silkworm flips its head around in a figure-eight pattern. As the air hits this liquid it turns into a hard, solid strand of silk with sericin coating the two fibroins, gluing them together. This process of spinning usually takes at least two days for the cocoon to completely enclose the silkworm in its new home. The single, two-filament strand of silk has been wrapped and glued together to form the cocoon that can reach up to a mile in length. It is at this stage the silkworm sheds its skin for the last time and the yellow pupal body is formed.

The third stage of metamorphosis occurs when the larva changes into a chrysalis. It is at this stage the silk farmer harvests the cocoons by heating or stifling the larvae inside the cocoons to produce silk suited for reeling. They are then sorted and culled for defects.

When the moth is allowed to mature, it changes from the yellow pupa into a silk moth in about three weeks. The encased chrysalis' hard shell splits open and a black-eyed, feathery antennaeed moth emerges. It spits out a liquid that dissolves the fibers enough to allow the fully developed moth to tear a hole in the weakened fibers and escape. It has six legs and a pair of large wings attached to a white furry-looking oversized body that looks disproportional to the weak wings. As the blood rushes to the wings they
expand and harden, becoming strong enough for wild silk moths to fly. These silks are not suited for reeling because as the pupa matures it damages the fibers as it wiggles its way out of the cocoon.

Domesticated silkworms cannot fly but only flutter their wings and hop short distances. This inability to fly has been bred into the moths by modern farmers to help control their crop of fiber producing silkworms. These domesticated silkworms are grown in large trays and racks where millions of cocoons can be produced in a relatively small space. The diet of the silkworm is usually mulberry leaves. The domesticated silkworm is very lazy and not able to forage for food and is totally dependent on man for food. Wild silkworms are found in trees and able to forage for food.

Silkworm moths can vary in the number of reproductive cycles each year depending on the climate in which they grow. In cold climates one cycle per year is common while many reproductive cycles can occur in tropical climates. The most common silk is from Bombyx mori silkworms that produce shiny, soft, white silk fibers. The second most common silk is Tussah or wild silk. China and India produce more silk than any other country in the world.
Forms of silk for the handspinner

Reeled silk

The ultimate luxury of silks is reeled silk, also known as thrown silk. Throwing is the process of adding twist to long unspun filaments of reeled silk. A most important generic term in reeling of silks is organzine, which is a tightly twisted, plied yarn, used for warp in woven silk products. Tram, the second term, usually consists of four filaments with only enough twist to keep the fibers together (Cook, 2015). Reeled silk is not commonly found in the handspinner market but cocoons that can be reeled by a handspinner are readily available.

Bombyx mori cocoons, the most readily available cocoons, can be purchased from silk fiber suppliers. Equipment needed can be improvised from other spinning supplies the spinner might own (example: bobbin winder) or occasionally found from spinning sources. In this study the equipment used will be described as equipment of choice for reeling by the handspinner.

The first step in reeling silk is to place the cocoons in boiling water to soften the sericin. Using an aluminum or iron pan can act as a mordant and change the color of the silk if it is going to be dyed; therefore the pan of choice is stainless steel. Place as many cocoons as you think you can reel at one time (15 to 25), and a few more for replacements, in the pan. Excessive time in the pan may cause the cocoons to become a mushy glob and unusable for reeling. The object is to remove just enough sericin to
separate the two strands of silk extruded by the moth and soften the cocoon enough to unwind the filaments onto a bobbin. After the cocoons have been softened the outer layers of filament need to be removed. This fuzzy layer is called the blaze. Commercial cocoons may not have much of this layer as it may have been already removed. Homegrown cocoons will have this fuzzy layer as it is the fiber that holds the cocoon to the branch or cubical in which it is grown.

A stiff bristled brush with a handle is used to grope or dunk the cocoons in the water to catch a single strand from each cocoon. Expect to have several yards of fiber pulled off before you find the single strand. Keep this silk for other handspinning projects. When a strand is caught the cocoon is transferred to a crockpot or pan of hot water until enough strands are caught to start reeling. A croissure, or crossing device, is threaded with these strands to allow the silk to be compressed into a multi-strand filament of silk and to remove excess water. The crossing of the silk filament is twisted ten times to create a single strong filament that can be later thrown for the desired thread or yarn. If the filament is allowed to dry on the itomaki, or spool, it will become hard and unusable, therefore, the object is to have the silk dry before winding on a final spool. This process may require the silk to be wound several times from itomaki to itomaki, crisscrossing the filaments in a zigzag pattern to keep them from sticking together. The zigzag pattern is important as it keeps the filaments separated and not touching each other any more than necessary.
As a filament falls off the strand it can be replaced by adding a new filament from the reserve cocoons. This is done by allowing the new filament to be snagged into the multi-filament strand. It is desirable to keep the number of filaments the same to help keep a consistent diameter. Beware of running the filament over your fingers as the strength of the fibers is great that it can easily cut your skin. The cocoons will become more transparent when most of the silk is reeled. This end silk is not suitable for reeling and should be discontinued and replace with a new cocoon. The thin spent cocoons can be added to other silk waste and used in other projects.

After the filaments have been successfully reeled onto the number of desired itomakis for your project the filaments need to be thrown. This process can easily be done on a
spinning wheel or charkha. With the end purpose in mind, the type of yarn is determined by the number of filaments per ply of yarn and the number of plies in the desired end product. For example, a knitting yarn might have ten filaments per ply, two plies and eight to ten twists per inch. Set the itomaki or bobbins on the floor near the spinning wheel where the filament pulls off the end of the bobbins. A wire loop placed directly below the orifice of your wheel allows the filaments to be guided to the orifice and take the tension off the filament to help prevent breakage. The silk can then be successfully twisted into the desired silk product and plied for a lovely, lustrous yarn or thread.

A final step in reeling the silk is degumming the yarn. If the desired yarn is to be soft and lustrous, degumming is required. That is the process of removing the remaining sericin. Skein the yarn, tying in at least eight places in figure eights as the yarn can tangle very easily. Prepare a solution of four ounces of Orvis paste and ¼ cup washing soda in one gallon of water. Heat to a low boil and then add silk skeins and simmer for about one hour to fully degum the silk. If some crispness is desired just remove the silk yarn earlier from the pot. Rinse well and use four ounces of white vinegar in one gallon of water for a final rinse.

There are many great resources to help the novice silk enthusiast grow and reel silk. It is a fun process, albeit time consuming and labor intensive. For this study, the purpose was to give an overview, not a detailed how to of the process (Cook, 2015).
**Spun silks**

Spun silk is a term describing the silk that cannot be reeled or waste from the reeled silk. It can be obtained from bombyx, tussah or wild silks. Before the invention of the spindle or spinning wheel waste silk, because it could be so warm, was used for wadding and insulation. Today in commercial venues the reeled silk waste is schapped where it is tossed aside in a warm, moist place allowing the sericin to begin to ferment. The fermentation process is completed in a few days and the gum can then be washed off the soft supple fibers. The down side to this process is that it has an extremely offensive odor and cannot be used in populated areas (Kolander, 1985).

When the handspinner purchases roving or top they are getting silk that has been commercially processed. The fibers are pulled apart in mechanical rollers, smoothed and placed in parallel order then cut into uniform lengths. Some commercial products that appear very lustrous have been gassed, which is a finishing process where the yarn has been run through a flame and any stray fibers have been singed off the yarn. Handspinners of silk are not able to reproduce this gassing process (Kolander, 1985). Another form of spun silk is throwsters silk which differs from top or roving in that it is composed of threads of varying lengths (Lamb, 2014).

Silk can be purchased in roving form which is made up of compact fibers with just a bit of twist to hold them together until spinning can occur. If the fibers are parallel they have been combed but if they are somewhat random they have been carded. The more
parallel the fibers the shinier the yarn. Top is a combed preparation with the fibers longer and more in parallel order than roving. Silk top produces shinier yarn and makes the smoothest worsted spun yarns.

Hankies or mawata can be purchased or easily made by the handspinner. Cocoons are simmered in hot water until the sericin is softened to allow the handspinner to tear open the cocoons, removing the worm, then stretching the cocoon over a square or cap shaped frame. Multiple layers are stacked one on top of the next and then allowed to dry. Ten layers of cocoons to make caps or many layers stacked for making hankies can be dyed all at one time. Each cocoon layer, or flake, is separated and then stretched into a long, thin fiber strand by poking a hole in the center and working into a thin loop. Break this loop and spin adding as little or as much twist as is desired.
Brick is another form of silk easily obtained by the handspinner. It is formed when long continuous strips of combed fibers are folded into a brick-shaped package. There will be an end tucked into the center. When pulled out, that end will unwind into a long thick strip. The cut fibers lay parallel and usually range in length from two to six inches. The longer lengths can be spun into smooth, strong yarns while the shorter lengths are spun softer and are not as strong. Spinning over the fold, the fibers should easily slide off the finger to produce glossy yarns.

Noil silk can be from bombyx, tussah or other silks. The fibers are very short and need to be spun like cotton by making punis or blending the neps with other fibers for a textured effect.

Because of the nature
of the very short fibers going in all different directions there is very little luster. The yarns look more like cotton than other silk yarns and are not as strong as most silk yarns.

So, what about luster?

In the book *A Silk Worker’s Notebook* (Kolander, 1985), Kolander makes the case that less twist creates more luster and a softer hand and drape of the yarns. She states that with less twist, the fibers stay more in line and create luster. High twist breaks up the luster by bending the reflected light.

Sparkle is another factor in the discussion of luster. Sparkles are created wherever light hits the fiber at turns or inconsistencies; light strikes the minute surfaces created by the bends and crinkles, and is reflected back as though each surface were a little mirror. These bends create a small prismatic, rainbow effect, most noticeable in sunlight (Kolander, 1985).

In the book *The Practical Spinners Guide to Silk* (Lamb, 2014, p.72) Lamb states, “We can enhance the luster (of silk) by putting tighter twist in the yarn”. In my research I found this not to be an accurate statement. In comparing lower twist versus higher twist in the same fibers I found the lower twist yarns to be more lustrous.
Kolander and Lamb seem to have opposing views of the matter of the effects of twist on luster. They are not the first experts to disagree on this subject. Hopefully this test will settle this question.

The test

I tried very hard to treat all samples exactly the same. The two exceptions were the reeled silk and the noil that had to be made into punis to spin. All samples were spun Z and plied S to create two-ply yarns. To finish the yarns they were wrapped into skeins, dipped in very warm water and hung to dry. The samples had to be wrapped on weaving cards to accommodate the testing machines. Twist per inch was calculated before the skeins were wrapped on the cards for a more accurate measure.

For this study the samples were spun worsted using ratios of 6:1 and 17:1 on a Lendrum wheel. They were then wrapped on cards and sent to a testing facility in Kansas City, Missouri. Samples were tested in a commercial gloss meter that measures the reflective light on paints, inks and other non-metallic surfaces.

I tested the samples using a LUX photo meter that measures the luminance of light on any given surface. This type of light meter is often used by photographers to determine the reflective light and how to adjust the camera lens to take the best possible picture without glare or reflection.
I set up a light source using a small LED light on one side and the photo meter on the opposing side with a 90-degree angle where the sample was to be placed. I tried to make the sources as stable as possible during testing. With all other light sources turned off I measured the samples one at a time, trying to place the samples in the exact same space and direction in each test. In testing with both machines the higher the number the more reflected light occurs.

Photo 12. The test using the photo meter was conducted using a small LED lamp and the Lux meter set where the light and the beam from the light meter were at 90 degrees each from the silk sample. Photo by P. E. Duncan
Test results

The following chart is the testing results of the study of luster versus twist in silk.

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<thead>
<tr>
<th>Type of Silk (Breed)</th>
<th>Preparation</th>
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<th>Twist Per Inch</th>
<th>Gloss Meter</th>
<th>Light Meter</th>
<th>Cost/Gram</th>
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Conclusion

In analyzing the numbers produced from the testing of the samples it is obvious that the shiniest forms of silk had the higher numbers on the reflective measuring meters. The bombyx silks all tested higher than the tussah, muga and eri silks. The reeled bombyx was the highest tested on both testing devices. Bombyx top and brick ranked second and third respectively on the gloss meter. The bombyx brick and roving tested higher on the photo meter. When comparing the gloss meter and the LUX photo meter there were some questions on the accuracy of the numbers, especially on the photo meter. I feel it was a rather inexact measure as it was set up in my homemade testing facility and not a commercial laboratory. I trusted the commercial numbers more than my own. Still the results overwhelmingly showed that the less twist in the yarn the higher the luster in the silk samples.

The samples averaged 7.2 twists per inch (TPI) for the high twist versus 3.8 TPI for the low twist. It would be interesting to do another study comparing the more extreme twists of the silk yarns, say an average of 15-20 TPI compared to the 3-7 TPI.

When spinning the bombyx mori top, roving and throwsters fiber the one with the least luster was the throwsters fiber. It was also the more difficult to spin as the fibers were of short and long inconsistent lengths. It might have been easier to spin over the fold.
In my testing most of the samples reinforced my theory that less twist created more luster. There were two exceptions. The bombyx hankies and the tussah noil did not follow the trend. Several factors can affect luster in silk. Excess temperature and sericin not completely removed will make the yarns less shiny. The bombyx hankies were from my own processing. They may have been heated too high or not had all the sericin removed. With the noil, the sparkle of the tighter twist may have played a factor that came from spinning fibers that were placed in many directions in spinning. All other samples tested indicated that the less twist the more luster.

The cost comparison showed the bombyx roving to be the best buy for a nice amount of luster. There was a seven cent difference in the reeled and brick silks versus the roving. All three had nice luster and the roving would be a great silk to add to another fiber for a nice blend with lustrous qualities. To add nice luster to a wool blend no more than 50% silk should be used, however, if more luster is desired a 100% silk should be considered (McWilliams, 2014). All the silks except the reeled would be great blended with animal fibers to add luster.

Strength would be another reason to add long silk filaments to animal fibers such as wool to make the yarn so much stronger. Wonderful sock yarns can be created with the blend of silk and wool. Reeled and spun silk yarns have wonderful drape for knitted and woven garments. The warmth and moisture retention makes the silk very comfortable to wear next to the skin in undergarments as well as outer clothing.
Bibliography


http://digitalcommons.unl.edu/textiles_facpub/21


# Appendix B

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