THE ALPACA EYE STUDY

By Stephen R. Purdy, DVM[1]

PHASE 1[2]

Objectives:

1. To describe the normal appearance of the alpaca eye, including the following structures: globe, eyelids, cornea, conjunctiva, third eyelid, sclera, pupil, iris and pupillary ruff (granula iridica), lens, aqueous and vitreous humor, and the ocular fundus (retina, optic disc, and associated vasculature).
2. To investigate the incidence and significance of eye abnormalities in the alpaca, including the possible heritability of defects that are discovered.

Background:

Ocular defects such as cataracts, tumors, vascular diseases, and vitreous floaters have been described for many animal species. In 1993, I did an investigation of two small llama herds (30 animals total) in Massachusetts. I found that approximately 30% of the animals had an abnormality in at least one lens. These exams were performed in subdued light using a direct ophthalmoscope, but without the aid of topical medication to dilate the pupils and improve visualization of the eyes. These animals were of different ages, sexes, and genetic backgrounds. The abnormalities ranged from faint concentric rings to a completely opaque, white lens (a dense cataract). Other animals had faint, fuzzy, black opacities in their lenses. None of these animals displayed any outward clinical signs of visual deficit, although a few had absolutely no vision in one eye. A colleague[3] of mine had observed a similar high incidence of the same types of defects in llamas in western New York. Since that time, I have observed many lens opacities in alpacas during the course of performing prepurchase examinations for prospective buyers and insurance examinations. This detailed study was undertaken to investigate and catalogue the ocular findings in a number of alpacas from the North American herd. It will also serve to establish what may be considered "normal" for this animal species.

Materials and Methods:

Fifty alpacas of various ages, sexes, coat colors, and pedigrees were examined using a direct ophthalmoscope under subdued light conditions. An ocular fundus camera[4] was used to record the normal appearance of the alpaca eye and to record the types of abnormalities discovered. A breakdown of the animals in the study is included in Tables 1 through 4. The alpacas were found to very tolerant of topical eye medication to dilate the pupil.[5] They also were very tolerant of examination with an ophthalmoscope, and of photography of their eyes.

TABLE 1: Age and Sex of Study Animals

males	56%	28% geldings	28% studs
females	44%		
birth to 3 days	14%	40% males	60% females
1 week to 1 year	16%	62% males	38% females
1.1 to 3 years	30%	60% males	40% females
3.1 to 5 years	22%	73% males	27% females
5.1 to 14 years	18%	78% males	22% females

TABLE 2: Pedigrees of Study Animals			
Birth Country		**Country of Ancestry**	
United States	82%	Chile	54%
Peru	10%	Peru	28%
Chile	6%	Mixed	12%
Bolivia	2%	Bolivia	6%

TABLE 3: Breeds of Study Animals	
Huacaya	92%
male	46%
female	44%
Suri	8%
male	75%
female	25%

TABLE 4: Coat and Iris Colors of Study Animals			
Coat Colors	Light 42% (fawn, white, silver gray)	Dark 48% (red, brown, mahogany, light or dark coffee, dark bay, black, gray)	Mixed 10% (rose gray multi-colored (brown/ gray/ white)
Iris Colors	brown 36% blue 2% (nonpigmented)	gray 36% mixed 12% (blue and pigmented)	gray and brown 14%

Examinations:

Expert Assistance Mr. Patrick J. Saine, M.Ed., C.R.A.,F.O.P.S., an expert in ophthalmic photography from Dartmouth-Hitchcock Medical Center, Lebanon, New Hampshire assisted in this study. He taught the author how to use the ocular fundus camera. Mr. Saine established the camera settings to obtain the best photographs of the various ocular structures under consideration. He photographed some of the study animals, and was a valuable advisor throughout the study.

Photographic Technique The following data refer to the fundus camera used in this study.[6] The external ocular structures were photographed with a flash setting of 5 for darker coated animals and 6 for lighter coated animals. The camera was focused on the lid margins for the cornea, and on the pupillary rough for the lens. The ocular fundus (retina) was photographed with a flash setting of 4. This setting yielded consistently good photographs regardless of the coat color of the animal. The pupil was dilated with 2 drops of Mydriacil before photographing the ocular fundus. The camera was focused on the retinal vessels for the best view of this area. It was the author's clinical impression that the lighter coated animals, especially the white animals, were most sensitive to illumination of the eye with either the fundus camera or the direct ophthalmoscope. If the pupil was not dilated with medication, it contracted down fully so that the upper and lower portions of the pupillary ruff obscured visualization of the internal structures of the eye.

Examination Techniques Each alpaca was first identified by name. Photographing a name card before shooting their ocular structures identified the animals that were photographed, approximately half of the study group. The external appearance of the eyes, including the iris, was first examined using direct visualization and the direct ophthalmoscope or the fundus camera. At this time the medication to dilate the pupil was administered.[7] It took approximately 15 to 20 minutes for the pupil to become fully dilated. After that, the internal structures were examined and/or photographed starting at the lens and moving inward to the fundus. Not all of the animals were photographed, as it became apparent that the structures and peculiarities of all of the study animals' eyes were very similar. This saved money and time. All of the examination findings were recorded on field data sheets at the side of the animal. Other identification data was entered on the sheets before leaving the farms. This data was later entered into a computer database for storage and analysis.

Results:

Description of the Alpaca Eye See Figure 1

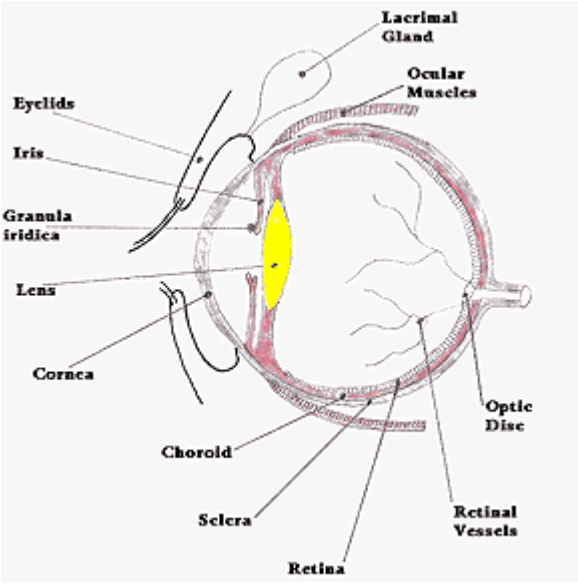

Figure 1 Adapted from a drawing by M.E. Fowler, DVM

External Appearance (see Figure 2) Alpaca eyes are relatively large for the size of the head, and are therefore very prominent. In fact, they are the first things most people notice about alpacas. The eyelashes are long and add to the distinctive appearance. The **eyelids** are usually pigmented, except in pure white animals. Some animals that are termed white in coat color actually have dark eyelid skin with no evidence of dark hairs in the coat. The **cornea** (transparent surface of the eye) is also relatively large and appears very prominent. One animal in this study had suffered a puncture wound of the cornea which involved the iris and lens as well. It was well healed and this animal did not show any evidence of visual deficit. Corneal injuries in general are uncommon in alpacas. The **conjunctiva** (the layer which covers the white external portion of the eye (sclera) and the inside of the eyelids may have varying degrees of dark pigmentation. It is usually similarly pigmented in both eyes. Some animals only have dark pigment at the limbus, the junction of the sclera and the transparent cornea. It appears as a dense, thick, thin, or speckled band in this area.

Alpacas have a **third eyelid** (nictitating membrane) which moves across the surface of the cornea from the inside corner to the outside corner. It serves to cover the eye and to protect it from perceived incoming objects. It is normally folded in the inner corner of the eye and not very prominent. This structure has a T shaped cartilage inside, which is easily visible. The surface of the third eyelid may also be pigmented to varying degrees. If pigmentation is present in this structure, it usually occurs to a similar degree in both eyes. Sometimes the pigmentation only occurs as a thin, dark line along the free edge of the third eyelid. There did not appear to be any association between coat color and the presence or amount of conjunctival pigmentation.

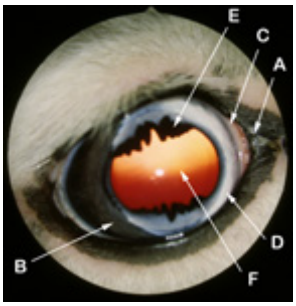

Figure 2: External Appearance of the Alpaca Eye *Note the darkly pigmented eyelid margins (A) in this all white coat colored animal. The third eyelid (nictitating membrane) (B) partially covering the bulbur conjunctiva (C) and iris (D). In this particular animal the third eyelid has heavy black pigment. The dorsal and ventral pupillary margins have prominent black granula iridica (E). The reflection from the nonpigmented ocular fundus (F) in this animal may be seen through the dilated pupil*

There are two small openings, termed the **lacrimal punta**, which collect the tears that are secreted from the lacrimal gland to lubricate the surface of the eye. They are located above

and below the inside corner of the lids on the inside. They act as funnels to collect surface fluid from the eye and direct it into a common duct system, which travels downward and exits inside the inside corner of the nostril. On occasion this duct system may become clogged and the animal will have an accumulation of mucus and debris in the eye. This duct (nasolacrimal duct) is flushed upwards into the eye through a very small catheter to hopefully clear the obstruction. In some animals the duct cannot be flushed due to scar tissue formation from chronic blockage and irritation, or due to a failure of the duct or the lacrimal puncta to form or grow properly.

Internal Structures The eye has two fluid cavities. The front or **anterior chamber** is bounded externally by the inside of the cornea and internally by the lens and iris. The normal alpaca anterior chamber is transparent, except when a traumatic injury or other inflammatory process causes precipitation of inflammatory products inside it. Injuries or inflammation may also result in prolapse of the iris or lens into the anterior chamber. One animal in this study had suffered a traumatic puncture of the eye which initially caused a portion of the iris (the colored structure surrounding the pupillary opening) to prolapse out through the cornea. Topical treatment alone with antibiotic ointment over two weeks and one month of healing time resulted in some corneal scarring and partial attachment of the iris to the inside of the cornea. The author was impressed at the lack of evidence of pain or discomfort, and the lack of evidence of visual deficit exhibited by this animal. The back or **posterior chamber** of the eye is bounded externally by the lens and iris and internally by the retina. None of the animals in this study appeared to have any posterior chamber opacities. These are sometimes observed in horses in particular among the domestic animal species.

The **iris** of the alpaca eye is a very interesting structure (see Figure 3). It is usually pigmented, often with more than one color based on the animals in this study (see Table 4). The most common colors seen were brown and gray. Some alpacas are termed blue-eyed, although this light color actually means that the iris is not pigmented at all. There has been some association found between white coat coloration, blue eyes, and deafness in alpacas. It does not occur in all white, blue eyed animals and the inheritance of this condition is under investigation. Many of the original, white, Chilean, alpaca imports and their US offspring had blue eyes. The incidence of deafness in these animals and others is not known because it has not been fully studied at present. Alpacas are also very adept at hiding weaknesses such as deafness, and this is further complicated by their herd-based behavior. A deaf alpaca could function extremely well by following its herd mates. One nine-month-old deaf male was identified in this study. He was white in color with nonpigmented (blue) irises. This animal and the other animals with fully or partially nonpigmented irises appeared to be particularly light sensitive compared to the other study animals.

There is a black structure called the **granula iridica or pupillary ruff** that extends into the pupillary opening in the iris of the alpaca. It has upper and lower sharply fringed portions which interdigitate in bright sunlight and eliminate the pupillary opening. The upper portion is more prominent than the lower portion. This structure probably serves a protective function for the deeper structures of the eye against UV light damage, especially at high altitude in the native countries of alpacas in South America. The pupillary opening is horizontally oriented and is roughly oval in shape.

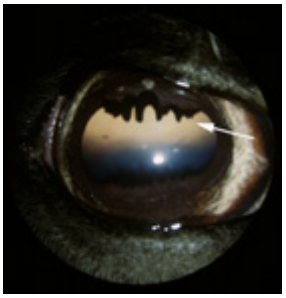

Figure 3: Alpaca Iris and Pupil (not dilated) *Eye of a 12 year-old, rose grey colored female. Note the brown and gray iris pigmentation. The light and dark coloration of the ocular fundus can be seen through the pupil. The dorsal granula iridica (arrow) is very prominent in this animal.*

The **lens** had many interesting findings in this study. In fact only one of the fifty animals had a clear lens

with no opacities of any kind. The strict definition of the term cataract is any opacity of the lens of the eye or its capsule (containment structure). This definition assumes that all opacities are abnormal. It appears that **lens opacities** are a normal finding in alpacas of all ages. The types of lens opacities seen in this study are described below and summarized in Table 5. One common opacity was a ring or rings in the area where the junction of the outer lens cortex and the inner nucleus would be expected to be. A single ring (see Figure 4) was seen in 12 animals. Multiple rings (see Figure 5) were found in the lenses of 23 animals. These lens rings varied from faint to dense in appearance. Some of the rings were distinctly round and some were thick and wavy in appearance. A single ring half way in from the periphery of the lens was seen in two animals. One animal had a faint ring and the other animal had a distinct ring in the lens at this location. Focal, distinct lens opacities seen in six animals in this study included straight and curved lines, bubbles, comets, and dots. It was noted that usually both eyes in the same animal had a similar opacity. However, one animal had a Y suture, posterior lens capsule cataract in one eye with multiple dense peripheral rings in the other eye. Three animals had large, dense opacities (see Figure 6), but no behavioral evidence of visual deficit was observed.

TABLE 5: Lens Opacities Observed in Study Animals

peripheral rings	70%	single rings 24%	multiple rings 46%
rings at midradius distance	4%		
focal opacities	12%	straight and curved lines, bubbles, comets and dots	
large, dense, central opacities	6%		
Y suture cataract	2%		

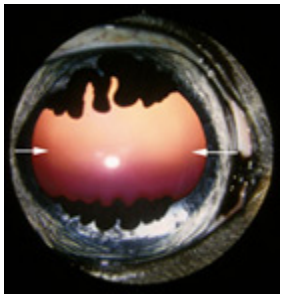

Figure 4 *Alpaca iris and lens (5 year-old gelding; red coat body with white on face). Note the mixed pigmentation of this animal's iris. It is a mixture of grey and nonpigmented (called "blue") areas. A faint lens ring is seen (arrows) through the dilated pupil of this animal. The prominent granula iridica at the dorsal and ventral margins of the pupil are easily seen in this photograph.*

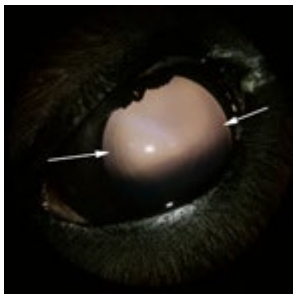

Figure 5 *Alpaca lens with multiple rings (arrows) at periphery (1.5 year-old female). Pupil was dilated with Mydriacil.*

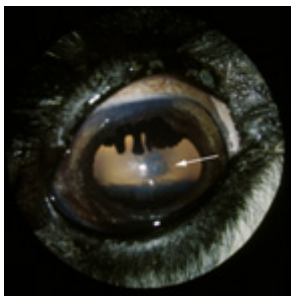

Figure 6 *Alpaca lens: Dense Central Lens Opacity (arrow) in a 14 year-old gelding.*

A **hyaloid vascular system** in the vitreous fluid in the posterior chamber of the eye apparently occurs in newborn alpacas as it does in sheep, goats, and cattle less than two weeks of age. These blood vessels have a webbed appearance and probably serve to nourish the growing lens as they do in these other species. The alpacas in this study all had obvious vessels in the first two days of life. By two weeks of age these vessels had disappeared. A large blood vessel leading from the optic nerve area of the back of the eye to the lens was also visible in most of these newborns. It sometimes appeared to wave in the posterior chamber of the eye. These vessels may be difficult to see, especially in a moving baby, unless the animal is examined in subdued or darkened light conditions. One three-year-old female did have very faint blood vessel remnants visible in the lens of one eye. She also had multiple, dense, peripheral rings in both lenses, and the other lens was partially opaque.

The **ocular fundus**, or back portion of the eye, includes the retina and optic disc (optic nerve attachment). This structure was found to have varying degrees of pigmentation, brown to gray in color (see Table 6). This coloration is from the pigment in the light sensitive retinal layers. The pigment was symmetrical in distribution, i.e.; both eyes were similarly pigmented. The retinas of two animals were not clearly visible due to the presence of dense lenticular opacities. Most of the study animals had brown pigment above the area of the optic disc and gray pigment below it (see Figure 7). Five of the fifty animals had no retinal pigment (see Figure 8). Four of these animals had white colored coats, and one was red with white on its face. Only one these five had nonpigmented irises. Their retinas appeared red in color, as the underlying choroidal blood vessels were evident. Two animals had a mixture of no pigment in the fundus above the optic disc and dark pigment below that level. Only one of these animals had any nonpigmented areas in its irises.

Usually three or four pairs of major **retinal blood vessels** exit the optic disc area at the 3, 6, 9, and 12 o'clock positions (see Figures 7, 8, and 9). On occasion a hyaloid artery remnant is seen attached to the optic disc (see Figure 9). These retinal vessels are very prominent in alpacas, and they branch out to supply the entire retina. No evidence of inflammatory disease was seen in any of the study animals.

TABLE 6: Ocular Fundus Pigmentation	
brown above and gray below the optic disc	77 %
nonpigmented	10 %
mixed pigmentation (nonpigmented above and pigmented below the optic disc	13 %

Alpaca Fundus Pictures

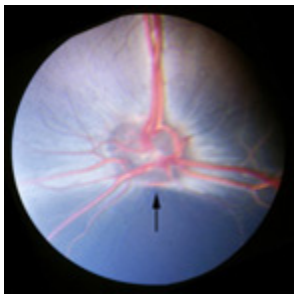

Figure 7 *Alpaca Ocular Fundus (1.5 year-old female: mahoghany coat color). Note the brown pigmentation above and the gray pigmentation below the optic disc (arrow). Three major pairs of retinal blood vessels are seen radiating out from the optic disc.*

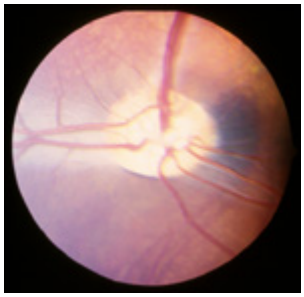

Figure 8 *Nonpigmented Alpaca Fundus (5 year-old gelding; red coat color on body and white on the face). The lack of retinal pigmentation allows direct visualization of the choroidal vasculature, and gives a red appearance on fundus examination*

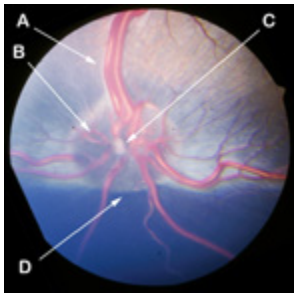

Figure 9 *Alpaca Ocular Fundus (9 month-old female; white coat color with black markings). Note the prominent retinal blood vessels (A). In this animal four major pairs radiate out from the optic disc (B). A hyaloid artery remnant (C) is seen protruding outward from the optic disc. Note the obvious demarcation in retinal pigmentation (D) which is present below the optic disc in this animal.*

PHASE 2[8]

Objectives:

1. To determine the changes in the lens appearance in both the older and neo-natal alpacas of the original study group.
2. To thereby describe what changes may be expected to normally occur in the alpaca lens over 1.5 years.

Materials and Methods:

The second phase of this study included follow-up examinations of 33 of the original 50 study animals (66 %), using a direct ophthalmoscope under subdued light conditions. These examinations were conducted approximately 1.5 years after the initial ones. The lens findings were emphasized because of the high percentage of opacities noted as previously described. All animals were treated with topical eye medication[9] prior to the examinations to dilate the pupil as in Phase 1 of the study. All of the examination results were recorded on field data sheets at the side of the animals. This data was later entered into a computer database for storage and analysis.

Results:

Neonate Group (now approximately 1.5 years old) -- All seven of the original study group neonates were reexamined. Hyaloid artery remnants were still visible after 1.5 years in 3 of the 7 animals (43%). The types of lens rings found in the original group of older animals were seen in all members of this subgroup. It is possible that some of these animals already had peripheral lens rings but they were not noted, as the pupils were not dilated in the neonates for the initial exams. This could have prevented visualization. Two of the neonates had distinct lens rings at 0.5 and 0.7 radius distance outward from the center of the lens. These should have been obvious even in a neonate and are assumed to have developed during the 1.5 years between exams. Three of the neonates were found to have dots or lines that were not observed at birth located centrally in the lens. It is assumed that these may be remnants of the hyaloid vascular system seen at birth.

Older Group of Animals The rest of the animals [26/33 (79%)] that were reexamined varied between 2.3 and 9.5 years of age. Fourteen of the twenty-six (54%) were noted to have a change in the appearance of the lens. The type of changes observed included:

1. Increase in density of peripheral rings.

2. Extension of peripheral rings inward towards the center of the lens.

3. Appearance of peripheral or more centrally located rings.

4. Appearance of central spots.

5. Appearance of a Y suture cataract in the second lens of an animal which originally only had a similar cataract in the opposite eye.

6. Appearance of hyaloid artery remnants in the posterior chamber which attached to the posterior lens capsule (This was most likely missed at the original examination.).

STUDY CONCLUSIONS

1. Alpacas have a high percentage of lens opacities.
    a. Rings in the lens are very common in alpacas of all ages and should not be considered abnormal. These rings may increase in number or density as an animal ages.
    b. Faint lines and dots in the lens are probably hyaloid vessel remnants or congenital (present at birth) defects and should not be considered significant unless they become progressively denser. Some animals appear to develop these opacities in a relatively short period of time.
    c. Hyaloid artery remnants do not appear to be associated with any opacities of the lens over a short period of time.
    d. Relatives of animals affected with lens opacities should be examined to decide about the inheritance of such findings. If no other relatives have a severe lens defect, the animals should not be removed from the breeding population. It is advisable not to repeat the same breeding pair that produced an undesirable defect. A mating which results in a neonate who has a large, dense lens opacity (i.e., one that is liable to affect vision adversely) at birth should not be repeated be-cause these abnormalities may be heritable. Affected animals should not be used for breeding as these defects may be passed on to future offspring, possibly in a more severe form.
    e. Any lens finding which becomes denser over time and maybe affect vision ought to be considered significant. Sequential exams are needed to determine if a finding is progressive, and may lead to loss of vision.
2. Buyers should have the eyes of all breeding animals carefully checked by a veterinarian as part of the

prepurchase examination .

a. Use of a short acting topical drug (Mydriacil, 1%) should be considered to do a complete exam.
b. Darkened conditions are mandatory for eye exams. In bright sun-light, the alpaca pupil tightly constricts to prevent a thorough exam.

3. Alpacas are a prey species and accordingly do not show weaknesses such as blindness in one eye or dense cataracts.
    a. An alpaca may not show any evidence of a deficit unless the vision in both eyes is severely compromised.
    b. The herd behavior of alpacas may allow a compromised animal to function normally by following its herd mates.
4. The alpaca gene pool is relatively small, and this will result in the promulgation of defective traits, such as blindness or at a minimum poor vision, if breeders do not act responsibly with regards to severe defects. All alpacas should not be selected as breeding animals for good of the species.

ENDNOTES

1. New England Camelid Services, 1847 Trebo Road, Chester, Vermont, USA 05143; Tel.: 802-875-4503; fax: 802-875-1797; email: steve@purdyvet.com; www.purdyvet.com
2. Funded through a grant by the Turro Institute for Animal Health Studies, Marietta, California.
3. Jean Feldman, DVM, Hamburg, New York
4. Hand held portable Kowa Fundus Camera.
5. Mydriacil 1% (tropicamide ophthalmic solution, USP), Alcon.
6. The author thanks the Ophthalmology Department at Dartmouth-Hitchcock Medical Center for the use of their portable fundus camera in this study.
7. The pupils of the neonates were not dilated with Mydriacil to avoid the stress as many were examined during the first few days of their life.
8. Funded by Ian, Jennifer, and Sam Lutz, Cas-Cad-Nac Farm, Perkinsville, Vermont
9. Mydriacil 1% (tropicamide ophthamalic solution, USP), Alcon.