In Depth Study Permission and License

By signing and submitting this agreement, I grant Olds College the non-exclusive license to archive and make accessible my Master Spinner Program In Depth Study in whole or in part in all forms of media now or hereafter known for educational, research, and scientific nonprofit uses during the full term of copyright. I retain all other ownership rights to the copyright including the right to use in future works (such as articles or books) all or part of my work.

I represent that the submission is my original work, and that I have the right to grant rights contained in this license. I also represent that my submission does not, to the best of my knowledge, infringe on anyone's copyright and that I have obtained written permission from the owner(s) of any third party copyrighted matter included in the work.

I understand that my In Depth Study will be placed in the Olds College's library for access to the public. I will understand that I will clearly be identified by name as the author of the submitted work and that Olds College will not make any alteration other than as allowed by this license to my submission.

Signed: [Signature]

Date: 7/11/19
Angora Blends for Luxury Knitting Yarn

Submitted to Olds College on April 4, 2014 by Sandy Hellebrand
Abstract

This study examines the potential of eight luxury fibers when blended with angora for use as luxury knitting yarn. It considers nine sample yarns with accompanying knitted swatches and it offers analysis of each. The samples form three distinct subgroups that I call the Long and Lush Group, the Soft and Sound Group, and the Exotic Group. I didn’t set out to study angora blends within subcategories; rather, I simply chose fibers commonly sought for their luxury qualities such as smoothness, softness, and luster. The natural result of the varying staple lengths of these luxury fibers is that the resulting yarn shared characteristics with those of like staple length. The Long and Lush Group was too inelastic for traditional knitting yarn and I recommend it for further study as weaving yarn. The Soft and Sound Group yarns have ready application to retail yarn and fiber shops. These often service novice spinners and knitters who want the tactile experience of working with luxury fibers, but still need more immediate gratification to stay motivated. The Exotic Group yarns have qualities that will keep the fine spinner/knitter busy for a long time and are worth the added practice and improved technique required to achieve them. Each blend makes a definite contribution to the creation of luxury fabric.
Table of Contents

Abstract ........................................................................................................... 2

Introduction .................................................................................................... 5

Materials and Methods .................................................................................. 8

Results ............................................................................................................ 24

100% Angora samples and analysis ................................................................. 24

50%/50% Angora/Merino samples and analysis ............................................. 25

20% Merino/40% angora/40% silk samples and analysis ............................... 26

20% Merino/40% Angora/40% Paco-Vicuña samples and analysis ................. 27

20% Merino/40% Angora/40% Yak Down samples and analysis .................... 28

20% Merino/40% Angora/40% Bison Down samples and analysis ............... 29

20% Merino/40% Angora/40% Qiviut samples and analysis ......................... 30

20% Merino/40% Angora/40% Camel Down samples and analysis ............... 31

20% Merino/40% Angora/40% Cashmere samples and analysis ................... 32

Conclusion .................................................................................................... 33
Introduction:

The purpose of this study is to examine angora in fiber blends to determine their combined potential in luxury knitting yarn. Luxury here is defined by the tactile traits of the yarn, including the traits experienced while the knitter is knitting with it. The yarn needs to have adequate volume and full round structure to fill in the stitch in a stockinette swatch. The tactile traits of the completed fabric knitted from the yarn are examined as well. In addition to these practical measures of the term “luxury”, there is an aspect of the word which also suggests extravagance, as if the luxurious thing is out of reach to most, or scarce or exotic.

The tactile traits of luxurious yarn include elasticity, softness, and smoothness. Loft and drape are also considered in the finished fabric. There is some tension between these desirable traits. The fine fibres with deeply lobed crimp like cashmere will offer beautiful loft, but will be less sleek and smooth. Silk will be smooth with lovely drape, but lack loft and elasticity.

Angora has especially consequential traits as they pertain to luxury knitting yarn. It has halo; it is soft; and it is relatively inelastic.

Halo is one of the defining traits of angora yarns. Traditionally, only mohair is associated with this unique trait to the extent that angora is among animals
raised for fiber. This exceptional quality in angora makes it more luxurious in the scarce or extravagant aspect of that term.

The halo affects the way we experience the softness as well. Softness is a major tactile trait for luxury yarn. The halo is created by guard hair that is slightly smoother and that has slightly more body than the other fibers. These guard hairs free themselves from the twist of the softer, more cohesive ones in the yarn. So when I touch the surface of a skein or a swatch, I feel the smooth surface of the fibers lying lengthwise under my hand as well as the loft created by the trapped air and by the crimp in the fiber, but I also feel the ends of the fiber that are sticking out free from those lengthwise fibers.

Despite these clear advantages, the relative inelasticity of angora fiber presents a significant technical problem. For a knitting yarn to be considered ideal, it must be elastic. Angora fiber has little elasticity on its own and because this study is for knitting yarn, that is a real limitation. Blending is an attempt to add elasticity without detriment to the luxury qualities of angora fiber. The given blending fiber also offers some luxury traits of its own to benefit the finished yarn and fabric.

The coats of all rabbits are comprised of four different fiber types. Angora wool is the expression of a mutation which allows the coat to grow longer than that of normal coated rabbits. Each of these fiber types has a distinct structure
and a purpose in the architecture of an insulating, water-shedding, protective coat.

Figure 1. Four Fiber Types. From Angora coat synchronization by Lesley Samson 2014, http://iagarb.com/understanding-the-differences-between-synchronized-and-non-synchronized-growth-of-angora-wool/
Materials and Methods

All of the blending of fibers was done by hand on cotton cards. I found that hand carding gave me the best control and that the key to preparing very fine fragile fibers is to card very slowly. I took 1.5 seconds per stroke. The silk blend was hand carded into sausages, but the rest of the samples were hand carded and rolled off into punis on a ½ inch dowel rod. All samples are three ply yarns.

The following samples were spun worsted style: 100% Angora, 50/50 Angora/Merino, Silk, Paco-Vicuña, and Cashmere. The worsted spinning I did in these samples involved a backward sliding motion. I don’t find any consensus on the names of various drafting techniques, so rather than name it, I’ll describe it. The fiber is drafted between my two hands while my fingers slide backward over the forming yarn the span of the 12 inch draft. The hand closest to the orifice never lets go to allow twist to form in the drafting zone. Twist forms between the orifice and that front hand.

I spun all of these worsted samples on a Schacht Sidekick spinning wheel and all but cashmere on the 6.25:1 ratio whorl. I spun the cashmere sample with the 9:1 ratio whorl.

All of my woolen samples are spun on a charkha to accommodate the very short blended fibers. The high ratio between the drive wheel and the spindle whorl of the charkha provides more twist per turn of the drive wheel than does a
standard flyer assembly wheel. This catches and holds the spun short fibers firmly in the finished yarn. I used a long draw that involved returning to a spun length of yarn to neutralize slubs as needed. I accomplished this by untwisting the slub slightly with my hands on either side of it and gently drafting it further apart to narrow the diameter of the slub and to even out the rate of twist across the length of yarn.

I originally planned to spin all samples woolen out of a desire to trap as much air as possible and give the finished yarn as much loft as I could. I also wanted to standardize the yarns to each other as much as possible, thinking it would make for more useful comparisons. I found, however, that loft was only one aspect of luxury yarn and that in some cases, by putting too much emphasis on that characteristic, I lost the inherent qualities of the blend best suited to be spun worsted. I also found that the goal itself was flawed; standardization in this way is unnecessary to the study of these blends. The blends become, in a sense, a new fiber and spinning with the technique that best suits any fiber is the only way to fully consider its potential.

Similarly, I wanted to standardize the Bradford count numbers and do all the calculations by the worsted system. (See Appendix A) My samples include several fibers and techniques; each with their own Bradford systems. So with a blend of silk, merino, and angora fiber spun worsted style, for example, one must
make the call between using the silk system, or the worsted system. For the purpose of a yarn count, is the angora more like silk? -- or is it more like wool? Is the fiber the first consideration in that decision or is the spinning technique the deciding factor? With those questions to grapple with, times nine samples, it made sense to me that an apples to apples regulation must yield more objectivity. I find, however, that like unto trying to standardize the spinning technique; it contributed too little and cost too much to proceed in this way. An accurate count is part of the identification of a yarn. In order to really consider the potential of a given fiber blend, the individual yarn must be identified by applying the count system most closely suited to it.

In addition to the Bradford count, I include a yards per pound measure among the data on each sample in the results section. I find considering the yards per pound in conjunction with the wraps per inch measure helpful in determining the best knitting needle size to start with when knitting the stockinette swatches. My own knitting tension is very average, neither loose nor tight, so charts on the matter are very useful to me. Indeed for these samples, my tension was the same that the chart suggests for each needle size I used. (See Appendix B: The Standard Yarn Weight System Handy Chart) The swatch samples are hand knit in stockinette stitch and lightly blocked. The needle sizes for each are noted with the sample analyses.
An understanding of the structure of an individual fiber is useful in understanding its properties en masse in yarn and fabric. Certainly it helps explain why the properties of blended fibers occur as they do.

Figure 2. Structures. From “Structures” by Hair Loss Talk (2011), http://www.hairlosstalk.us/structures.html

The outer covering of cells in an animal fiber is called the cuticle. Often these cuticle cells form scales. The main part of the fiber is called the cortex. Often there is what is known as medulla in the cortex. These are air cells. The way the cuticle cells are configured determines the luster of the fiber; large smooth scales reflect the light and create more luster. Smaller, rougher ones create a more matte finish. If the fiber has a more closed cuticle structure, it will feel smoother. If it is more open, it will feel more abrasive. (Breeling, 2008) If the cortex of the fiber has fewer air cells or smaller ones, it will be denser. If it has more or larger medulla it will be less dense or lighter.
Artist Ani Difranco sings about the nature of the union of two people with the following words:

I know there is strength
in the differences between us
and I know there is comfort
where we overlap

(YouTube, 2008)

Most of the beauty and utility of the fibers blended with angora in this study is the result of either the way the blending fiber's characteristics are so different from those of the angora fiber that they accentuate those appealing features, or the way the blending fiber's characteristics are so similar they bring continuity. The contrasting smooth sheen of silk highlights the soft halo of the angora because those textures are so different. The contrast improves the overall effect. The light, soft Paco-Vicuña fiber that has the same staple length as prime German angora and nearly the same micron count (8-13) as well mimics some of the traits of the angora fiber. These comparable traits mesh and merge and become indistinguishable. It is the interplay between these two types of positive interactions between the blended fibers that make the improved luxury outcome.
Angora

All of the angora used in this study is 100% prime German angora fiber (2.5 - 3 inches long). It is used directly from the shorn rabbit without washing or processing of any kind. It all comes from Desert Bloom Angora in Oak Hills, California. German angora wool has a higher micron count than English or French angora wool. The wool is still so fine that the difference isn’t distinguishable for most human fingertips, but the coarser fiber has the advantage of slightly more body. The guard hair has a very smooth surface, and all of the hairs that make up angora wool are very light. German angora wool grows continuously without molting or shedding, so it must be cut. Commercial producers shear every ninety days to protect the life and health of the rabbit as well as to maximize the productivity of the rabbit. The growth rate of the wool is fastest at the first part of the growth cycle and slows as it progresses from day 1 to day 90. Because of this, the more frequently the rabbit is sheared the more pounds of wool it will produce. Of course twice the weight of little snippets of fiber is not an improvement. Prime wool in the German Angora world, therefore, is 2.5 inches or longer. Seconds are 1-2.5 inches and thirds are under 1 inch, or soiled or matted fiber.

Sometimes angora is reported to be considered prime only if it is combed or plucked. This is because other breeds of angora have asynchronous coats.
They molt. They don’t grow continuously, so by definition fiber harvested from such a rabbit by shearing would be of varying lengths. Therefore, German fiber over 2.5 inches long is legitimately considered prime even though it has a cut edge.

The luxury traits of angora that I’ll be comparing and contrasting with the luxury traits of the blending fibers include that it is: soft, light and has halo. The word “halo” as a textile term has differences and similarities to the larger meaning of the word.

Halo Defined:

1 a circle of light that is shown in a religious painting, drawing, etc., around the head of a holy figure (such as an angel, saint, or god)

2 a circle of light appearing to surround the sun or moon and resulting from refraction or reflection of light by ice particles in the atmosphere

3 something resembling a halo: as
   a : a region of space surrounding a galaxy that is sparsely populated with luminous objects (as globular clusters) but is believed to contain a great deal of dark matter
   b : a differentiated zone surrounding a central zone or object
   c: an orthopedic device used to immobilize the head and neck (as to treat fracture of neck vertebrae) that consists of a metal band placed
around the head and fastened to the skull usually with metal pins and
that is attached by extensions to an inflexible vest — called also *halo*

*brace*

4 the aura of glory, veneration, or sentiment surrounding an idealized person or
thing

Synonyms: air, ambience or ambiance, aroma, atmosphere, climate, flavor, aura,
karma, mood, nimbus, note, odor, patina, smell, temper, vibration(s)

(Merriam-Webster, 2014)

I especially like “a differentiated zone surrounding a central zone or object.” In
the case of yarn which has halo, the halo is the space around the yarn where the
guard hair is protruding from the spun fibers. It creates an in between zone
around the yarn that has a cloud-like quality. It is translucent visually, and if there
is such thing as being translucent tactiley, it’s that too. It is there and yet not
there. In some circumstances, it effectively takes up space; filling up stitches and
not letting go if one tries to unravel. In others it behaves as if it is without body or
substance.

This soft, light, halo adorned sample was spun on a Schacht Sidekick
spinning wheel, using the smaller pulley of the standard whorl (6.25:1). I spun the
singles worsted style from punis at 10 treadles per 12 inch draft, and plied at 8
treadles per 12 inch draft.
Merino

All of the merino used in this study is Super 150’s merino combed top with a natural micron count of 15.5 and a staple length of three inches. This wool is naturally this fine; it is not a coarser merino stretched to 15.5 microns. It comes from Village Spinning and Weaving in Solvang, California. According to the shop ad, (Village..., 2014) many consider it one of the world’s most perfect fibers because it has all of the great properties of wool with the fineness of cashmere. I find it exceptional as well. It has the same staple length as the angora and very similar if not the same micron count as well. Its contributing, but contrasting qualities are that it is denser than the angora, offering a stabilizing effect. It also brings the much desired elasticity trait to the blend. It clings to itself and traps air in the finished yarn, making it fuller and more cohesive as well.

For this sample I used a Schacht Sidekick spinning wheel. I again used the 6.25:1 whorl and spun the punis worsted style 6 treadles per 12 inch draft and 4.5 treadles per draft in the ply.

Silk

I used A1 grade bombyx silk sliver with a staple length of 5-6 inches from Treenway Silks in Lakewood, Colorado. The comparable characteristics of the silk include its relative inelasticity and its light weight. While not a fiber characteristic per se, I was really struck with the brilliance of the natural white color of both the
silk and the angora. It’s striking that they could both, in their natural state, realize such a glistening, clean color. It doesn’t seem like anything earthly could be so white. The contrasting, but contributing traits include its luster, smooth texture, and its strength and stability.

I cut the silk staple in half before blending it by hand with the angora and the merino on cotton cards and rolling it into sausages. I then spun it worsted style on a Schacht Sidekick spinning wheel with the (6.25:1) whorl at 10 treadles per 12 inch draft in the singles and 7.5 treadles per 12 inch draft in the ply.

**Paco-Vicuña**

The Paco-Vicuña I used is mill carded roving 17-18 microns in natural mahogany from Switzer Land Farm in Estes Park, Colorado. Its comparable traits include staple length, micron count and lightness of weight. Its contrasting, but contributing qualities include deeper crimp, more density/stability and a cuticle surface on the individual fibers that is clingier than that of angora fiber.

This sample is spun worsted style on a Schacht Sidekick spinning wheel with the 6.25:1 whorl. It is spun from hand carded punis at 8 treadles per 12 inch draft in the singles and 6 treadles per 12 inch draft in the ply.
Yak Down

I used commercially cleaned and carded yak down roving for this sample. It came from Louet North America in Prescott, Ontario. According to Robson/Ekarius (2011), yak down can be short, shiny, and slippery or short, matte and crimp. This sample is of the latter type with a staple length of 1.25 inches. Its only relatively comparable trait with angora is fineness. Its contrasting, but contributing traits are its crimp, elasticity and density. This fiber has some contrasting traits that are also detrimental in the blend. These include a very open cuticle that is almost abrasive despite its fine micron count. It also has a very short staple length. The shortness itself doesn’t seem to be the problem; most very fine fibers are short, but there is stubbiness to it as if the fiber is too short for its diameter. Perhaps this too is just a function of the open cuticle.

According to Caroline Sommerfeld (2009), commercial yak down roving readily available in North America often has either an unfortunate amount of guard hair or is bleached or otherwise over processed. The fiber I accessed for this sample seems to be of consistent diameter, so I don’t suspect that it was poorly dehaired, but it is cream colored and this, combined with the very open cuticle, makes me wonder if it was a darker color in its natural state and bleached in processing. I cut the angora and merino fibers almost as short as the yak down for a more complete blend and for a more consistent yarn. The slippery angora
fibers can shed out unless the fibers are adequately twisted and all the same length. This is a consideration when the prime fiber is still 2.5 to 3 inches long. Certainly the physics of getting enough twist in the yarn to make it secure yet still make it pleasing at about a one inch length is challenging.

I spun the sample on a Babe Charkha Spindle Wheel (14:1) with the woolen technique described previously at 12 turns per 28 inch draft on the singles. I then plied the yarn on the Schacht at 15 treadles per 12 inch draft with the fast whorl (11:1). I found the resulting yarn to be too hard so I ran it back through the Schacht on the slow whorl (4:1) --untwisting the ply as fast as I could feed the yarn through the orifice. This improved the yarn, but I put it through again to see if I could soften it up more without hurting its integrity. I liked the results after the second untwisting pass through. Judith Mackenzie (2010a) says that woolen yarns get their structure from the ply, meaning when creating woolen yarns, one errs on the side of soft or low twist in the singles and on the side of sturdy or firm twist in the ply. Charkha-spun yarns are technically woolen, but in this case, it is much more secure to soundly twist the singles and soften the ply twist –especially in a three-ply yarn when a stable yarn is easy to achieve with far less than ¾ of the spinning twist in the ply. The angle of twist changed from 45° before the two runs through to untwist the ply to 21° after. The twists per inch went from 7 to 4 in the finished yarn.
Bison

The bison down is commercially cleaned and carded roving from Ancient Arts Fibre Crafts Calgary, Alberta. It has a staple length of .9 inches.

For this sample, I cut both the angora and the merino into thirds to achieve the length closest to that of the bison without wasting any fiber. As with the other exotics, I blended the fibres on hand cards and rolled them into punis. I spun the singles on a Babe Charkha Spindle Wheel (14:1) with the woolen technique previously described at 11 turns per 28 inch draft. I plied the yarn on the Schacht fast whorl (13:1) at 9 turns per 12 inch draft. Since the exotics are so similar, I wanted to see if I could back off the ply twist even more in favor of more softness without losing adequate strength. It worked, but I’m not sure why. The bison fiber feels much smoother than the yak down. According to Robson/Ekarius (2011), yak down and bison down both have the same expected range of diameters, but that range is notably wide; from 12-29 microns. Perhaps this bison sample is finer and so the ratio between the diameter and the length of the fiber changed the dynamics of the spinning. Or possibly its closed cuticle accounts for the difference, but this blend had more integrity with less twist in the singles.

The comparable traits bison down offers is that it is soft and light. It is even less dense than the angora. Its contrasting, but contributing quality is very deeply lobed crimp.
Qiviut

The Qiviut I used is commercially prepared roving from Celeigh Wool in Millet, Alberta. It has a staple length of 1.1 inches. For this sample also, I cut the angora in half and the merino into thirds to achieve the length closest to that of the qiviut without wasting any fiber. Qiviut is so special, I don’t know if I can talk about its traits in terms of which ones compare and contrast with the angora. It is very fine, as low as 10 microns in diameter when derived from carefully combed, carefully dehaired fiber from wild animals in cold climates. With that, any but the gentlest handling will cause some fibers to break under the stress of preparation. When an individual fiber snaps under too much tension, the ends snap back and curl up in tiny balls forming a nepp. I have never seen a commercial preparation of qiviut that wasn’t filled with the texture of tiny soft nepp balls. I took care while blending to card slowly (1.5 seconds/stroke) enough to minimize how much my own handling would add to this phenomenon. The crimp that would usually add elasticity to an angora blend lacked enough body relative to the angora fiber to really contribute in this way. Of course the merino helped, but the lack of body in the qiviut is still noticeable. I spun the singles on a Babe Charkha Spindle Wheel (14:1) at 15 turns per 28 inch draft. The yarn was plied on the Schacht (15:1) at 12 turns per 12 inch draft. The fineness of the blend really made it more appropriate to spin a very thin yarn, and the lack of body kept me from getting a
nice full yarn. The fullness problem is a result of lack of body in the fiber, not the fineness of the yarn, nevertheless adding plies to make it thicker might offset some of this concern.

**Camel Down**

I used commercially cleaned and carded camel down roving from Louet North America in Prescott, Ontario. It has a 1-2 inch staple length.

For this sample, I cut the angora staple in half and the merino staple in thirds. This achieved the closest similarity in staple lengths of the three fibers being blended without wasting any fiber. The angora, merino and camel down in this sample blended very nicely. The density of the camel fiber seems to be exactly between that of the other two. The smoothness of the cortical surface texture also seemed to lie exactly between them on the texture continuum: smoother than the surface of the merino, but not as smooth as the angora. I spun the singles on a Babe Charkha Spindle Wheel at 11 turns per 28 inch draft on the charka (14:1.) I plied the singles on the super high whorl (15:1) of the Schacht Sidekick spinning wheel at 6 treadles per 12 inch draft.

**Cashmere**

I used commercially prepared cashmere roving from Celeigh Wool in Millet, Alberta. This is the long stapled variety, about 2 inches in length. I blended it without cutting the angora or the merino. It was still shorter than these, but
the difference in length was less than if I had cut the longer ones in half. I therefore spun the singles on the Schacht Sidekick spinning wheel using the standard whorl (9:1) at 8 treadles per 12 inch draft and plied the yarn with the same whorl at 6 treadles per 12 inch draft. This cashmere is superb. The tight, closed cuticle offers smooth sheen despite its fine diameter. Likewise, the crimp and body that it offers the blend is extraordinary, especially when it is so very fine and soft. The smooth cortical surface of the cashmere fiber approaches that of the angora. Its deeply lobed crimp surpasses that of the merino. This blend is a singular luxury spinning triad.
Results

Angora

Blend 100%  Angle of Twist 21°  Count 2.4 worsted system

Preparation Hand carded punis Twist per inch 2.7  Yards/Pound 454

Spinning worsted style  Wraps per inch 9  Knitting needle size 5mm

100% angora fiber is relatively inelastic. The process of rolling it into punis and then adding twist while spinning it into yarn offers some elasticity, but not really enough for a luxury knitting yarn. Plying the singles into a 3-ply yarn adds extra twist tension between the singles twist and the ply twist giving the finished yarn more life and a bit more elasticity, but still not enough. The third ply does offer a nice full round shape to the yarn though. This, plus the signature halo, makes it full enough to fill out the knitted stitch nicely. According to my own 35 years experience canvassing shop owners and teachers of knitting in any capacity, most teaching occurs at the basic level. Many novice knitters find knitting on needles between 4.5mm and 5.5mm in diameter to be the most comfortable to their hands. The thickness of this yarn adds to the pleasure of knitting with it as does its softness and warmth. The fabric knitted from this yarn has only minimal drape. The halo effect of the yarn slightly obscures the stitch definition and gives the surface of the knitted swatch a more even appearance as
a result. It also makes the fabric visually and tactiley interesting. The relatively long staple length and third ply renders this fabric much less vulnerable to pilling and shedding and to abrasion.

**Merino**

**Blend** 50% angora/50% merino  
**Angle of Twist** 27°  
**Count** 2 worsted system  

**Preparation** hand carded punis  
**Twist per inch** 3  

**Spinning** worsted style  
**Wraps per inch** 7  

The 50/50 blend of angora with merino is a standing favorite for many. I admit the elasticity gained by the addition of the merino did not cost significantly in terms of loss of the characteristics of the smooth, soft, light angora. The loft that the fine merino added to the yarn improved its stitch-filling quality. It was certainly a pleasure to knit with on 6mm needles. I like the possibilities this blend offers, especially for bulkier yarns with lower twist and/or fewer plies. The stabilizing effect of the merino indirectly improves the yarn’s luxury qualities because with it, the stability of the blend affords lower twist in the singles and in the ply and thus softer yarn. Also, the merino cuts the warmth of the angora, allowing one to create bulky yarns without excessive warmth. This yarn may not excel with any particularly outstanding quality as a luxury knitting yarn, but it
meets the minimum standards and may be the most utilitarian of all the samples in this study.

**Silk**

**Blend** 40 silk/40 angora/20 merino  
**Angle of Twist** 33°  
**Count** 3 worsted system  
**Preparation** hand carded sausages  
**Twist per inch** 4  
**Yards per Pound** 614  
**Spinning** worsted style  
**Wraps per inch** 10  
**Knitting needle size** 4.5mm

The combination of silk and angora is absolutely exquisite. The smoothness and drape of the silk and the softness of the angora makes a fantastic luxury union. The halo in addition to this is like whipped cream on top.

Unfortunately, the merino drastically diminishes the effect of the angora/silk amalgamation. The blended fiber is lovely indeed; there is some interesting textural contrast between the soft matte look of the merino and angora against the striking sheen of the silk, but the resulting yarn and fabric suffer from the mix. The otherwise desirable features of each of the three fibers on their own seem to mute each other when combined. The drape of the fabric of this blend is superior to that of either angora on its own or the angora/merino combination, but this isn’t enough to compensate for the way the silk reduces the stitch filling quality of the yarn or the way the resulting fabric is too unyielding. Even with the
merino, it doesn’t have enough elasticity to keep from stretching in knitted fabric. Perhaps it could be more useful if the ratios of the blend were changed; but as it is, this blend falls short as a luxury knitting yarn.

**Paco-Vicuña**

**Blend** 40 paco-vicuña/40 a./20 m.  **Angle of Twist** 39°  **Count** 3 worsted system  
**Preparation** hand carded punis  **Twist per inch** 3.7  **Yards per Pound** 568  
**Spinning** worsted style  **Wraps per inch** 9  **Knitting needle size** 4.5mm

This yarn is pleasingly full and elastic. It is soft and lofty with just enough body to give the fabric a resilient hand. The halo from the angora is slightly muted by the Paco-Vicuña and the merino in a way that makes it more subtle and very appealing. The yarn is very pleasant to knit with and at this thickness, very comfortable on 4.5 mm needles. The staple length of each contributing fiber is very close to three inches which makes the yarn very stable and keeps the angora well-anchored and protected from shedding. The knitted fabric has a very flat, matte, velvety surface, with enough substance to hold its shape, yet very light and comfortable. This is an especially successful fiber blend for luxury knitting yarn.
Yak Down

Blend 40 yak down/40 angora/20 merino  A of T 21°  Count 9 woolen system

Preparation hand carded punis  Twist per inch 4  Yards per Pound 908

Spinning woolen style  Wraps per inch 12  Knitting needle size 3.75mm

The yak down blend is the most ordinary of the exotics in this study, perhaps due to some of the fiber issues described previously. If I didn’t have bison down or camel down to compare it to, I might only focus on the even texture in the yarn facilitated by the merging of these three fibers. The yarn is lofty and light and with enough body to hold its shape. It has pleasing volume, within its fine diameter. The unfortunate open cuticle which reduces the soft smooth texture seems to have the accompanying positive trait of adding firm stability. Since I do have bison and camel down to compare it to, however, it is clear that the stability is not worth the smooth, pliable consistency lost to the brittleness of this yak down component in the blend. The final swatch is certainly light and charming with resilient hand. It is possible that this blend would be improved with yak down fiber that doesn’t have the open cuticle problem, but I can only evaluate what’s in front of me. As it is, this blend has produced what can only barely qualify as a luxury knitting yarn.
### Bison Down

**Blend** 40 bison /40 angora/20 merino  
**A of T** 21°  
**Count** 10 woolen system

**Preparation** hand carded punis  
**Twist per inch**.5  
**Yards per Pound** 1041

**Spinning** woolen style  
**Wraps per inch** 12  
**Knitting needle size** 3.75

This yarn is soft, smooth, light, lofty, and relatively rare and sought after. It is practically perfect in every way (Stevenson, 1964). It meets every definition of luxury and every standard for ideal knitting yarn. The bison doesn’t quiet the halo of the angora so much as make it more refined and understated. The padded volume of the yarn amply fills the knitted stitches. The fabric is light and soft. It has little drape, but surprising resilience for how soft it is. The most successful aspects of this blend is its elasticity, fullness and bounce and the fact that these fine traits don’t cost significantly in other categories of what makes luxury yarn desirable. I consider it a very successful luxury knitting yarn blend indeed.
Qiviut

Blend  40 qiviut/40 angora/20 merino   AofT 21°  Count 17 woolen system
Preparation hand carded punis   Twist per inch 6   Yards per Pound 1747
Spinning woolen style  Wraps per inch 16   Knitting needle size 2.75mm

This yarn is very light. The fine, even tender, quality of the qiviut combines with the halo of the angora to create an ethereal quality. The nepps that are noticeable in the fiber are greatly reduced in the yarn and even more in the fabric. I expect the qiviut fiber is so soft that even the nepps are submissive enough to smooth out in the spinning. The yarn lacks fullness and the process of knitting the very fine fabric on fine needles is less pleasurable than the fabric product. The fabric however is truly unique. It creates the impression of having mass so low for its volume that it defies physics. It is light and soft with minimal buoyancy and almost no drape. This blend has the most unique qualities in this study.
Camel Down

Blend  40 camel down/40 a./20 m.  Angle of Twist 39°  Count 14 woolen system
Preparation hand carded punis  Twist per inch 5  Yards per Pound 1377
Spinning  woolen style  Wraps per inch 16  Knitting needle size 2.75mm

This yarn is utterly delightful. It has less volume than that of yak or bison
down, but the smoothness it brings to the softness of the yarn more than makes
up for it. This yarn is beatific; it has little crush resistance, but remains wholly
stable. The physics involved in using a quill wheel rather than a flyer wheel means
less drag on the yarn as it’s being formed. Because there is no flyer assembly to
pull the yarn in and wind it on the bobbin, I am in charge of how much tension is
on the yarn as it’s being formed and then as it’s wound on the bobbin. In the case
of this yarn, this phenomenon gave just the right amount of air and loft without
interfering with the smooth drape. It has the best drape of all the exotics in this
study. The fabric is light and smooth and soft. This is a very successful blend for
luxury knitting yarn.
Cashmere

Blend  40 cashmere/40 a./20m.  Angle of Twist 33°  Count 6 woolen system
Preparation hand carded punis  Twist per inch 3  Yards per Pound 591
Spinning worsted style  Wraps per inch 10  Knitting needle size 4.5mm

Like the bison down blend yarn, this cashmere blend yarn excels in every category that defines a luxury knitting yarn. It has considerable luster for a yarn that is so soft. It has remarkable loft for a yarn that is so smooth. It is luscious to knit and comfortable on 4.5mm needles. The fabric has outstanding drape for a yarn that is so light. I consider this to be the most successful blend for luxury knitting yarn in this study because it excels so absolutely in every category that no one of them especially stands out.
Conclusion

These 9 blends of luxury fibers make yarns and fabrics that fall into three distinct subgroups. The staple length of the blending fiber is the most significant predictor of a given blend’s allocation to a subgroup, but there are other shared traits within subgroups as well.

I call the first group the Long and Lush Group. It includes the 100% angora sample and the silk sample. The lack of elasticity of these yarns renders them inferior as knitting yarns. Knitters use inelastic knitting yarns all the time and apply stratagem to minimize the accompanying problems of so doing. Knitting with a tighter gauge, employing special laundering techniques and taking extra measures to stabilize strained areas of knitted garments like necklines and shoulder seams are among these. Nevertheless, elasticity is essential to ideal knitting yarn and the yarn from a blend made specifically for luxury knitting can hardly be suitable if it’s missing an essential element.

With that said, these findings can be applied to further study of angora as a luxury weaving yarn. This study might include angora blended with just one other fiber at a time and without wool or any elastic inputs. Some of these might be silk, mohair, some extruded fibres like corn silk and soy silk and maybe bleached flax or hemp. I’d like to see some experimentation within each of these,
maybe have three samples each: one 30/70, one 50/50, and one 70/30. I see stimulating opportunities here.

I call the next group the Soft and Sound Group. This group includes the merino sample, the paco-vicuña sample, and the cashmere sample. I consider this group to be immediately useful. These are blends I would have the mill make for me to sell. They are accessible luxury blends that a beginning spinner could have pleasurable success with right away, and they lend themselves to thicker yarns that knit up fast for the ultimate in instant gratification. Cashmere is usually considered an exotic fiber. (MacKenzie, 2010b) It is included in this group for the purposes of this study because my sample has a longer staple length causing it to possess all of the qualities that define this group.

I call the remaining group the Exotic Group. It includes the yak sample, bison sample, camel sample and the qiviut sample. The Exotic Group interests me for its potential in very fine knitting as well as lace work. The short fibres lend themselves to fine spinning and knitting for light, lovely, comfortable, beautiful garments. Often hairy yarns with halo aren’t recommended for lace fabric because the halo obscures the holes, but blended in this way, they have real potential. I like the added textural interest of the halo over the texture of the lace.
When I arrived at the eight fibers I wanted to blend with angora for this study, I considered each individually. I didn’t predict that through the course of examining them that they would combine into three subgroups in this way, and thus point me in three definite directions for application and further research. I look forward to all future angora explorations and discoveries.
Bibliography


Spinderella’s Fiber Mill. (2013). *The standard yarn weight system handy chart*

Retrieved March 4, 2014, from


Stevenson, R. (Director) (1964). *Mary poppins* [Theater].


http://www.alpacaland.com/Spinning.htm


Village Spinning and Weaving. (2014). *Merino 150’s combed wool top* retrieved March 4, 2014, from


http://www.merriam-webster.com/dictionary/halo

### Bradford Count Calculation Table

<table>
<thead>
<tr>
<th>System</th>
<th>Number of yards</th>
<th>Weight</th>
<th>One pound (16 oz or 454 grams)</th>
<th>Number of Plies</th>
<th>Fixed Weight System (FWS)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worsted</td>
<td>÷</td>
<td>x</td>
<td>x</td>
<td>÷ 560</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Woolen</td>
<td>÷</td>
<td>x</td>
<td>x</td>
<td>÷ 300</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td>÷</td>
<td>x</td>
<td>x</td>
<td>÷ 840</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Linen</td>
<td>÷</td>
<td>x</td>
<td>x</td>
<td>÷ 300</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Silk</td>
<td>÷</td>
<td>x</td>
<td>x</td>
<td>÷ 840</td>
<td>=</td>
<td></td>
</tr>
</tbody>
</table>
Appendix B

The Standard Yarn Weight System Handy Chart

©- Compliments of Spinderella’s Fiber Mill

Categories of yarn, wraps per inch or WPI, gauge ranges, and recommended needle and hook sizes will give you general starting place.

Remember: Many manufacturers have their own standard weights of yarn.

Please note: that a gauge range is difficult to determine, and following the gauge stated in your pattern is the best way to insure success. For instance- Lynn almost always goes down 2 needle sizes from the suggested in the pattern. She is a loose knitter and knows 2 sizes smaller is a good starting point. Learning to gauge saves time and head aches.

A Side note: Steel crochet hooks are sized differently from regular crochet hooks—the higher the number, the smaller the hook, which is the reverse of regular hook sizes.

**Chunky** Is heavier than Bulky, Can be roving

- Knitting = 6 - 11 stitches per 4 inches on an 8 mm or 11 US needle or larger
- Crochet = 5 - 9 stitches per 4 inches on an 9 mm or M13 US needle or larger

**Bulky Weight:** Less than 8 wraps per inch - 400 to 700 yards per pound

- Knitting = 12 - 15 stitches per 4 inches on an 5.5 - 8 mm or 9 - 11 US needle
Crochet = 8 - 11 stitches per 4 inches on an 6.5— 9 mm or K-10 1/2 to M-13 US needle

**Aran Weight:** 6 to 10 wraps per inch - 700 to 1000 yards per pound

Knitting = 16-20 stitches per 4 inches on an 4.5 - 5.5 mm or 7 - 9 US needle

Crochet = 11 - 14 stitches per 4 inches on an 5.5 - 6.5 mm or I-9 to K-10 1/2 US needle

**Worsted Weight:** 10 to 12 wraps per inch - 900 to 1100 yards per pound;

Knitting = 16 - 20 stitches per 4 inches on an 4.5 - 5.5 mm or 7 - 9 US needle

Crochet = 12 - 17 stitches per 4 inches on an 5.5 - 6.5 mm or I-9 to K-10 1/2 US needle

**Double Knitting (DK):** 12 to 18 wraps per inch - 1000 to 1400 yards per pound;

Knitting = 21 - 24 stitches per 4 inches on an 3.75 - 4.5 mm or 5 - 7 US needle

Crochet = 11 - 14 stitches per 4 inches on an 4.5 - 5.5 mm or 7 to I - 9 US needle

**Sport Weight:** 18 to 24 wraps per inch - 1300 to 1800 yards per pound

Knitting = 23 - 26 stitches per 4 inches on an 3.25 - 3.75 mm or 3 - 5 US needle
Crochet = 16 - 20 stitches per 4 inches on an 3.5 - 4.5 mm or E4 - 7 US needle

Fingering: 24 to 30 wraps per inch - 1800 to 2400 yards per pound

Knitting = 27 - 32 stitches per 4 inches on an 2.25 - 3.25 mm or 1 - 3 US needle

Crochet = 21 - 32 stitches per 4 inches on an 2.25 - 3.5 mm or B1- E4 US needle

Baby: 30 to 36 wraps per inch - 2400 to 3000 yards per pound;

Lace Weight: 36 to 40 wraps per inch - 3000 to 6000 yards per pound

Lace weight yarns are most often knitted or crocheted on larger needles/hooks to create the lacy patterns.

Cobweb: 40 or more wraps per inch - 6000 or more yards per pound;

Zephyr weight yarn is finer than Cobweb

WPI: Take a ruler and wrap your yarn around for 2”. Divide that number by 2.

This will give you a wraps per inch number. DO NOT wrap too tightly – or overlap the yarn.
Appendix D

Angora Rabbit (Wee Middlebranch Farm, 2010)

Guard hair - notice the v shaped structures on the outside of the hair shaft. I think that this is one reason English Angora is rather silky to the touch and is slippery when spinning. The scales appear to be aligned in such a way as to prevent them from becoming intertwined and matting. However, I know from experience that the under wool does matt.
The above three pictures show very nicely the gas pockets inside the hair shaft.

The top first two light micrographs show a guard hair. Structurally it looks like
four underwool strands which have grown together to make a fiber about four
times larger than the underwool. This is somewhat difficult to identify as one can
focus through the hair shaft as one could when using an actual microscope.
Appendix E

Glossary

Amalgamation: the action, process, or result of combining or uniting

Beatific: conferring a state of celestial happiness

Body: fullness or thickness of hair "designed to add body to limp and straight hair" synonyms fullness, thickness, substance, bounce, lift, shape

Bombyx: refers both to a variety of silk worm, and to the silk cultivated

Bouncy: when describing yarn it means voluminous and elastic

Bradford count: method of quantifying the thickness and density of yarn

Bulky: taking up much space, typically inconveniently; large and unwieldy

Cellulose Fiber: fiber from plants including cotton, hemp, flax, ramie etc.

Cohesion: the action or fact of forming a united whole

Cortex: the inside of an animal fiber. It makes up 90% of the fiber

Cuticle: the outermost layer of cells on an animal fiber

Density: as if relates to textile fibers, the density is solidity of the cortex of an animal fiber

Draft: to gently pull fibers between two hands while spinning to allow the correct number of fibers thru at a time to achieve the desired thickness of yarn

Dynamics: the branch of mechanics concerned with the motion of bodies under the action of forces
Ethereal: extremely delicate and light in a way that seems too perfect for this world

Excessive: more than is necessary, normal, or desirable; immoderate

Exotics: animal fibers that come from less typical sources, the most typical source being sheep's wool--some exotic fibers include those which come from alpaca, angora, musk ox, yak, cashmere goats, angora goats (called mohair), camel, and bison

Fiber: a slender and greatly elongated substance capable of being spun into yarn

Flyer wheel: The type of spinning wheel that allows the foot pedal action to put twist in the yarn, pull the yarn into the orifice, and wind it onto a bobbin in one motion without the spinner needing to stop or change the direction of her motion and while keeping both of her hands free

Fullness: 1- the state of being filled to capacity. 2 - the state of being complete or whole. 3 - the state of being filled out so as to produce a rounded shape

Synonyms: plumpness, roundedness, roundness

Guard Hair: long, coarse hair forming an animal's outer fur

Halo:

1 a circle of light that is shown in a religious painting, drawing, etc., around the head of a holy figure (such as an angel, saint, or god)
2 a circle of light appearing to surround the sun or moon and resulting from refraction or reflection of light by ice particles in the atmosphere

3 something resembling a halo: as
   a: a region of space surrounding a galaxy that is sparsely populated with luminous objects (as globular clusters) but is believed to contain a great deal of dark matter
   b: a differentiated zone surrounding a central zone or object
   c: an orthopedic device used to immobilize the head and neck (as to treat fracture of neck vertebrae

4 the aura of glory, veneration, or sentiment surrounding an idealized person or thing

Synonyms: air, ambience or ambiance, aroma, atmosphere, climate, flavor, aura, karma, mood, nimbus, note, odor, patina, smell, temper, vibration(s)

Hand: as in Fabric Hand: What humans sensorially assesses from the mechanical properties of a fabric

Interesting: arousing curiosity or interest; holding or catching the attention synonyms absorbing, engrossing, fascinating, riveting, gripping, compelling, compulsive, captivating, engaging, enthralling; appealing, attractive; amusing, entertaining, stimulating, thought-provoking, diverting, intriguing; bloggable
Life: as in yarn that has life: Often this refers to some kind of movement either in the literal or abstract sense. The artistic definition of “movement” (as in movement-of-line-in-composition) also counts. A yarn that is slightly over spun or under plied or unbalanced in either direction has more life than one that is absolutely inactive

Knitters: those who make fabrics by intertwining yarn or thread

Light: 1- relatively low in density, amount, or intensity. 2- gentle or delicate.

Loft: 1 - the resiliency of fabric or yarn, esp. wool. 2-the thickness of a fabric or of insulation used in a garment, as a down-filled jacket

Luscious: 1- highly pleasing to the taste or smell 2 - richly satisfying to the senses or the mind: the luscious style of his poetry 3 - richly adorned; luxurious: luscious furnishings 4 - arousing physical, or sexual, desire; voluptuous: a luscious figure.

5 - sweet to excess; cloying

Luster: amount of light reflected from fiber either from the structure of the fiber or from how it is spun to bring out that sheen

Luxury: a pleasure out of the ordinary allowed to oneself

Mass: the quantity of matter as determined from its weight or from Newton's second law of motion

Muted: of low intensity and reduced volume; softened
**Nepp:** a small ball of fuzz which can be left in, or added to a smooth roving of wool which will form a bump when spun. Nepps can be the result of poor fiber preparation, or added on purpose to make a tweed style yarn

**Novice Knitter:** a person who is new to knitting; a beginner

**Phenomenon:** 1-a fact, occurrence, or circumstance observed or observable 2-something that is impressive or extraordinary

**Physics:** the science that deals with matter, energy, motion, and force

**Ply:** one of the strands twisted together to make yarn or rope or thread; often used in combination; "three-ply cord"; "four-ply yarn." ν the act of twisting the strands together

**Quill wheel:** - Or spindle wheel: a spindle mounted on a frame with a wheel and axel connected by a drive band to a larger wheel used to turn the spindle

**Resilient:** 1 - springing back; rebounding 2- returning to the original form or position after being bent, compressed, or stretched -- Synonym: buoyant

**Roving:** a loose assemblage of fibers drawn or rubbed into a single strand, usually thicker than a sliver

**Sausage:** rolled section of carded wool fiber with parallel alignment in preparation for worsted spinning

**Sheen:** luster; brightness; radiance; shining, beautiful
**Singles**: one strand of spun yarn

**Skein**: coils of yarn

**Sliver**: a strand of loose, untwisted fibers produced in carding

**Slub**: a slight irregularity in yarn produced either accidentally or purposely by knotting or twisting or by including uneven lengths of fiber in spinning

**Soft**: yielding readily to touch or pressure; easily penetrated, divided, or changed in shape; not hard or stiff

**Sound**: 1 - in good condition; not damaged, injured. 2 - reliable

**Spinner**: a person occupied in making thread by spinning

**Stabilizing**: to make or cause to become unlikely to change, fail, or decline

**Staple**: the fiber of cotton or wool considered with regard to its length and degree of fineness

**Striking**: attracting attention by reason of being unusual, extreme, or prominent

**Swatch**: a small sample of fabric intended to demonstrate the look of a larger piece

**Tender**: as in tender wool or a tender fleece: the condition of wool or other animal fiber defined by weakness and easy breakage

**Texture**: the feel, appearance, or consistency of a surface or a substance

**Tactile**: of or connected with the sense of touch
Triad: 1 - a group or set of three connected people or things "The triad of medication, diet, and exercise are necessary in diabetes care" 2 - a chord of three musical notes, consisting of a given note with the third and fifth above it

Visual: of or relating to seeing or sight

Volume: the amount of space that a substance or object occupies, or that is enclosed within a container, especially when great

Warmth: of clothes or coverings made of a material that helps the body to retain heat; suitable for cold weather

Whipped cream: cream that has been beaten until light and fluffy often added to the top of a desert. In the case of this study used as a metaphor to add sensuality to the understanding of the effect angora's halo has on a luxury knitting yarn.

Woolen style: a style of spinning fiber into yarn that traps the maximum amount of air within the fibers by allowing twist to form in the drafting zone for the purpose of constructing comfortable and insulating fabrics

Worsted style: a style of spinning fiber into yarn without allowing twist to enter the drafting zone that aims to eliminate as much air, fuzz, lumps, and inconsistencies of all kinds for the purpose of constructing smooth, strong, yarn or thread
**Wraps per inch**: a measure which helps to quantify the thickness of yarn for the purpose of determining knitting gauge or weaving sett

**Yards per pound**: a measure which helps quantify the thickness and density of yarn and thread.
Appendix F

Abbreviations:

A of T- Angle of twist

WPI - Wraps per inch

TPI- Twists per inch

50/50 or any series of two or three numbers that add up to 100 and are separated by a forward slash - a representation of the percent of each respective fiber in a blend

a. - angora

m. - merino