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Signed: Carol A. Densmore

Date: July 17, 2019
Crossbreeding purebred sheep:
How a Bluefaced Leicester sire changes wool for handspinning

Submitted to Olds College on May 26, 2014

by

Carol A. Densmore
Dedication

I dedicate this in-depth study and all my work in the Master Spinner Program to my family and friends, especially:

To **Steve**, my husband, for your endless love and encouragement. Thank you for the support and sacrifices you made while I worked through this program. You are the true 24/7, 365 day shepherd.

To **Rachel and Oliver**, my children, who have grown into wonderful people. Without you I would not be where I am today. You are my rock in a sea of crashing waves.

To **Jane**, my beautiful late sister, whose art and weaving has truly inspired me. Your love resonates in every fiber of my projects. It was your world view and incredible creative influence that introduced me to the world of fiber art.

To **Joe and Rose**, my late parents, who instilled the importance of hard work and higher education. Your support in life and now in spirit has been the foundation of my victories.

To my many **fellow fiber artists and friends**. I have learned so much over the years while spinning, dyeing, knitting, and weaving together. Your friendships make my life a wonderful experience.

And finally, to my **sheep**, whose wool makes the world go round!
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Summary
This in-depth study examines wool variations through crossbreeding purebred sheep.

The aim of the study is to determine if the desirable qualities of Bluefaced Leicester wool carries from a Bluefaced Leicester sire to its progeny. In addition to crossbreeding purebred sheep, a pair of crossbred sheep were bred together to determine what wool characteristics pass on to the next generation.

In this report, I give a historical view of crossbreeding longwool sheep breeds, then I explain the process from the initial breeding groups, shearing the sheep, hand processing the wool, spinning the combed wool, hand blending purebred wool, knitting swatches, and dyeing the wool. All samples show that breeding a Bluefaced Leicester ram with a Lincoln and Romney ewe does produce wool that may be desirable to craftspeople and handspinners. The lambs born in the crossbreeding group produced wool that retains the characteristics from the sire and dam.

The results show that crossbred wool consists of qualities that may benefit handspinners or fiber artists when they are looking for wool to complete items for functional use or for artwork. If purebred wool is not available, crossbred wool could be used in its place and would possibly have additional qualities that may add to the piece. Further study in crossbreeding other sheep breeds may show different results. With the wide variety of sheep breeds available, crossbreeding is a valid way of expanding the wool available to handspinners in the fiber art community.
Introduction

Purpose
This in-depth study evaluates crossbreeding effects on wool traits in three long wool sheep breeds. A Bluefaced Leicester (BFL) ram was used as the sire for crossbreeding Lincoln and Romney ewes to determine if the crossbred progeny produce wool with measurable differences that would benefit handspinners.

Scope
The project group consisted of a BFL ram, Lincoln and Romney ewes, and crossbred sheep from my flock of 35 sheep (purebreds and crossbreds). Breeding different purebred sheep to produce crossbred offspring was the main focus of this study. To further evaluate how crossbreeding maintains wool traits through subsequent breeding, I also bred a first generation BFL/Lincoln ram to a first generation BFL/Lincoln ewe which produced a second generation lamb whose wool was evaluated and included in the study. The in-depth study includes the following nine sheep:

<table>
<thead>
<tr>
<th>Ram (Sire)</th>
<th>Ewe (Dam)</th>
<th>2013 Progeny (Offspring)</th>
</tr>
</thead>
<tbody>
<tr>
<td>581-Clyde</td>
<td>224-Haley</td>
<td>124-Hannibal (F1 BFL x Lincoln)</td>
</tr>
<tr>
<td>(BFL)</td>
<td>(Lincoln)</td>
<td>125-Halo (F1 BFL x Lincoln)</td>
</tr>
<tr>
<td></td>
<td>437-JonEllen</td>
<td>130-Juno (F1 BFL x Romney)</td>
</tr>
<tr>
<td></td>
<td>(Romney)</td>
<td></td>
</tr>
<tr>
<td>111-W</td>
<td>014-Harmony</td>
<td>129-Harper (F2 - BFL x Lincoln)</td>
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<tr>
<td>(F1 - BFL x Lincoln)</td>
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</table>

F1 = first generation  F2 = second generation

Once sheared the wool was hand processed from raw fleece to finished yarn. Sample skeins were spun to evaluate how purebred, hand blended and crossbred skeins compared in various qualities desirable to handspinners. Dyed samples were assessed to
determine how the various skeins take dye. Knitted swatches were also included to
evaluate the handle and stitch definition of the handspun yarn.

The limiting factors in this study included length of time, number of sheep used, and the
wool comparison. The ideal length of time to evaluate the wool from each sheep would
cover the lamb-to-adult age range so that comparisons in the wool could be made as
the sheep ages. I compared the wool from the first shearing of the offspring to its
parents, which are adult sheep; therefore, an age-to-age comparison was not possible.
Although not ideal, the comparison I used did give an initial starting point in terms of
fiber diameter, handle, and rate of growth in the wool from the offspring lambs.
However, the comparison of the wool from the second generation offspring was a closer
comparison in age. I did preserve the fleece from the first shearing in 2011 and 2012 of
the first generation sire and dam to use in the study. Finally, using nine sheep gave me
an introduction to comparing wool from crossbred sheep; however, more sheep and
more data to compare would lead to stronger conclusions and possibly a variety of
recommendations. Due to space limitations on my farm and the number of ewes and
rams on hand in 2012 for breeding, the small group of nine sheep was the maximum
number available for this study.

Background
Crossbreeding sheep to develop hybrid wool for handspinning could be used in place of
the purebred wool from the sheep used in the initial crossing. Crossbred wool typically
Crossbreeding is a well-accepted practice in the sheep industry and is used to take advantage of the strong and unique characteristics of two or more breeds. According to Mathis and Ross (2000) wool traits in sheep are the easiest to improve. Wool traits such as fleece weight, fiber diameter, and length of staple are highly heritable and easy to measure. Crossbreeding is used as a tool to quickly improve wool production and wool quality. Breeds such as Columbia, Montadale, Corriedale, Cormo, Coopworth, Targhee, and Polwarth are well established composite breeds—a new breed created by crossbreeding two or more existing breeds then treating the new crossbred as a purebred. The wool from these composite breeds has its own individual characteristics and merit and has been used and enjoyed by handspinners for many years.

Today crossbreeding sheep is done for a specific purpose. Livestock producers continually seek economical programs and systems that give them the best return. Thomas (2006) noted four characteristics of a good crossbreeding system: ease of management, utilizing strong points of different breeds or complementarity, optimizing hybrid vigor (stronger and more productive), and producing a uniform product. This in-depth study evaluates the results of a complementarity crossbreeding system by exploring the wool qualities of two different breeds and its offspring as well as a second generation crossbred ram and ewe and its offspring.
**Bluefaced Leicester (BFL)**
I chose to use a Bluefaced Leicester ram in the study because of its well-established crossing ability. "The vast majority of the genetic improvements in the flock come through the purchased rams" (Thomas, 2006, p. 2). The Bluefaced Leicester breed is a descendent of the famous livestock breeder Robert Bakewell's improved Dishley Leicester near Hexham in Northumberland, England in the 1700s. The BFL ram eventually replaced the Teeswater breed as the premier crossing sire. In the late 1800s and early 1900s the breed began to evolve into the sheep we see today on farms and in the show ring. Classified as a longwool breed, it has the finest and softest fleece of the longwool breeds with a staple length of three to six inches, an approximate fleece weight of two to five pounds, and a fiber diameter of 24 – 28 microns.

According to the Bluefaced Leicester Union of North America the BFL ram is used as a crossing sire because of its strong ability to pass on high quality traits. In England the BFL ram is bred to produce prolific crossbred ewes from native British hill breeds such as the Scottish Blackface, Swaledale, Welsh Mountain, Clun Forest, and Shetland. Ewes produced by this cross are called mules. These mules inherit the vigor and hardiness of their dam with the added benefit of improved wool production, increased body size, higher prolificacy, and early maturity from their Bluefaced Leicester sire.

**Lincoln Longwool**
The Lincoln Longwool is one of the world's largest breeds of sheep. Its fleece is heavy, long-stapled, and quite lustrous. Lincolns originated in a fertile area on the east coast of England, bordering the North Sea and the county of Lincolnshire. The National Lincoln
Breeders Association explains that when Robert Bakewell began improving his livestock in the 1700s he used the Lincoln as part of his breeding program. The *old* Lincoln was bred with other native stock while Bakewell was developing his *new* Leicester, the Dishley Leicester. Through selective crossbreeding the Dishley Leicester, which was the predecessor of the Bluefaced Leicester, was then used by sheep breeders and crossbred with the *old* coarse-wool Lincoln ewes to produce the improved Lincoln which included higher quality wool. The improved Lincoln still maintained its strong, coarse wool, but had wool of a finer diameter that took dye very well and retained its strength for the combing and worsted spinning processes used at that time. It was this *improved* Lincoln that led to the accumulation of great wealth in Lincolnshire and surrounding counties for many decades.

In the 1800's the value of using Lincolns in crossbreeding programs was recognized. Lincoln sheep were exported worldwide and used for upgrading local breeding stock. The use of Lincolns in crossbreeding eventually developed various breeds including Corriedale, Polwarth, Columbia, Bond, and Panama. From these breeds, second-generation breeds were subsequently developed in the United States, such as Montadale and Targhee. According to the British National Lincoln Sheep Breeders Association many of the longwool breeds likely have a similar developmental history involving Lincoln and Leicester foundations.
The American Romney traces its roots to marshy wetlands of England. According to Ryder (1964) Romney origins go back to the old, established dual purpose Romney Marsh breed. It evolved from medieval longwool types similar to the Romney and Leicester breeds which was improved in body type and fleece quality through crossbreeding with Bakewell’s English Leicester. The Romney sheep provided the foundation for the English woolen industry, which was the most important export commodity in the middle ages.

According to the American Romney Breeders Association Romney sheep were exported from England in the 1870s to New Zealand and other countries with similar climates. New Zealand had similar landscape and weather conditions making an easy transition for the Romney, which quickly became an established breed and remains the predominant breed today. In 1904, William Riddel of Oregon imported the first Romney sheep to North America where they became a popular breed in the Northwest. The present-day Romney is a product of both English and New Zealand blood lines.

Rawahi Romneys of New Zealand explains that the Romney breed produces wool under diverse climate conditions and management systems. The breed’s unique fleece characteristics make it an excellent choice for purebred or crossbred programs. The handspinning qualities of the Romney fleece make the breed attractive for small flocks or a spinner’s flock. The low grease content of Romney wool makes it easy to wash and
The wool clip from the purebred Romney flock is sought after by commercial wool buyers, craftspeople, and handspinners.

**Breed Rationale**

I chose the Bluefaced Leicester, Lincoln Longwool, and Romney breeds for this in-depth study for a few reasons. First, they are the breeds on my farm. I did not have to rent or purchase a ram or ewe of another breed to complete the study. Moreover, in 2010 we had a BFL ram (Amos) that could not be bred to the BFL ewes in our flock due to the same genetic lineage; therefore, we experimented and bred him to a Lincoln ewe (224-Haley) which produced our first crossbred lambs. The lambs exhibited various desirable qualities including wool that had qualities from the sire and dam including strength, luster, and volume. In 2011 we repeated the same type of breeding with a different BFL ram (581-Clyde) and a different Lincoln ewe (221-Winnie) with the intent of pairing the two second generation crossbreds for breeding (see Figure 1).

Second, the three breeds were of the same wool type—longwool—making the focus of this study on wool characteristics that range from similar fiber diameter differences to obvious differences in staple structure and handle, all within the same wool type. Susan Schoenian, author of the website Sheep101 states, “There is usually as much difference within a breed as between breeds.”

Third, using a BFL ram as the sire on the Lincoln and Romney ewes ensured less difficulty at birth. The BFL lamb is smaller than Lincoln and Romney lambs and its head is
narrower at birth. The large frame of the Lincoln and Romney ewes made delivery of a smaller lamb easier. The crossbreeding program in Figure 1 shows the timeline and breeding pairs used in this study.

**Crossbreeding Program**

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</thead>
<tbody>
<tr>
<td>Year Lambs Were Born</td>
<td>2011</td>
<td>2012</td>
<td>2013</td>
<td>2013</td>
<td>2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1 Hybrid* Lambs</td>
<td>BFL/Lincoln Cross (014-Harmony)</td>
<td>BFL/Lincoln Cross (311-W)</td>
<td>BFL/Lincoln Cross (124-Hamilton &amp; 325-Haley)</td>
<td>BFL/Romney Cross (130-Juno)</td>
<td>BFL/Lincoln Cross (128-Reo)</td>
<td>BFL/Romney Cross (127-Yaya)</td>
<td></td>
</tr>
<tr>
<td>Year Lambs Were Born</td>
<td>2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F2 Hybrid* Lambs</td>
<td>Full Breed Cross (129-Harper)</td>
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</table>

* F1 Hybrid is a term used in genetics and selective breeding. F1 stands for the filial first filial generation animal offspring resulting from a cross breeding.

**Materials and Methods**

Finally, these three breeds have an important place in history in terms of crossbreeding to improve, among other things, the wool of other breeds and to create new breeds. It seemed appropriate, and a tribute, to include them in a study of crossbred wool.

The data and information collected at each phase of the study were recorded on a data sheet for each sheep. See Appendix B to review the data sheets. The subsections of this
Materials and Methods section follow the same order as the sections outlined on the data sheets.

Sheep
The sheep used for this study reside on my farm in Michigan, USA. This provided unlimited access to the sheep throughout the breeding, gestation, lambing, and growing phases. The breeding groups were put together September 1, 2012. The Bluefaced Leicester ram was paired with two Lincoln ewes and two Romney ewes and were placed in a dedicated pasture. Two ewes of each breed were in the initial breeding group to ensure that I had enough lambs for the project in case there was loss due to unexpected circumstances (still born, sickness, etc). The first generation crossbred ram was paired with the first generation crossbred ewe and placed in another separate pasture. The rams were left with the ewes for approximately ten weeks to ensure that each ewe was bred. With a 145-day gestation period, the lambs were born in January and February 2013. At birth each lamb was ear tagged and their lineage, weight, and date of birth recorded. Six live lambs were born from the initial five ewes. When the lambs were approximately six months old, I selected the ones whose wool I would use for this study. Three groups were formed.

Group 1: BFL x Lincoln
The two Lincoln ewes produced three lambs. One ewe had twins and the other a single lamb. I chose to include both twins instead of the single lamb because the twins had distinctive differences in their wool—one looked more like Lincoln wool and the other
like a BFL/Lincoln combination. By including the twin lambs I could evaluate wool samples from both and compare them to their sire and dam.

**Group 2: BFL x Romney**

The two Romney ewes each had a single lamb. Both Romney lambs were comparable with respect to wool characteristics. One was a ram and the other a ewe. I selected the ewe because ewes stay on the farm longer than rams, which could give me the opportunity to study her wool as she ages.

**Group 3: First Generation BFL x Lincoln Crossbred**

The crossbred ram and the crossbred ewe are both first generation BFL x Lincoln crosses. Each have different sires and dams which allowed for genetic diversity. The breeding of these two first generation crosses produced one second generation crossbred lamb. By including the first and second generation breeding in this study, I could evaluate wool traits to determine if wool quality remains consistent in subsequent breedings.

Nine sheep were included in the final project and divided into these three groups. The three groups represent the three groups used throughout this study. Eleven wool samples were hand washed, combed, spun, dyed, and evaluated. The additional two samples were the wool blended together from the purebred sheep in Groups 1 and 2 in order to compare with the offspring of those same purebreds. This comparison would
attempt to answer the question of whether it is beneficial to hand blend wool from two separate sheep or breed those sheep and blend the wool traits at the genetic level.

Figure 2 illustrates the make-up of the groups and what sheep were bred together and what offspring they produced. In Groups 1 and 2 the additional blended samples were included. These samples were made up of the purebred wool from the sire and dam and were used to compare against the wool samples from the crossbred lambs of the same sire and dam. Group 3 is the extension of the generation breeding—two crossbred sheep bred to produce a second generation lamb in order to evaluate whether the wool improves in the next generation.

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>581-Clyde (Purebred BFL)</td>
<td>581-Clyde (Purebred BFL)</td>
<td>111-W (F1 BFL x Lincoln)</td>
</tr>
<tr>
<td>224-Haley (Purebred Lincoln)</td>
<td>417-Jordi (Purebred Romney)</td>
<td>014-Harmony (F1 BFL x Lincoln)</td>
</tr>
<tr>
<td>Blended BFL x Lincoln (Hand Combed)</td>
<td>Blend BFL x Romney (Hand Combed)</td>
<td>129-Harper (F2 Crossbred)</td>
</tr>
<tr>
<td>124-Hannibal (F1 Crossbred)</td>
<td>130-Juno (F1 Crossbred)</td>
<td></td>
</tr>
<tr>
<td>125-Halo (F1 Crossbred)</td>
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</table>

Figure 2—Project groups include purebred sire, dam, and progeny.

Wool
Because the main focus of this study was to spin the fiber from long wool sheep, I waited until the wool was at least four inches long on each sheep. Periodically I checked the wool length by gathering the sheep together and measuring the wool with a ruler. This gave me an indication of when to shear the sheep.
On June 2, 2013 I sheared the BFL, Lincoln, and Romney adult sheep and on July 20, 2013 I sheared the four lambs. The crossbred ewe and ram were sheared as lambs in 2011 and 2012, respectively, and their fleeces kept in a cool, dry environment which prevented any deterioration of the wool. I stored the first fleece of the crossbred ram and ewe with the intention of doing future comparisons, so when the topic of this in-depth study was finalized I knew I would have a close comparison with the wool of the second generation offspring.

By the time I sheared each sheep their wool varied in length from four to six inches due to factors including breed type, sheep age, health and nutrition, and length of time since the last shearing, or in the case of the lambs since their date of birth. The sheep were placed on a stand where I sheared them. I used manual shearing scissors and electric wool clippers to shear the sheep. Both pieces of equipment allowed me to shear all areas of the sheep without nicks or cuts to their skin. While shearing, I continuously skirted the fleece as I removed the wool. Wool from the belly, legs, britch, head, back of neck, and top line of the back (if filled with excessive vegetable matter) was discarded as it came off the sheep and only the favorable wool was retained for processing and spinning. Shearing each sheep took on average 90 minutes (see Appendix A).

As a normal practice before shearing I took a sample of wool from each sheep. A wool sample consisting of two or three locks is typically taken from the mid region on the side of the sheep. Using scissors the wool is cut at the point right next to the sheep's body in
order to collect a sample that represents the entire lock of wool. The sample was placed in a plastic bag and identified with the sheep's name and ear tag number.

The wool samples were sent to the Texas A & M AgriLife Wool and Mohair Research Laboratory in San Angelo, Texas for analysis. The results identified the fiber diameter, standard deviation, coefficient of variation, comfort factor, curvature, and spinning fineness using OFDA 2000 technology. See Appendix C for the lab reports. The OFDA 2000 is an instrument the lab uses to measure greasy wool and provide a diameter profile along the staple.

Throughout the washing, combing, spinning, and dyeing phase of the study I completed each task following the Group 1, Group 2, and Group 3 sequence. This allowed me to observe similarities and differences on a spectrum beginning with purebred wool and ending with second generation crossbred wool.

**Processing**

I collected two pounds (907 grams) of raw wool from each of the nine fleeces. Two pounds provided enough wool for the spinning and dyeing samples and the knitted swatches, as well as extra in case I needed more or had to redo a sample.

Before each two-pound portion was washed, I soaked it overnight in a container of tepid water. This pre-wash soak pulled a large amount of dirt off of the wool and softened it, which helped in the washing process. A combination of Ecos Laundry detergent and
Dawn dish washing liquid was used to wash the raw wool. Two washes and one rinse was enough to produce clean wool. The two pounds of wool was emerged in a tub used to wash and rinse the wool. A mesh-type bag was not used, the wool floated freely in the water. Each of the nine portions of wool was washed this way. I did not weigh the clean wool after each portion was dry because the weight difference between the raw wool and clean wool was not relevant for this study. My intention was to wash enough wool from each sheep so that I had enough for the samples as opposed to processing the entire fleece of each sheep.

Because the breeds included in the study are long wools, combing was the preferred method of processing the wool. According to Field (2010) wool combs produce the best parallel arrangement of fiber which is necessary for worsted spinning. However, Ross (1983) explains that medium length wool, three to six inches, can be combed or carded and spun woolen or worsted, but the choice must be an early decision in the planning process. I chose to comb the wool and spin using a worsted technique in order to produce a smooth yarn with as much luster as possible. Combing and blending was completed on English combs, St. Blaise hand combs, Louet mini combs, and hackles made by Ray Thomas in British Columbia and Charles Vereschagin in Alberta.

Four ounces (112 grams) of clean wool from each sheep was combed, with the exception of the BFL. An additional two and a half ounces (71 grams) of BFL was used in each hand blended sample in Group 1 and Group 2; therefore, nine ounces (255 grams)
of BFL was combed. Because the BFL locks were the smallest in circumference, it was
difficult to secure them on any of the combs or hackles except the mini combs; however
due to the amount of BFL wool that required combing the mini combs were not an
option. I used a Fancy Kitty Cradle Picker to open up the BFL locks and then processed
the opened locks through a Strauch Drum Carder in order to produce batts that I
subsequently combed on the hackle (see Appendix A). Because the wool locks were not
kept in a cut-end-to-tip consistent direction, the BFL yarn produced from the picking,
drum carding, and combing was worsted, yet not true worsted.

The Lincoln wool was combed on the English combs. It seemed that the length of the
Lincoln locks made combing with the English combs more efficient. The strength of the
Lincoln wool also easily stood up to the heavy English combs. The Romney wool was
easily combed with the St. Blaise hand combs. Both hand blended samples were
combed and blended on the hackle. The hackle was very effective in blending two wools
together. The wool from the lambs in Group 1 and Group 2 and the three sheep in
Group 3 was combed with the St. Blaise hand combs. I used the mini combs to work
through areas of the wool locks that were tightly packed and hard to comb with the St.
Blaise combs. I also used the mini combs to comb through wool left on the hackles in an
attempt to remove as much usable fiber as possible.

After the four ounces (112 grams) of wool from each sheep was combed (nine ounces of
BFL) it was weighed on a Jennings CJ-4000 digital scale to determine the after-combing
weight. The after weight allowed me to calculate the percentage of loss from combing. Percentage of wool loss is defined as the difference of the before and after weight of the combed wool divided by the before weight. The amount of fiber lost in combing could give a spinner an indication of how much wool may be needed for a larger project (e.g. a sweater, blanket, or jacket). If the percentage of loss is more than the spinner is comfortable with, he or she may decide to card the wool instead.

After the combing phase was complete, a comparison of handle was performed to determine if each combed sample had a noticeable difference by way of touch. As shown in Figure 2, Group 1 and Group 2 consisted of a hand blended sample from the wool of each purebred sheep in that group. These hand blended samples were compared to the purebred wool and the offspring lamb(s) in the group.

The comparison of handle was performed by a non-spinner who has no affinity towards sheep, fiber, and the fiber arts. I choose her so that complete focus could be put towards identifying the differences in handle without any preconceived bias of wool preference. She sat blindfolded as I placed a combed sample in each hand. She spent an average of three minutes comparing the samples by placing them in her hands and on her neck and face. The results were recorded on the data sheet for each sample.

**Spinning**
The goal of spinning the combed samples was to evaluate the yarn to determine if differences exist between the purebred wool, hand blended wool, and crossbred wool.
that would benefit handspinners. Because a specific use for the yarn was not identified (e.g. historical embroidery, lace knitting, weaving, etc.), I did not spin the sample skeins to specific specifications (twists per inch, angle of twist, etc.). The wool was from long wool breeds of sheep; therefore a worsted method of spinning was best suited for the yarn. According to Teal (1976) it is possible to spin from a sliver before it is turned into roving; however, spinning that way is more likely to produce yarn that seems hairy. A true worsted yarn is spun after the sliver has been turned into top or roving. Then when the fiber is drafted it is already condensed at the point where it enters the twist making a smooth, less-hairy yarn. When spinning a true worsted yarn “always keep in your mind’s eye a stream of fibre from the sheep to the comb to the spindle, in which the direction of the fibre flow does not change” (Teal, 1976, pg. 73). I veered from the true worsted described by Teal and spun from the sliver thereby producing yarn that has a hairy surface. My goal was to evaluate the wool produced by crossbreeding and how it behaves once spun into yarn.

The sample skeins were spun on a Lendrum Traveler spinning wheel using the 8:1 ratio whorl. Spinning proceeded in the previously mentioned order of Group 1, Group 2, and Group 3. I divided the combed sliver into two even portions by weighing it on the Jennings CJ-4000 scale. Each portion was spun onto one bobbin. A worsted short forward draw technique was used for each skein. Typically the short forward draft was approximately a three inch draw, however when spinning the Lincoln the forward draw increased to about four inches due to the length of the fiber. The drafting zone was
approximately three inches at all times which allowed me to control the twist as it entered the unspun wool. The drafting zone was 12 inches from the wheel’s orifice and the spun yarn between the drafting zone and orifice advanced three inches with each treadle.

Each skein took an average of five hours to complete. It took approximately two hours to spin each half of the sliver and one hour to ply the two singles. A 78 inch (2.17 yards) niddy-noddy was used to remove the two-ply yarn from the bobbin. The niddy-noddy was home made using PVC pipe, therefore it was not a standard commercial length, but it was used for each sample skein. Each skein was wet finished with warm water and Eucalan Wool Wash. Each skein was hung to dry without any weight attached. Table 1 lists the final yardage, twists per inch, and wraps per inch of each skein.

<table>
<thead>
<tr>
<th>Sheep</th>
<th>Yardage</th>
<th>TPI</th>
<th>WPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>581-Clyde</td>
<td>165</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>224-Haley</td>
<td>121</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Clyde-Haley Blend</td>
<td>156</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>124-Hannibal</td>
<td>120</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>125-Halo</td>
<td>116</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>437-JonEllen</td>
<td>132</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Clyde-JonEllen Blend</td>
<td>161</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>130-Juno</td>
<td>102</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>111-W</td>
<td>120</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>014-Harmony</td>
<td>118</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>129-Harper</td>
<td>112</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total Yardage Spun</strong></td>
<td><strong>1,423</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The amount of shrinkage a skein undergoes is important to a spinner. After the 11 skeins were spun, plied, and finished, I hung them next to each other and noted the
difference in length due to shrinkage after the fibers resumed their natural crimp or wavy pattern after being stretched out on the bobbin and niddy-noddy. The shrinkage was calculated based on the 78 inches each skein measured before washing and the length of each skein after it was completely finished and dry. The difference between the two lengths was divided by the original 78 inches which produced the percentage of shrinkage. The formula and results are noted on each data sheet.

Elasticity in yarn is another factor to consider when spinning wool for a specific project. "Elasticity is perhaps wool's most valuable asset, for so many of its other important features, such as fullness of handle, softness and felting capacity are to a great measure products of elasticity" (D'arcy, 1990, p. 80). Elasticity is how much the yarn can be stretched from its original relaxed position. According to MacKenzie-McCuin (2009) crimp structure gives fiber its elasticity. Depending on the fiber's crimp, elasticity can range from no elasticity to an abundance of elasticity. Typically wool with more crimp has more elasticity. The wool of long wool sheep tends to be wavy rather than crimpy thereby consisting of less elastic qualities. However, some of the crossbred wool in this study seemed to have more elasticity than expected.

I measured the elasticity of each skein by stretching it from its relaxed position to the point where it could go no further. I subtracted the outstretched measurement from the relaxed measurement and divided the difference by the outstretched measurement. The formula and results are noted on each data sheet.
Each sample skein has a corresponding knitted swatch from the same yarn. The swatch for each sample was knitted in stockinette stitch so that the stitch definition, handle, and behavior of the yarn could be evaluated as a finished item. The knitted swatches were included to demonstrate how the yarn looked as a finished piece.

**Dyeing**
The intent of the dye exercise was to determine if the various samples took dye differently. Because the two hand blended samples are made up of different wool, the assumption was there may have been a variation in the final outcome—each type of wool could have taken the dye differently and the final skein may have had a variegated or two-toned appearance. Another assumption is the wool of the offspring may have taken dye at a different rate than the purebred wool resulting in a different hue.

Landscapes dye by Kraft Kolour was used to dye the samples. Initially I measured six yard skeins for the dye samples. The samples were placed in their respective groups. The skeins were weighed and then soaked in warm water with Synthrapol for approximately 30 minutes. The dye instructions for Landscapes dyes were followed. Dye powder was measured according to the weight of fiber and mixed with hot tap water. A color from the Landscapes palette was chosen at random and assigned to Group 1, 2, and 3. Three separate glass jars were prepared, one for each color. The dyes were mixed in the glass jar that the yarn was going to be dyed in. Water and vinegar were added to fill the jar, then the skeins were submerged in the jars.
The jars were placed in a large pot of heated water on the stove for approximately one hour. The heat was slowly increased until it reached a point where it was just below a boil which took approximately 35 minutes. The water held at that temperature for the remaining time. After one hour the heat was turned off and the jars removed from the pot. The jars were placed outside to cool for four hours. The skeins were rinsed and hung to dry (see Appendix A).

Results/Findings
The information collected on each sheep’s data sheet was compiled and evaluated to determine if a noticeable difference existed between purebred wool, hand-blended purebred wool, and the crossbred wool. Table 2 lists those items that may make a difference to handspinners.

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Sheep</th>
<th>Fiber Diameter</th>
<th>% Loss from Combing</th>
<th>Handle Comparison*</th>
<th>% Shrinkage after Spinning</th>
<th>% of Elasticity</th>
<th>Dye Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>581-Clyde</td>
<td>25.9</td>
<td>26%</td>
<td>n/a</td>
<td>10%</td>
<td>5.40%</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>224-Haley</td>
<td>44.4</td>
<td>19%</td>
<td>n/a</td>
<td>23%</td>
<td>1.60%</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Cl-Hy Blend</td>
<td>n/a</td>
<td>36%</td>
<td>S:Cr/D:Sf</td>
<td>8%</td>
<td>2.70%</td>
<td>Same</td>
<td></td>
</tr>
<tr>
<td>124-Hannibal</td>
<td>33</td>
<td>31%</td>
<td>S:Cr/D:Sf/B:Sf</td>
<td>10%</td>
<td>5.40%</td>
<td>Same</td>
<td></td>
</tr>
<tr>
<td>125-Halo</td>
<td>38.8</td>
<td>20%</td>
<td>S:Cr/D:Sf/B:Sf</td>
<td>8%</td>
<td>1.37%</td>
<td>Same</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 2</th>
<th>Sheep</th>
<th>Fiber Diameter</th>
<th>% Loss from Combing</th>
<th>Handle Comparison*</th>
<th>% Shrinkage after Spinning</th>
<th>% of Elasticity</th>
<th>Dye Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>581-Clyde</td>
<td>25.9</td>
<td>26%</td>
<td>n/a</td>
<td>10%</td>
<td>see above</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>437-JonEllen</td>
<td>40.9</td>
<td>21%</td>
<td>n/a</td>
<td>10%</td>
<td>4.11%</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Cl-Jon Blend</td>
<td>n/a</td>
<td>37%</td>
<td>S:Sf/D:Sf</td>
<td>12%</td>
<td>2.82%</td>
<td>Same</td>
<td></td>
</tr>
<tr>
<td>130-Juno</td>
<td>40.1</td>
<td>26%</td>
<td>S:Sf/D:Sf/B:Sf</td>
<td>15%</td>
<td>9.59%</td>
<td>Same</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 3</th>
<th>Sheep</th>
<th>Fiber Diameter</th>
<th>% Loss from Combing</th>
<th>Handle Comparison*</th>
<th>% Shrinkage after Spinning</th>
<th>% of Elasticity</th>
<th>Dye Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>111-W</td>
<td>31.1</td>
<td>29%</td>
<td>n/a</td>
<td>10%</td>
<td>5.40%</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>014-Harmony</td>
<td>36.2</td>
<td>25%</td>
<td>n/a</td>
<td>8%</td>
<td>1.37%</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>129-Harper</td>
<td>31.1</td>
<td>30%</td>
<td>S:Sf/D:Sm</td>
<td>8%</td>
<td>2.70%</td>
<td>Same</td>
<td></td>
</tr>
</tbody>
</table>

*S = sire, D = dam, B = blend, Cr = coarser, Sf = softer, Sm = same

Table 2 – Results of testing. Fiber diameter (in microns), combing, handle, shrinkage, elasticity, and dye absorption.
There was a noticeable reduction in average fiber diameter (microns) in the two crossbred sheep in Group 1 compared to their dam’s fiber diameter. This indicates the BFL wool traits were carried from the sire 581-Clyde to the twin offsprings and softened the wool. The noticeable difference between 124-Hannibal and 125-Halo (the twins) confirmed the variation that is possible even when the sire and dam are the same. The slight change in fiber diameter in Group 2 is immaterial which shows the BFL x Romney crossbreeding did not improve the softness of the offspring’s wool. The fiber diameter change in Group 3 showed a slight improvement in terms of fineness.

Fiber diameter is one measure yet is not the only consideration a handspinner makes. The handle comparison is also an important aspect of evaluating the wool, albeit subjective and non-quantifiable. Group 1 shows that the Clyde-Haley hand blended sample was coarser than 581-Clyde but softer than 224-Haley. That stands to reason because 581-Clyde (BFL) and 224-Haley (Lincoln) are at opposite ends of the micron spectrum, 25.9 and 44.4, respectively. The results of the handle comparison for 124-Hannibal and 125-Halo showed their wool is coarser than 581-Clyde’s yet softer than 224-Haley’s and the hand blended sample.

Group 2 handle comparisons showed that both samples were softer than the sire and dam. The hand blended sample was softer than the sire and dam, and 130-Juno’s sample was softer than the sire, dam, and the hand blended sample. This finding is unexpected because 581-Clyde’s fine micron count of 25.9 should have felt softer. And
even though 130-Juno’s micron count is 40.1 once combed her wool had a soft handle. The fact that 130-Juno’s fleece is a lamb’s fleece may account for the softness.

Group 3 handle comparisons showed that 129-Harper’s combed wool felt softer than his sire’s even though they have the same micron count, and it appeared to feel the same as his dam’s combed wool. Even though 014-Harmony’s micron count was slightly higher than 129-Harper’s, it seemed the handle was the same once the wool was combed.

One variable on the lab report from Texas AgriLife Research that suggested the wool of the crossbred sheep in Group 3 may continue to soften through subsequent breeding was the comfort factor percentage (CF%)—the percentage of fibers equal to or less than 30 microns. The micron count for 111W’s shoulder sample was 30.9 but the lab identified 46.8% of the fibers in that sample to be less than 30 microns. His side sample was 31.3 microns and 43.4% of fibers in that sample were under 30 microns. The same variable exists for 129-Harper. His shoulder and side samples were 31.4 and 30.7 microns, respectively and the lab identified 42.5% and 48% of the fibers to be under 30 microns. This indicates that a large percentage of the wool from these two crossbred sheep was finer than the average micron. According to Malik and Singh (2006) breeding of first generation crossbred sheep has not resulted in a decline in wool quality traits in the second generation cross. This seems to coincide with the three sheep in Group 3.
Possibly through future selective breeding the average micron for my crossbred sheep could fall below 30. See Appendix C for the summary report showing the CF% variable.

The loss of wool during combing is important because the efficiency of wool processing could determine what type of fleece a handspinner may purchase. The results in Table 2 show 224-Haley and her twin ewe, 125-Halo, have the lowest percentage of loss after combing, and the two hand blended samples—Clyde/JonEllen and Clyde/Haley—had the highest percentage of loss after combing. The common variable in the two hand blended samples is the BFL wool which on its own had a loss of 26%. The range of loss from combing among all the samples is between 19% and 37% which showed there seems to be no significant difference between purebred and crossbred at any step in the combing process. However, hand blending two separate types of wool to produce a blended fiber one would use in a project may offer more choice to the handspinner. Through trial and error the desired blend could be achieved. Conversely, breeding two sheep to produce a new wool variation produces one type of fiber which may seem restrictive to a handspinner or fiber artist, however that new wool could be hand blended to adjust the handle.

After spinning the sample skeins the shrinkage and elasticity were measured. According to the results gathered in Table 2 the shrinkage among 12 of the samples was between 8% and 23%. The wool from 224-Haley had the highest shrinkage at 23%. I re-measured this skein twice to verify the percentage which initially seemed high. The wool from 130-
Juno shrunk by 15% and had the highest elasticity at 9.59%. After spinning the yarn from 130-Juno's wool it was apparent that this was a very comfortable knitting yarn. Other sample yarns with high elasticity were 581-Clyde, 124-Hannibal and 111-W all at 5.40%.

Typically desirable wool yarn for knitting is more soft and elastic when knitting a wearable item. The goal of knitting the swatches in this in-depth study was to evaluate which yarn produced the best knitted fabric. The knitted swatches were completed using a size 3 US (3.25 mm) knitting needle. The feel of the yarn while knitting and the handle of the swatches were compared. Of the 11 knitted swatches the top three that seemed to be the best for knitting was 581-Clyde from Group 1, 130-Juno from Group 2, and 111-W from Group 3. These results showed that the finer fiber diameter and the handle of the Bluefaced Leicester does carry through to the first and second generation crossbred sheep. See Appendix H to view the knitted swatches.

The results of the dyed sample skeins showed that there was no difference in the dye absorption among all the skeins. It appears that the skeins in each group took dye at the same rate and the same saturation level. No difference in hue was observed. See Appendix G to view the dyed samples.

**Conclusion**
It seems likely that wool from crossbred sheep could be used for those applications which the purebred wool of its sire and dam are suitable. This study indicates that
crossbred sheep have compatible wool that could be used in place of purebred wool for handspinning. Through careful examination and selection of fleeces at the time of purchase, a handspinner can reap the benefits of wool characteristics that originated from purebred sheep.

It could be concluded that crossbreeding between longwools resulted in improved fiber diameter, fiber volume, and uniformity in the second generation crossbred sheep. A finer fiber diameter in crossbred wool indicated that there is a good potential for finer wool production. It would be feasible to use the crossbred sheep for producing finer fiber.

In this study, crossbreeding has demonstrated that wool characteristics can be increased without substantially losing fleece weight. The results have shown that crossbreeding BFL sires with other longwool breeds produce wool that would give handspinners an additional option when it comes to fleece selection, processing, and handspinning. The BFL sire seems to soften coarser wool such as Lincoln and add crimp to wool such as Romney.

Further selective crossbreeding with a BFL ram can produce wool that is sound, voluminous, and finer than a typical longwool sheep. A crossbred sheep sired by a BFL ram provides more options for craftspeople and handspinners.
References


Glossary of Terms

**Balanced Yarn:** A balanced yarn is one where the twist in the singles is matched by the twist in the plied yarn. Once balanced the yarn will not twist on itself if you hold two ends of a short length together. The fibers which make up the yarn lie more or less exactly in the direction of the length of yarn.

**Batt:** A fiber preparation usually made on a drum carder. Batt are rectangular, usually a woolen or semi-woolen preparation and may be used for spinning, felting, quilting, or for stuffing pillows or other items.

**Blend:** A blend can be more than one fleece of a specific breed, a combination of different breeds, or a combination of different types of fiber.

**Carded:** Fiber that has been prepared on hand cards or a drum carder. Typically the fiber has not been combed to remove the shorter fibers.

**Combed:** Fiber that has been combed to remove short fibers and to align the fibers into a worsted preparation.

**Crimp:** Crimp is the wave in wool fiber. Generally finer wool will have tighter crimp.

**Curl:** The wave in fibers that have no crimp. Fibers with curl are generally medium grade wools like Cotswold or Lincoln.

**Dam:** The female parent of an animal.

**Direction of Twist:** Yarn can be spun or plied clockwise or counterclockwise. The direction refers to the direction the wheel or whorl is turning. Clockwise yarn has a Z-Twist. Counterclockwise yarn has an S-Twist.

**Diz:** A small and light tool consisting of a hole, similar to a button. It is used to pull combed fiber from the combs or hackle into a continuous sliver to spin from. The fiber is pulled off of the comb through the hole to hold the thickness of the sliver consistent.

**Drafting:** The process of attenuating fibers to allow them to slip past each other as twist is added to them.

**Drafting Zone:** The unspun fibers between the spinners back hand that is holding the fiber source and the newly spun yarn. There will be some twist in the drafting zone in woolen spinning and no twist in the drafting zone in worsted spinning.
**Drive Ratio:** The ratio between the drive wheel and the whorl on a spinning wheel. A higher ratio will turn the flyer faster. Use a higher ratio for thinner yarns and a lower ratio for thicker yarns.

**Drum Carder:** A tool which cards fiber by feeding it onto a drum covered in teeth. It is the same process as hand carding only a drum carder has more capacity and can be quicker. A drum carder creates a batt.

**F1/F2:** An F1 hybrid (or Filial 1 hybrid) is the first generation offspring of different parental types. F1 hybrids are used in genetics and selective breeding. F2 hybrid is the second generation offspring of F1 parents. Mules are F1 hybrids between horse and donkey.

**Fiber Diameter:** The diameter of an individual fiber, usually measured in microns.

**Hackles:** Hackles are a piece of wood with many nail-like tines protruding from a wood base. Hackles are used for straightening, combing, and blending fiber.

**Hand Cards:** Cards are multi-teeth tools that allow one to blend fibers creating a carded or woolen preparation.

**Hand Combs:** Combs are used for straightening and smoothing long fibers. The process of combing also removes short pieces of fiber.

**Lanolin:** A fatty wax secreted by the sebaceous glands of sheep. This is commonly called grease.

**Lock:** A tuft of fiber that is still in the same formation as when it was on the animal.

**Micron Count:** The average fiber diameter measured in microns (1/25,400th of an inch). Superfine fiber is below 18 microns, fine fiber is between 18 and 21 microns, medium grade fiber is between 22 and 30 microns, and coarse fiber is above 30 microns.

**Niddy-Noddy:** A tool for winding yarn into hanks. Usually it makes a hank of a specific circumference like 2 yards so it can also be used for counting yardage.

**Picker:** A tool used for opening up locks of fleeces. The lock structure will not be retained. This is typically done before using a drum carder.

**Progeny:** A descendant or the descendants of a person, animal, or plant; offspring.

**Roving:** A long, even strand of fibers that have been carded or combed. The fibers in the strand have been drawn out and slightly twisted.
**Second Cuts:** Short lengths of wool caused when the shearer makes a second pass with the clippers. Second cuts are not desirable in a handspinner's fleece. Second cuts that are not removed will become neps in the spun wool.

**Setting the Twist:** A soak or wash of handspun yarn. As the fibers get wet they settle into the twist of the yarn. Twist is set before using the yarn.

**Short Forward Draw:** A worsted spinning method where twist is not allowed to enter into the drafting zone. The fiber is slicked down as the twist enters the fiber. The resulting yarn is dense and durable. This method brings out the luster in the yarn.

**Sire:** The male parent of an animal.

**Skirt:** To remove the wool around the edges of a fleece. This removes the belly wool and any tags or urine stained wool. A heavy skirting will also remove the brich wool.

**Staple or Staple length:** The length of the individual fibers.

**Tags:** Dirt or manure attached to a fleece.

**Top:** Fibers that have been commercially carded and combed so that the short fibers and neps are removed. Fibers are aligned and lay parallel with each other.

**Twist per Inch or TPI:** The number of twists in an inch of yarn.

**Vegetable Matter or VM:** Straw, hay, seeds, or burrs in a fleece or prepared fiber. Most VM will fall out during processing and spinning.

**Woolen Preparation:** Fiber prepared in a woolen preparation such as carding. In woolen preparations the fibers are not aligned.

**Woolen Spun:** Yarn spun in a woolen method such as long draw. Woolen spun yarns have more loft and warmth due to air pockets caught inside the spun yarn. While spinning twist enters the drafting zone.

**Worsted Preparation:** Fiber prepared so that the fibers are aligned and straight with short pieces and neps removed in processing.

**Worsted Spun:** Yarn spun in a worsted method such as short forward draw. Worsted spun yarns are dense and durable. While spinning no twist enters the drafting zone.

**Wraps per Inch or WPI:** The number of times yarn wraps around a ruler or yarn gauge. Spinners and knitters use this method to estimate the grist or weight (as in fingering, sport, bulky) of their yarn.
Project Sires and Dams

581 Clyde (Bluefaced Leicester)

224 Haley (Lincoln Longwool)

437 JonEllen (Romney)

014 Harmony (BFL x Lincoln)

111 W (BFL x Lincoln)

(later pictures of W were not available)
125 Halo

Ear tag his number

Halo in pasture

Ready for shearing

Wool before shearing

Sheared

Wool before shearing
Wool Processing

Raw wool—2 pounds from each sheep in project.

Washed wool ready to comb.

Combing Lincoln on English combs.

Pulling combed Lincoln through diz.

Organizing washed locks and combed samples.

Picking BFL with Fancy Kitty cradle picker.
Wool Processing

Picked BFL.

BFL through drum carder.

BFL batts ready to be combed.

Combing BFL on the hackle.

Used other combs to hold BFL before combing on hackle.

BFL
Handspun Skeins

437JonEllen - Romney

Hand blended (combed) BFL and Romney.

130Juno - BFL x Romney crossbred

111W - BFL x Lincoln crossbred

014Harmony - BFL x Lincoln crossbred

129Harper - F2 BFL x Lincoln crossbred
Dyeing Handspun Skeins

Weighing skeins before soaking in water.

Set in separate glass jars.

Maintaining heat in dye pot.

Cooling for hours outside.

Skeins drying.
Miscellaneous Photos

Relaxed skein

Stretched skein to measure elasticity.

129Harper at three months.

124Hannibal – Wool at four months.

All project lambs – born in Jan/Feb 2013.

125Halo – Wool at four months.
### Data Sheet – 581 Clyde

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>581 Clyde</strong></td>
<td><strong>581 Clyde</strong></td>
<td><strong>111 W</strong></td>
</tr>
<tr>
<td>(Purebred BFL)</td>
<td>(Purebred BFL)</td>
<td>(F1 BFL x Lincoln)</td>
</tr>
<tr>
<td>Blended BFL x Lincoln</td>
<td>Blend BFL x Romney</td>
<td>129 Harper</td>
</tr>
<tr>
<td>(Hand Combed)</td>
<td>(Hand Combed)</td>
<td>(F2 Crossbred)</td>
</tr>
<tr>
<td>124 Hannibal</td>
<td>130 Juno</td>
<td></td>
</tr>
<tr>
<td>(F1 Crossbred)</td>
<td>(F1 Crossbred)</td>
<td></td>
</tr>
<tr>
<td>125 Halo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(F1 Crossbred)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sheep**

- Date of Birth: February 3, 2010

**Wool**

- Date: June 8, 2013
- Frequency: 3rd shearing
- Staple Length/Fiber Diameter: Staple Length: 5.5 inches, Fiber Diameter: 25.9 microns

**Processing**

- Raw Fleece Weight: 2 lbs – 907 gr
- Weight Before/After Combing: Before: 4 oz – 112 gr, After: 2.88 oz – 82.5 gr
- % of Loss From Combing: 26% -- (112 – 82.5 = 29.5/112 = .2633)
- Handle compared to sire, dam, and blended: N/A

**Spinning**

- TPI and WPI: TPI: 5, WPI: 16
- Yardage: 165 yds
- Shrinkage After Finishing*: 10% -- (78 inches – 70 inches = 8/78 = .1025)

* A 78" (or 2.17 yard) niddy noddy was used to transfer plied yarn from bobbin before finishing. After yarn dried it measured 70".

- Elasticity**: 5.4 % -- (37 – 35 = 2/37 = .0540)

** 70° relaxed skein, 74° stretched skein. The 37° and 35° in the formula above represent half of the length.

**Dyeing**

- Dye Product/Color: Landscapes Dyes by KraftKolour/(Group 1-Opal, Group 2-Fuchsia)
- Dyed yarn compared to sire, dam, and blended: N/A

**NOTES:** Dye sample comparison to 'sire, dam, and blended' is not applicable because Clyde is the sire.
## Data Sheet – 224 Haley

### Sheep

**Date of Birth:** April 14, 2008  
NOTES: Haley's dam was a product of artificial insemination. Haley's lineage is from the UK.

### Wool

**Shearing Date/Frequency:** Date: December 28, 2012  |  Frequency: 5th shearing  
**Staple Length/Fiber Diameter:** Staple Length: 5 inches  |  Fiber Diameter: 44.4 microns  
NOTES: Heavy lanolin. Raw wool contained high amount of dirt that was removed when washed.

### Processing

**Raw Fleece Weight:** 2 lbs - 907 gr  
**Weight Before/After Combing:** Before: 4 oz - 112 gr  |  After: 3.2 oz - 91 gr  
**% of Loss From Combing:** 19% -- (112 - 91 = 21/112 = .1875)  
**Handle compared to sire, dam, and blended:** N/A  
**Notes:** Handle comparison to 'sire, dam, and blended' is not applicable because Haley is the dam.

### Spinning

**TPI and WPI:** TPI: 4  |  WPI: 14  
**Yardage:** 121 yds  
**Shrinkage After Finishing:** 23% -- (78 inches - 60 inches = 18/78 = .2308)  
*A 78" (or 2.17 yard) niddy noddy was used to transfer plied yarn from bobbin before finishing. After yarn dried it measured 60".*  
**Elasticity:** 1.6% -- (30.5 - 30 = .5/30.5 = .0164)  
**60" relaxed skein, 61" stretched skein. The 30.5" and 30" in the formula above represent half of the length.**  
**Notes:** The short forward draw used was sometimes extended past three inches due to length of fiber.

### Dyeing

**Dye Product/Color:** Landscapes Dyes by KraftKolour/(Group 1-Opal)  
**Dyed yarn compared to sire, dam, and blended:** N/A  
**Notes:** Dyed sample comparison to 'sire, dam, and blended' is not applicable because Haley is the dam.
**Data Sheet – Blended BFL x Lincoln**

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>581 Clyde (Purebred BFL)</td>
<td>581 Clyde (Purebred BFL)</td>
<td>111 W (F1 BFL x Lincoln)</td>
</tr>
<tr>
<td>224 Haley (Purebred Lincoln)</td>
<td>437 JonEllen (Purebred Romney)</td>
<td>014 Harmony (F2 Crossbred)</td>
</tr>
<tr>
<td>Blended BFL x Lincoln (Hand Combed)</td>
<td>Blend BFL x Romney (Hand Combed)</td>
<td></td>
</tr>
<tr>
<td>124 Hannibal (F1 Crossbred)</td>
<td>130 Juno (F1 Crossbred)</td>
<td>129 Harper (F2 Crossbred)</td>
</tr>
<tr>
<td>125 Halo (F1 Crossbred)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sheep**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

**Date of Birth:**

**NOTES:**

**Wool**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

**Shearing Date/Frequency:**

<table>
<thead>
<tr>
<th>Date:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Staple Length/Fiber Diameter:**

<table>
<thead>
<tr>
<th>Staple Length:</th>
<th>Fiber Diameter:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

**Processing**

**Raw Fleece Weight:** N/A

2.5 oz of combed BFL and 2.5 oz of combed Lincoln were used for the blend.

**Weight Before/After Combing:**

<table>
<thead>
<tr>
<th>Before: 5 oz – 168 gr</th>
<th>After: 3.8 oz – 107 gr</th>
</tr>
</thead>
</table>

% of Loss From Combing:

36% -- (168 – 107 = 61/168 = .3630)

Handle compared to sire, dam, and blended:

<table>
<thead>
<tr>
<th>Sire</th>
<th>Dam</th>
<th>Blended</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Same</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Same</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Softer</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Soft</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Coarser</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Coarse</td>
</tr>
</tbody>
</table>

**NOTES:**

**Spinning**

**TPI and WPI:**

<table>
<thead>
<tr>
<th>TPI: 3</th>
<th>WPI: 14</th>
</tr>
</thead>
</table>

**Yardage:**

156 yds

**Shrinkage After Finishing:**

8% -- (78 inches – 72 inches = 6/78 = .0769)

* A 78" (or 2.17 yard) niddy noddy was used to transfer plied yarn from bobbin before finishing. After yarn dried it measured 72".

**Elasticity:**

2.70% -- (37 – 36 = 1/37 = .0270)

* * A 72" relaxed skein, 74" stretched skein. The 37" and 36" in the formula above represent half of the length.

**NOTES:**

**Dyeing**

**Dye Product/Color:**

Landscapes Dyes by KraftKolour/(Group 1-Opal)

<table>
<thead>
<tr>
<th>Sire</th>
<th>Dam</th>
<th>Blended</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Same color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Same</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Lighter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lighter</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Darker</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Darker</td>
</tr>
</tbody>
</table>

**NOTES:** This sample took dye the same as the BFL and Lincoln purebred wool that made up the blend.
Sheep
Date of Birth: January 24, 2013

NOTES:

Wool
Shearing Date/Frequency: Date: July 20, 2013 Frequency: 1st shearing
Staple Length/Fiber Diameter: Staple Length: 5 inches Fiber Diameter*: 33 microns
NOTES: *Samples were taken from the shoulder and side (shoulder=33 microns, side=33 microns)

Processing
Raw Fleece Weight: 2 lbs – 907 gr
Weight Before/After Combing: Before: 4 oz – 115 gr After: 2.8 oz – 79 gr
% of Loss From Combing: 31% -- (115 – 79 = 36/115 = .3130)

Handle compared to sire, dam, and blended:

<table>
<thead>
<tr>
<th>Sire</th>
<th>Dam</th>
<th>Blended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same</td>
<td>Same</td>
<td>Same</td>
</tr>
<tr>
<td>Softer</td>
<td>Softer</td>
<td>Softer</td>
</tr>
<tr>
<td>Coarser</td>
<td>Coarser</td>
<td>Coarser</td>
</tr>
</tbody>
</table>

NOTES: Hannibal's combed wool is slightly softer than the BFL/Lincoln hand blended combed wool.

Spinning
TPI and WPI:
TPI: 4 WPI: 12
Yardage: 120 yds
Shrinkage After Finishing*: 10% -- (78 inches – 70 inches = 8/78 = .1025)

*A 78" (or 2.17 yard) niddy noddy was used to transfer plied yarn from bobbin before finishing. After yarn dried it measured 70".

Elasticity**: 5.4% -- (37 – 35 = 2/37 = .0540)

**70" relaxed skein, 74" stretched skein. The 37" and 35" in the formula above represent half of the length.

NOTES:

Dyeing
Dye Product/Color: Landscapes Dyes by KraftKolour/(Group 1-Opal)

<table>
<thead>
<tr>
<th>Sire</th>
<th>Dam</th>
<th>Blended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same color</td>
<td>Same color</td>
<td>Same color</td>
</tr>
<tr>
<td>Lighter</td>
<td>Lighter</td>
<td>Lighter</td>
</tr>
<tr>
<td>Darker</td>
<td>Darker</td>
<td>Darker</td>
</tr>
</tbody>
</table>

NOTES: Took dye the same as the other samples in the group.
Data Sheet – 125 Halo

Sheep
Date of Birth: January 24, 2013

NOTES:

Wool
Shearing Date/Frequency: Date: July 20, 2013  Frequency: 1st shearing
Staple Length/Fiber Diameter: Staple Length: 5.5 inches  Fiber Diameter*: 38.8 microns

NOTES: *Samples were taken from the shoulder and side (shoulder=36.8 microns, side=40.7 microns)

Processing
Raw Fleece Weight: 2 lbs – 907 gr
Weight Before/After Combing: Before: 4 oz – 115 gr  After: 3.2 oz – 92 gr
% of Loss From Combing: 20% -- (115 – 92 = 23/115 = .20)

Handle compared to sire, dam, and blended:
- □ Same
- □ Softer
- □ Coarser

NOTES: Halo’s combed wool is slightly softer than the BFL/Lincoln hand blended combed wool.

Spinning
TPI and WPI:
- TPI: 4
- WPI: 14
Yardage: 116 yds
Shrinkage After Finishing*: 8% -- (78 inches – 72 inches = 6/78 = .0769)

*A 78" (or 2.17 yard) niddy noddy was used to transfer plied yarn from bobbin before finishing. After yarn dried it measured 72".

Elasticity**: 1.37% -- (36.5 – 36 = .5/36.5 = .0137)

**72" relaxed skein, 73" stretched skein. The 36.5" and 36" in the formula above represent half of the length.

NOTES:

Dyeing
Dye Product/Color: Landscapes Dyes by KraftKolour/(Group 1-Opal)

Dyed yarn compared to sire, dam, and blended:
- □ Same color
- □ Lighter
- □ Darker

NOTES: Took dye the same as the other samples in the group.
# Data Sheet – 437 JonEllen

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>581 Clyde (Purebred BFL)</td>
<td>581 Clyde (Purebred BFL)</td>
<td>111 W (F1BFL x Lincoln)</td>
</tr>
<tr>
<td>224 Haley (Purebred Lincoln)</td>
<td>437 JonEllen (Purebred Romney)</td>
<td>014 Harmony (F1BFL x Lincoln)</td>
</tr>
<tr>
<td>Blended BFL x Lincoln (Hand Combed)</td>
<td>Blend BFL x Romney (Hand Combed)</td>
<td>129 Harper (F2 Crossbred)</td>
</tr>
<tr>
<td>124 Hannibal (F1 Crossbred)</td>
<td>130 Juno (F1 Crossbred)</td>
<td></td>
</tr>
<tr>
<td>125 Halo (F1 Crossbred)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Sheep

**Date of Birth:** March 24, 2006

*NOTES: JonEllen was purchased and brought to our farm in 2010.*

## Wool

**Shearing Date/Frequency:**

- **Date:** December 28, 2012
- **Frequency:** 6th shearing

**Staple Length/Fiber Diameter:**

- **Staple Length:** 4 inches
- **Fiber Diameter:** 40.9 microns

*NOTES: Wool had a yellowish hue possibly due to age. This was the second shearing since owning her.*

## Processing

**Raw Fleece Weight:** 2 lbs – 907 gr

**Weight Before/After Combing:**

- **Before:** 4 oz – 112 gr
- **After:** 3.3 oz – 92 gr

**% of Loss From Combing:** 21% – (116 – 92 = 24/116 = .2068)

<table>
<thead>
<tr>
<th>Handle compared to sire, dam, and blended: N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Same</td>
</tr>
<tr>
<td>☐ Softer</td>
</tr>
<tr>
<td>☐ Coarser</td>
</tr>
</tbody>
</table>

*NOTES: Handle comparison to ‘sire, dam, and blended’ is not applicable because JonEllen is the dam.*

## Spinning

**TPI and WPI:**

- **TPI:** 5
- **WPI:** 14

**Yardage:** 132 yds

**Shrinkage After Finishing:**

- **10%** – (78 inches − 70 inches = 8/78 = .1025)

*A 78" (or 2.17 yard) niddy noddy was used to transfer plied yarn from bobbin before finishing. After yarn dried it measured 70".*

**Elasticity:**

- **4.11%** – (36.5 – 35 = 1.5/36.5 = .0411)

**70" relaxed skein, 73" stretched skein. The 36.5” and 35” in the formula above represent half of the length.**

*NOTES:*

## Dyeing

**Dye Product/Color:** Landscapes Dyes by KraftKolour/(Group 2-Fuchsia)

<table>
<thead>
<tr>
<th>Dyed yarn compared to sire, dam, and blended: N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Same color</td>
</tr>
<tr>
<td>☐ Lighter</td>
</tr>
<tr>
<td>☐ Darker</td>
</tr>
</tbody>
</table>

*NOTES: Sample comparison to ‘sire, dam, and blended’ is not applicable because JonEllen is the dam.*
### Data Sheet – Blended BFL x Romney

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>581 Clyde (Purebred BFL)</td>
<td>581 Clyde (Purebred BFL)</td>
<td>111 W (F1 BFL x Lincoln)</td>
</tr>
<tr>
<td>224 Haley (Purebred Lincoln)</td>
<td>437 JonEllen (Purebred Romney)</td>
<td>G14 Harmony (F1 BFL x Lincoln)</td>
</tr>
<tr>
<td>Blended BFL x Lincoln (Hand Combed)</td>
<td>Blend BFL x Romney (Hand Combed)</td>
<td>129 Harper (F1 Crossbred)</td>
</tr>
<tr>
<td>124 Hannibal (F1 Crossbred)</td>
<td>130 Juno (F1 Crossbred)</td>
<td></td>
</tr>
<tr>
<td>125 Halo (F1 Crossbred)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Sheep

- **Not Applicable**

#### Wool

- **Not Applicable**

#### Processing

- **Raw Fleece Weight:** N/A
- **Weight Before/After Combing:**
  - **Before:** 5 oz – 168 gr
  - **After:** 3.9 oz – 106 gr
- **% of Loss From Combing:** 37% -- (168 – 106 = 62/168 = .3690)

<table>
<thead>
<tr>
<th>Sire</th>
<th>Dam</th>
<th>Blended</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Same</td>
<td>□ Same</td>
<td>□ Same</td>
</tr>
<tr>
<td>✓ Softer</td>
<td>✓ Softer</td>
<td>□ Softer</td>
</tr>
<tr>
<td>□ Coarser</td>
<td>□ Coarser</td>
<td>□ Coarser</td>
</tr>
</tbody>
</table>

#### Spinning

- **TPI and WPI:**
  - **TPI:** 4
  - **WPI:** 14
- **Yardage:** 161 yds
- **Shrinkage After Finishing:** 12% -- (78 inches – 69 inches = 9/78 = .1153)
  - **A 78” (or 2.17 yard) niddy noddy was used to transfer plied yarn from bobbin before finishing. After yarn dried it measured 69”.

- **Elasticity:** 2.82% (35.5 – 34.5 = 1/35.5 = .0282)
  - **69” relaxed skein, 71” stretched skein. The 35.5” and 34.5” in the formula above represent half of the length.**

#### Dyeing

- **Dye Product/Color:** Landscapes Dyes by KraftKolour/(Group 2-Fuchsia)

<table>
<thead>
<tr>
<th>Dyed yarn compared to sire, dam, and blended:</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Same color</td>
</tr>
<tr>
<td>□ Lighter</td>
</tr>
<tr>
<td>□ Darker</td>
</tr>
</tbody>
</table>

#### NOTES:

- Took dye the same as the BFL and Romney purebred wool that made up the blend.
# Data Sheet – 130 Juno

## Sheep
- **Date of Birth:** February 18, 2013
- **NOTES:**

## Wool
- **Shearing Date/Frequency:**
  - **Date:** July 20, 2013
  - **Frequency:** 1st shearing
- **Staple Length/Fiber Diameter:**
  - **Staple Length:** 4 inches
  - **Fiber Diameter:** 40.1 microns

## Processing
- **Raw Fleece Weight:** 2 lbs – 907 gr
- **Weight Before/After Combing:**
  - **Before:** 4 oz – 112 gr
  - **After:** 2.9 oz – 83 gr
- **% of Loss From Combing:**
  - 26% (112 – 83 = 29/112 = .2589)
- **Handle compared to sire, dam, and blended:**

## Spinning
- **TPI and WPI:**
  - **TPI:** 5
  - **WPI:** 10
- **Yardage:** 102 yds
- **Shrinkage After Finishing:**
  - 15% (78 inches – 66 inches = 12/78 = .1538)

## Dyeing
- **Dye Product/Color:** Landscapes Dyes by KraftKolour/(Group 2-Fuchsia)
- **Dyed yarn compared to sire, dam, and blended:**

---

## Diagrams

### Group 1
- 581 Clyde (Purebred BFL)
- 224 Haley (Purebred Lincoln)
- 124 Hannibal (F1 Crossbred)
- 125 Halo (F1 Crossbred)

### Group 2
- 581 Clyde (Purebred BFL)
- 437 JonEllen (Purebred Romney)
- 129 Harper (F1 Crossbred)

### Group 3
- 111 W (F1 BFL x Lincoln)
- 014 Harmony (F1 BFL x Lincoln)

---

**NOTES:**
- Only one sample lock was taken for micron testing because shearing took place before two samples could be collected.
- A 78" (or 2.17 yard) niddy noddy was used to transfer plied yarn from bobbin before finishing. After yarn dried it measured 66".
- Elasticity: 9.59% (36.5 – 33 = 3.5/36.5 = .0959)
- 66" relaxed skein, 73" stretched skein. The 36.5" and 33" in the formula above represent half of the length.
- Took dye the same as other samples in the group.
**Data Sheet – 111 W**

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>581 Clyde</strong> (Purebred BFL)</td>
<td><strong>581 Clyde</strong> (Purebred BFL)</td>
<td><strong>111 W</strong> <em>(F1 BFL x Lincoln)</em></td>
</tr>
<tr>
<td><strong>224 Haley</strong> (Purebred Lincoln)</td>
<td><strong>437 JonEllen</strong> (Purebred Romney)</td>
<td><strong>014 Harmony</strong> <em>(F1 BFL x Lincoln)</em></td>
</tr>
<tr>
<td>Blended BFL x Lincoln <em>(Hand Combed)</em></td>
<td>Blend BFL x Romney <em>(Hand Combed)</em></td>
<td></td>
</tr>
<tr>
<td>124 Hannibal <em>(F1 Crossbred)</em></td>
<td>130 Juno <em>(F1 Crossbred)</em></td>
<td>129 Harper <em>(F1 Crossbred)</em></td>
</tr>
<tr>
<td>125 Halo <em>(F1 Crossbred)</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sheep**
- **Date of Birth:** February 13, 2012

**NOTES:** W was the first BFL x Lincoln crossbred ram on our farm. His sire and dam were a BFL ram and Lincoln ewe not listed above.

**Wool**
- **Shearing Date/Frequency:** Date: October 4, 2012 Frequency: 1st shearing
- **Staple Length/Fiber Diameter:** Staple Length: 5.5 inches Fiber Diameter*: 31.1 microns

**NOTES:** *Wool samples were taken from the shoulder and side (shoulder=30.9 microns, side=31.3 microns)

**Processing**
- **Raw Fleece Weight:** 2 lbs – 907 gr
- **Weight Before/After Combing:** Before: 4 oz – 114 gr After: 2.9 oz – 81.5 gr
- **% of Loss From Combing:** 29% -- (114 – 81.5 = 32.5/114 = .2851)

**Spinning**
- **TPI and WPI:** TPI: 4 WPI: 12
- **Yardage:** 120 yds
- **Shrinkage After Finishing**: 10% -- (78 inches – 70 inches = 8/78 = .1025)

**NOTES:** *A 78" (or 2.17 yard) niddy noddy was used to transfer plied yarn from bobbin before finishing. After yarn dried it measured 70".

**Elasticity**: 5.40% (37 – 35 = 2/37 = .0540)

**NOTES:** *70" relaxed skein, 74" stretched skein. The 37" and 35" in the formula above represent half of the length.

**Dyeing**
- **Dye Product/Color:** Landscapes Dyes by KraftKolour/(Group 3-Fern)
- **Dyed yarn compared to sire, dam, and blended:** N/A

**NOTES:** Dyed sample comparison to 'sire, dam, and blended' is not applicable because W is the sire.
# Data Sheet – 014 Harmony

## Sheep

**Date of Birth:** March 1, 2011

NOTES: Harmony was the first BFL x Lincoln crossbred ewe born on our farm. Her sire and dam were a BFL ram and Lincoln ewe not listed above.

## Wool

**Shearing Date/Frequency:**
- **Group 1:** Date: October 4, 2012  
  Frequency: 1st shearing
- **Group 2:** Date: October 4, 2012  
  Frequency: 1st shearing
- **Group 3:** Date: October 4, 2012  
  Frequency: 1st shearing

**Staple Length/Fiber Diameter:**
- **Group 1:** Staple Length: 5.5 inches  
  Avg. Diameter*: 36.2 microns
- **Group 2:** Staple Length: 5.5 inches  
  Avg. Diameter*: 36.2 microns
- **Group 3:** Staple Length: 5.5 inches  
  Avg. Diameter*: 36.2 microns

NOTES: *Wool samples were taken from the shoulder and side (shoulder=34.6 microns, side=37.7 microns). Some locks had BFL characteristics. Most locks had BFL and Lincoln characteristics.

## Processing

**Raw Fleece Weight:**
- **Group 1:** 2 lbs – 907 gr
- **Group 2:** 2 lbs – 907 gr
- **Group 3:** 2 lbs – 907 gr

**Weight Before/After Combing:**
- **Group 1:** Before: 4 oz – 114 gr  
  After: 3 oz – 85 gr
- **Group 2:** Before: 4 oz – 114 gr  
  After: 3 oz – 85 gr
- **Group 3:** Before: 4 oz – 114 gr  
  After: 3 oz – 85 gr

**% of Loss From Combing:**
- **Group 1:** 25% -- (114 – 85 = 29/114 = .2544)
- **Group 2:** 25% -- (114 – 85 = 29/114 = .2544)
- **Group 3:** 25% -- (114 – 85 = 29/114 = .2544)

**Handle compared to sire, dam, and blended:**
- **Group 1:** N/A
- **Group 2:** N/A
- **Group 3:** N/A

**Sire** | **Dam** | **Blended**
---|---|---
☐ Same | ☐ Same | ☐ Same
☐ Softer | ☐ Softer | ☐ Softer
☐ Coarser | ☐ Coarser | ☐ Coarser

NOTES: Handle comparison to 'sire, dam, and blended' is not applicable because Harmony is the dam.

## Spinning

**TPI and WPI:**
- **Group 1:** TPI: 4  
  WPI: 12
- **Group 2:** TPI: 4  
  WPI: 12
- **Group 3:** TPI: 4  
  WPI: 12

**Yardage:**
- **Group 1:** 118 yds
- **Group 2:** 118 yds
- **Group 3:** 118 yds

**Shrinkage After Finishing:**
- **Group 1:** 8% -- (78 inches – 72 inches = 6/72 = .0769)
- **Group 2:** 8% -- (78 inches – 72 inches = 6/72 = .0769)
- **Group 3:** 8% -- (78 inches – 72 inches = 6/72 = .0769)

*A 78" (or 2.17 yard) niddy noddy was used to transfer plied yarn from bobbin before finishing. After yarn dried it measured 72".*

**Elasticity:**
- **Group 1:** 1.37% (36.5 – 36 = .5/36.5 = .0137)
- **Group 2:** 1.37% (36.5 – 36 = .5/36.5 = .0137)
- **Group 3:** 1.37% (36.5 – 36 = .5/36.5 = .0137)

**NOTES:**
- **Group 1:**
- **Group 2:**
- **Group 3:**

## Dyeing

**Dye Product/Color:** Landscapes Dyes by KraftKolour/(Group 3-Fern)

**Dyed yarn compared to sire, dam, and blended:**
- **Group 1:** N/A
- **Group 2:** N/A
- **Group 3:** N/A

**Sire** | **Dam** | **Blended**
---|---|---
☐ Same color | ☐ Same color | ☐ Same color
☐ Lighter | ☐ Lighter | ☐ Lighter
☐ Darker | ☐ Darker | ☐ Darker

NOTES: Sample comparison to 'sire, dam, and blended' is not applicable because Harmony is the dam.
# Data Sheet – 129 Harper

## Group 1
- 581 Clyde (Purebred BFL)
- 224 Haley (Purebred Lincoln)
- Blended BFL x Lincoln (Hand Combed)
- 124 Hannibal (F1 Crossbred)
- 125 Halo (F1 Crossbred)

## Group 2
- 581 Clyde (Purebred BFL)
- 437 JonEllen (Purebred Romney)
- Blend BFL x Romney (Hand Combed)
- 130 Juno (F1 Crossbred)

## Group 3
- 111 W (F1 BFL x Lincoln)
- 014 Harmony (F1 BFL x Lincoln)
- 129 Harper (F2 Crossbred)

### Sheep
- **Date of Birth:** February 17, 2013

### Wool
- **Shearing Date/Frequency:** Date: July 20, 2013 Frequency: 1st shearing
- **Staple Length/Fiber Diameter:** Staple Length: 4 inches Avg. Diameter*: 31.1 microns
- **NOTES:** *Wool samples were taken from the shoulder and side (shoulder=31.4 microns, side=30.7 microns)

### Processing
- **Raw Fleece Weight:** 2 lbs – 907 gr
- **Weight Before/After Combing:** Before: 4 oz – 112 gr After: 2.7 oz – 78 gr
- **% of Loss From Combing:** 30% -- (112 – 78 = 34/112 = .3036)

<table>
<thead>
<tr>
<th>Sire</th>
<th>Dam</th>
<th>Blended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same</td>
<td>Same</td>
<td>Same</td>
</tr>
<tr>
<td>Softer</td>
<td>Softer</td>
<td>Softer</td>
</tr>
<tr>
<td>Coarser</td>
<td>Coarser</td>
<td>Coarser</td>
</tr>
</tbody>
</table>

**NOTES:** Harper’s combed wool is slightly softer than his sire’s combed wool.

### Spinning
- **TPI and WPI:** TPI: 4 WPI: 12
- **Yardage:** 112 yds
- **Shrinkage After Finishing:** 8% -- (78 inches – 72 inches = 6/72 = .0769)
  - *A 78" (or 2.17 yard) niddy noddy was used to transfer plied yarn from bobbin before finishing. After yarn dried it measured 72".*
- **Elasticity:** 2.70% (37 – 36 = 1/37 = .0270)
  - **72” relaxed skein, 74” stretched skein. The 37” and 36” in the formula above represent half of the length.**

### Dyeing
- **Dye Product/Color:** Landscapes Dyes by KraftKolour/ (Group 3-Fern)

<table>
<thead>
<tr>
<th>Sire</th>
<th>Dam</th>
<th>Blended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same color</td>
<td>Same color</td>
<td>Same color</td>
</tr>
<tr>
<td>Lighter</td>
<td>Lighter</td>
<td>Lighter</td>
</tr>
<tr>
<td>Darker</td>
<td>Darker</td>
<td>Darker</td>
</tr>
</tbody>
</table>

**NOTES:** Took dye the same as the other samples in the group.
September 23, 2013

Mrs. Carol Densmore
10909 Stow Road
Webberville, MI 48892

Dear Mrs. Densmore,

The 14 wool samples you sent to the lab have been tested. The results and your receipt for this work are enclosed.

Yours sincerely,

Faron Pfeiffer
Senior Research Associate
The Bill Sims Wool and Mohair Research Laboratory

jlh
enclosures

P.S. For your future reference, we are also including a Wool & Mohair Research Laboratory fee schedule and a glossary of abbreviations used in OFDA2000 reports.
## Glossary of abbreviations used in OFDA2000 reports

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mic Ave</td>
<td>Average fiber diameter of the tested sample expressed in microns.</td>
</tr>
<tr>
<td>SD Mic</td>
<td>Standard deviation of fiber diameter expressed in microns.</td>
</tr>
<tr>
<td>CV Mic</td>
<td>Coefficient of variation of fiber diameter expressed as a percentage ((= \frac{SD \text{ Mic}}{Mic \text{ Ave}} \times 100))</td>
</tr>
<tr>
<td>CEM</td>
<td>Coarse edge micron. The number of microns above the average diameter where the coarsest 5% of fibers lie.</td>
</tr>
<tr>
<td>&lt; 15 %</td>
<td>The percentage of fibers finer than 15 microns.</td>
</tr>
<tr>
<td>CF %</td>
<td>Comfort factor; the percentage of fibers equal to or less than 30 microns.</td>
</tr>
<tr>
<td>SF Mic</td>
<td>Spinning fineness; represents “spinning quality” and is calculated from CV Mic and Mic Ave.</td>
</tr>
<tr>
<td>SL mm</td>
<td>Average relaxed staple length expressed in millimeters.</td>
</tr>
<tr>
<td>Min Mic</td>
<td>The finest point along the staple expressed in microns.</td>
</tr>
<tr>
<td>Max Mic</td>
<td>The coarsest point along the staple expressed in microns.</td>
</tr>
<tr>
<td>FPFT mm</td>
<td>Finest point from the tip of the staple expressed in millimeters. The tip of the staple is at the left-hand side of the staple profile.</td>
</tr>
<tr>
<td>MFE mic</td>
<td>Mean fiber ends; the average fiber diameter of the fiber ends (tip and base) expressed in microns.</td>
</tr>
<tr>
<td>SD along</td>
<td>The standard deviation of fiber diameter measured along the staple expressed in microns.</td>
</tr>
<tr>
<td>CRV Dg/mm</td>
<td>Average fiber curvature expressed in degrees per millimeter, an estimate of crimp.</td>
</tr>
<tr>
<td>SDC Dg/mm</td>
<td>Standard deviation of fiber curvature expressed in degrees per millimeter.</td>
</tr>
</tbody>
</table>

**PLEASE NOTE:** The abbreviations are those used by the programmer and manufacturer of the OFDA2000 instrument. They are not necessarily standard abbreviations.
### Averages

<table>
<thead>
<tr>
<th>Animal</th>
<th>EarTag</th>
<th>Mic Ave</th>
<th>SD Mic</th>
<th>CV Mic</th>
<th>CEM</th>
<th>&lt;15 %</th>
<th>CF %</th>
<th>SF Mic</th>
<th>SL Min</th>
<th>SL Max</th>
<th>SD Along</th>
<th>CRV SD</th>
<th>SDC SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Averages</td>
<td></td>
<td>35.1</td>
<td>7.3</td>
<td>20.9</td>
<td>11.9</td>
<td>0.3</td>
<td>31.4</td>
<td>34.2</td>
<td>125.4</td>
<td>28.6</td>
<td>38.4</td>
<td>6.4</td>
<td>33.0</td>
</tr>
</tbody>
</table>

### Individual Samples

- **014 Harmony Sh**: Mic Ave 34.6, SD Mic 7.6, CV Mic 21.9, CEM 12.5, <15 % 0.2, CF % 27.9, SF Mic 34.0, SL Min 135.0, SL Max 29.0, SD Along 39.8, 5.0, 33.3, 2.84
- **014 Harmony Side**: Mic Ave 37.7, SD Mic 8.2, CV Mic 21.8, CEM 12.5, <15 % 0.2, CF % 18.3, SF Mic 37.0, SL Min 155.0, SL Max 32.7, SD Along 41.2, 0, 36.5, 2.11
- **111 W Sh**: Mic Ave 30.9, SD Mic 6.6, CV Mic 21.4, CEM 10.8, <15 % 0.7, CF % 46.8, SF Mic 30.2, SL Min 120.0, SL Max 23.8, SD Along 34.0, 0, 28.6, 2.80
- **111 W Side**: Mic Ave 31.3, SD Mic 6.8, CV Mic 21.9, CEM 11.2, <15 % 0.5, CF % 43.4, SF Mic 30.7, SL Min 125.0, SL Max 26.6, SD Along 35.4, 0, 31.0, 2.36
- **124 Hannibal Sh**: Mic Ave 33.0, SD Mic 6.9, CV Mic 20.8, CEM 11.0, <15 % 0.3, CF % 32.3, SF Mic 32.0, SL Min 130.0, SL Max 26.6, SD Along 35.8, 0, 30.6, 2.45
- **124 Hannibal Side**: Mic Ave 33.0, SD Mic 6.3, CV Mic 19.2, CEM 9.9, <15 % 0.3, CF % 29.8, SF Mic 31.7, SL Min 115.0, SL Max 24.3, SD Along 35.8, 0, 29.8, 3.19
- **125 Halo Sh**: Mic Ave 36.8, SD Mic 8.9, CV Mic 24.2, CEM 14.4, <15 % 0.2, CF % 25.3, SF Mic 36.8, SL Min 140.0, SL Max 26.5, SD Along 40.6, 0, 33.3, 3.95
- **125 Halo Side**: Mic Ave 40.7, SD Mic 9.5, CV Mic 23.3, CEM 14.7, <15 % 0.3, CF % 14.5, SF Mic 40.5, SL Min 140.0, SL Max 28.4, SD Along 46.2, 0, 37.3, 5.14
- **129 Harper Sh**: Mic Ave 31.4, SD Mic 6.1, CV Mic 19.5, CEM 10.1, <15 % 0.2, CF % 42.5, SF Mic 30.2, SL Min 100.0, SL Max 25.3, SD Along 33.8, 0, 29.5, 2.09
- **129 Harper Side**: Mic Ave 30.7, SD Mic 7.3, CV Mic 23.7, CEM 12.1, <15 % 0.5, CF % 48.0, SF Mic 30.6, SL Min 115.0, SL Max 24.5, SD Along 33.8, 0, 27.9, 2.31
- **130 Juno**: Mic Ave 40.1, SD Mic 8.5, CV Mic 21.3, CEM 14.7, <15 % 0.2, CF % 12.0, SF Mic 39.2, SL Min 100.0, SL Max 32.0, SD Along 43.5, 0, 37.8, 2.75
- **224 Haley**: Mic Ave 44.4, SD Mic 8.2, CV Mic 18.5, CEM 13.0, <15 % 0.1, CF % 5.0, SF Mic 42.4, SL Min 125.0, SL Max 40.2, SD Along 46.9, 5.0, 42.3, 1.94
- **437 Jonny**: Mic Ave 40.9, SD Mic 7.2, CV Mic 17.7, CEM 11.7, <15 % 0.0, CF % 7.7, SF Mic 38.8, SL Min 110.0, SL Max 35.3, SD Along 43.8, 0, 38.4, 2.63
- **581 Clyde**: Mic Ave 25.9, SD Mic 4.5, CV Mic 17.4, CEM 8.1, <15 % 0.2, CF % 86.3, SF Mic 24.5, SL Min 145.0, SL Max 24.6, SD Along 27.1, 80.0, 26.2, 0.77

---

OFDA 2000 is under license to Interactive Wool Group Pty Ltd. (OFDA #2081)
|                | Count | Mic Ave | SD Mic | CV Mic | CEM | <15% | CF% | SF Mic | SL mm | Min Mic | Max Mic | FPFT mm | MFE Mic | SD Along | CRV Dg/mm | SDC Dg/mm |
|----------------|-------|---------|--------|--------|-----|------|-----|--------|-------|---------|---------|---------|---------|---------|----------|-----------|-----------|
| All Animals    |       | 35.1    | 7.3    | 20.9   | 11.9| 0.3  | 31.4| 34.2   | 125.4 | 28.6    | 38.4    | 6.4     | 33.0    | 2.67    | 22.9     | 19.5      |
| Selected       |       | 35.0    | 7.0    | 20.0   | 11.0| 0.0  | 100.0| 34.0   | 125.0 | 28.0    | 38.0    | 6.0     | 33.0    | 2.60    | 22.0     | 19.0      |
| Total Selected |       |         |        |        |     |      |      |        |       |         |         |         |         |         |          |           |           |
OFDA 2000 REPORT: SORTED BY TAG
14 Wool Samples (14 Records)
Test Date: 09/19/13

EarTag: 014 Harmo
Micron: 34.6 mic
SD: 7.6 mic
CV: 21.9%
CEM: 12.5 mic
<15: 0.2%
CF: 27.9%
SF: 34.0 mic
CRV: 22.2 Dg/mm
SDC: 18.1 Dg/mm

EarTag: 014 Harmo
Micron: 37.7 mic
SD: 8.2 mic
CV: 21.8%
CEM: 12.5 mic
<15: 0.2%
CF: 18.3%
SF: 37.0 mic
CRV: 19.2 Dg/mm
SDC: 17.7 Dg/mm

Staple Len: 135.0 mm
Min Mic: 29.0 mic
Max Mic: 39.8 mic
Finest Point From Tip: 5.7 mm
Mean Fibre Ends: 33.3 mm
SD Along: 2.84 mic

Staple Len: 155.0 mm
Min Mic: 32.7 mic
Max Mic: 41.2 mic
Finest Point From Tip: 0 mm
Mean Fibre Ends: 36.5 mic
SD Along: 2.11 mic

OFDA 2000 is under license to Interactive Wool Group Pty Ltd. (OFDA #2081)
OFDA 2000 REPORT : SORTED BY TAG
14 Wool Samples (14 Records)

EarTag: 111 W Sh
Micron: 30.9 mic
SD: 6.6 mic
CV: 21.4 %
CEM: 10.8 mic
<15: 0.7 %
CF: 46.8 %
SF: 30.2 mic
CRV: 31.5 Dg/mm
SDC: 25.8 Dg/mm

Staple Len: 120.0 mm
Min Mic: 23.8 mic
Max Mic: 34.0 mic
Finest Point From Tip: 0 mm
Mean Fibre Ends: 28.6 mic
SD Along: 2.80 mic

EarTag: 111 W Sid
Micron: 31.3 mic
SD: 6.8 mic
CV: 21.9 %
CEM: 11.2 mic
<15: 0.5 %
CF: 43.4 %
SF: 30.7 mic
CRV: 29.4 Dg/mm
SDC: 22.2 Dg/mm

Staple Len: 125.0 mm
Min Mic: 26.6 mic
Max Mic: 35.4 mic
Finest Point From Tip: 0 mm
Mean Fibre Ends: 31.0 mic
SD Along: 2.36 mic

OFDA 2000 is under license to Interactive Wool Group Pty Ltd. (OFDA #2081)
Ear Tag: 124 Hannib

- Micron: 33.0 mic
- SD: 6.9 mic
- CV: 20.8 %
- CEM: 11.0 mic
- <15: 0.3 %
- CF: 32.3 %
- SF: 32.0 mic
- CRV: 23.0 Dg/mm
- SDC: 20.2 Dg/mm

Staple Len: 130.0 mm
- Min Mic: 26.6 mic
- Max Mic: 35.8 mic
- Finest Point From Tip: 0 mm
- Mean Fibre Ends: 30.6 mic
- SD Along: 2.45 mic

Ear Tag: 124 Hannib

- Micron: 33.0 mic
- SD: 6.3 mic
- CV: 19.2 %
- CEM: 9.9 mic
- <15: 0.3 %
- CF: 29.8 %
- SF: 31.7 mic
- CRV: 26.4 Dg/mm
- SDC: 20.3 Dg/mm

Staple Len: 115.0 mm
- Min Mic: 24.3 mic
- Max Mic: 35.8 mic
- Finest Point From Tip: 0 mm
- Mean Fibre Ends: 29.8 mic
- SD Along: 3.19 mic
OFDA 2000 REPORT : SORTED BY TAG
14 Wool Samples (14 Records)

EarTag: 125 Halo S
Micron: 36.8 mic
SD: 8.9 mic
CV: 24.2 %
CEM: 14.4 mic
<15: 0.2 %
CF: 25.3 %
SF: 36.8 mic
CRV: 15.5 Dg/mm
SDC: 15.5 Dg/mm

EarTag: 125 Halo S
Micron: 40.7 mic
SD: 9.5 mic
CV: 23.3 %
CEM: 14.7 mic
<15: 0.3 %
CF: 14.5 %
SF: 40.5 mic
CRV: 11.8 Dg/mm
SDC: 12.5 Dg/mm

Staple Len: 140.0 mm
Min Mic: 28.4 mic
Max Mic: 46.2 mic
Finest Point From Tip: 0 mm
Mean Fibre Ends: 37.3 mic
SD Along: 5.14 mic

OFDA 2000 is under license to Interactive Wool Group Pty Ltd. (OFDA #2081)
EarTag: 129 Harper
Micron: 31.4 mic
SD: 6.1 mic
CV: 19.5%
CEM: 10.1 mic
<15: 0.2%
CF: 42.5%
SF: 30.2 mic
CRV: 24.8 Dg/mm
SDC: 20.0 Dg/mm

Staple Len: 100.0 mm
Min Mic: 25.3 mic
Max Mic: 33.8 mic
Finest Point From Tip: 0 mm
Mean Fibre Ends: 29.5 mic
SD Along: 2.09 mic

EarTag: 129 Harper
Micron: 30.7 mic
SD: 7.3 mic
CV: 23.7%
CEM: 12.1 mic
<15: 0.5%
CF: 48.0%
SF: 30.6 mic
CRV: 22.8 Dg/mm
SDC: 22.3 Dg/mm

Staple Len: 115.0 mm
Min Mic: 24.5 mic
Max Mic: 33.8 mic
Finest Point From Tip: 0 mm
Mean Fibre Ends: 27.9 mic
SD Along: 2.31 mic
OFDA 2000 REPORT: SORTED BY TAG
14 Wool Samples (14Records)

EarTag: 130 Juno
Micron: 40.1 mic
SD: 8.5 mic
CV: 21.3%
CEM: 14.7 mic
<15: 0.2%
CF: 12.0%
SF: 39.2 mic
CRV: 26.6 Dg/mm
SCD: 21.8 Dg/mm

EarTag: 224 Haley
Micron: 44.4 mic
SD: 8.2 mic
CV: 18.5%
CEM: 13.0 mic
<15: 0.1%
CF: 5.0%
SF: 42.4 mic
CRV: 10.3 Dg/mm
SCD: 10.2 Dg/mm

Staple Len: 100.0 mm
Min Mic: 32.0 mic
Max Mic: 43.5 mic
Finest Point From Tip: 0 mm
Mean Fibre Ends: 37.8 mic
SD Along: 2.75 mic

Staple Len: 125.0 mm
Min Mic: 40.2 mic
Max Mic: 46.9 mic
Finest Point From Tip: 5.0 mm
Mean Fibre Ends: 42.3 mic
SD Along: 1.94 mic

OFDA 2000 is under license to Interactive Wool Group Pty Ltd. (OFDA #2081)
OFDA 2000 REPORT: SORTED BY TAG
14 Wool Samples (14 Records)

EarTag: 437 Jonny
Micron: 40.9 mic
SD: 7.2 mic
CV: 17.7%
CEM: 11.7 mic
<15: 0%
CF: 7.7%
SF: 38.8 mic
CRV: 26.8 Dg/mm
SDC: 21.8 Dg/mm

EarTag: 581 Clyde
Micron: 25.9 mic
SD: 4.5 mic
CV: 17.4%
CEM: 8.1 mic
<15: 0.2%
CF: 86.3%
SF: 24.5 mic
CRV: 29.7 Dg/mm
SDC: 24.9 Dg/mm

Staple Len: 110.0 mm
Min Mic: 35.3 mic
Max Mic: 43.8 mic
Finest Point From Tip: 0 mm
Mean Fibre Ends: 38.4 mic
SD Along: 2.63 mic

Staple Len: 145.0 mm
Min Mic: 24.6 mic
Max Mic: 27.1 mic
Finest Point From Tip: 80.0 mm
Mean Fibre Ends: 26.0 mic
SD Along: 0.77 mic
581 Clyde (Hand Combed)

224 Haley (Hand Combed)

Clyde-Haley Blend (Hand Blended/Combed)

124 Hannibal (Hand Combed)

125 Halo (Hand Combed)
Group 3

111 W
(Hand Combed)

014 Harmony
(Hand Combed)

129 Harper
(Hand Combed)
581 Clyde (Bluefaced Leicester)

437 JonEllen (Romney)

Clyde-JonEllen Blend (BFL x Romney Blend)

130 Juno (BFL x Romney Cross)
Group 1

- 581 Clyde (Bluefaced Leicester)
- 224 Haley (Lincoln Longwool)
- Clyde-Haley Blend (BFL x Lincoln Blend)
- 124 Hannibal (BFL x Lincoln Cross)
- 125 Halo (BFL x Lincoln Cross)

Group 2

- 581 Clyde (Bluefaced Leicester)
- 437 JonEllen (Romney)
- Clyde-JonEllen Blend (Hand Blended/Combed)
- 130 Juno (BFL x Romney Cross)
- 014 Harmony (BFL x Lincoln Cross)

Group 3

- 111 W (BFL x Lincoln Cross)
- 129 Harper (BFL x Lincoln F2 Cross)
Clyde-Haley Blend
(BFL x Lincoln Blend)
Needle Size: 3 US, 3.25 mm
Group 3

111 W
(BFL x Lincoln Cross)
Needle Size: 3 US, 3.25 mm

014 Maternity
(BFL x Lincoln Cross)
Needle Size: US, 3.25 mm
129 Harper
(BFL x Lincoln F2 Cross)
Needle Size: 3 US, 3.25 mm