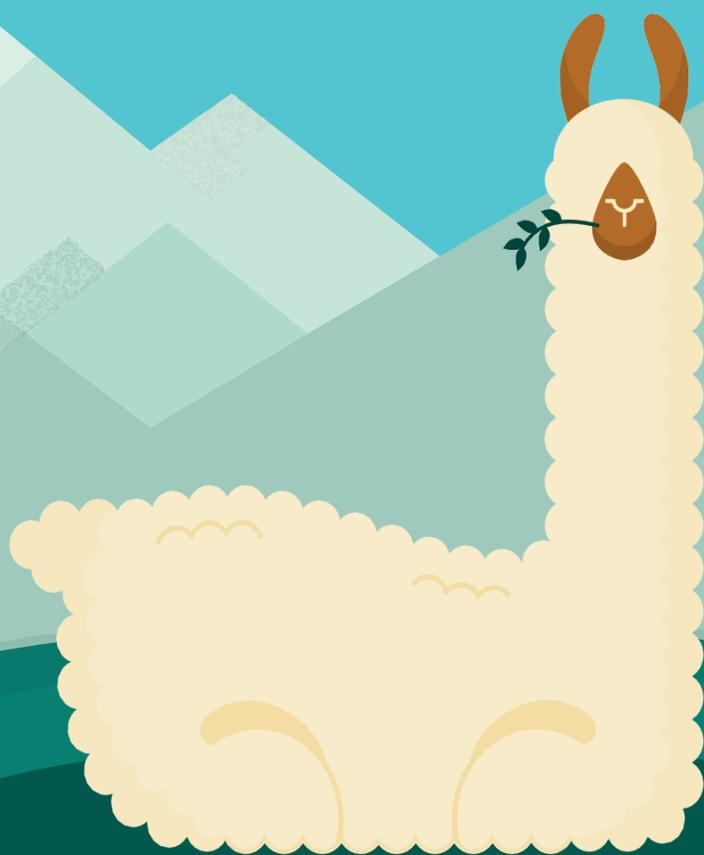


8th European Symposium on South American Camelids

4th European Meeting on Fibre Animals

# BOOK OF ABSTRACTS



26.09.2022 – 28.09.2022

Free University of Bolzano



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VEREIN ZUR FÖRDERUNG DER FORSCHUNG  
IM GESUNDHEITSEKTOR VON  
LAMAS UND ALPAKAS e.V.





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## Session 1. Biodiversity

### Colour variants of swedish finewool sheep and Rya sheep

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Swedish finewool sheep and Rya sheep are two Swedish short-tailed sheep breeds that are bred for wool traits, but the two breeds have different types of wool. Both breeds have an origin in old types of swedish sheep, but in Swedish finewool sheep some Finnsheep have been introgressed. In both breeds the sheep have three main colour types: white, black, and brown (and in rare cases also grey). Sheep owners tend to breed within the colour groups and only rarely make crosses between the different colour groups. In Swedish finewool sheep, a previous study has identified the previously known mutations in the genes ASIP and MC1R that can explain the black colour in this breed (Rochus et al. 2019). In Rya sheep no investigations of colour genes have been done before. The aims of this study are to investigate:

1. The difference between the two breeds
  2. If there are population structure within the breeds that correspond to the colour groups.
  3. If the same mutations in colour genes are responsible for colour variants in the two breeds.
- In the current study, Swedish fine wool sheep and Rya sheep from the different colour groups have been genotyped with a 50k SNP chip. Rya sheep have also been sequenced for the genes ASIP and MC1R. Analysis of the SNP data showed that the breeds are very similar to each other and they are not completely separated in a PCA plot. The SNP data also showed that although not completely separated there are some population structure that can be explained by the colour groups. The Rya sheep had a larger difference between the colour groups than the Swedish finewool sheep. We also describe the variation in ASIP and MC1R in Rya sheep and compare with previously published results from Swedish finewool sheep and a few other Swedish sheep breeds.

#### Reference:

Rochus CM, Westberg Sunesson K, Jonas E, Mikko S, Johansson AM. 2019. Mutations in ASIP and MC1R: Dominant black and recessive black alleles segregate in native Swedish sheep populations. *Animal Genetics* 50 (6): 712-717

## Study of the FGF5 gene in the fleece length on camelids of the new world

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In the four South American camelid species there are characteristics related to the fleece that differentiate the length of the fleece and even, as in the case of Suris and Huacayas alpacas, K'aras and Chak'us llamas, the type of fleece differentiates them phenotypically. The fibroblast growth factor 5 (FGF5) gene, which is a member of the fibroblast growth factor superfamily, plays an important role in the regulation of the hair growth cycle during the development of mammalian hair follicles. Mutations in the FGF5 gene have been associated with long hair phenotypes in several species including alpacas, llamas and camels. From the whole genome sequence information of the four South American camelid species we analyzed the polymorphisms present in the four species, where we found that the mutation c.499 C>T is present in both Huacaya and Suri alpacas, a synonymous SNP (c.210A>G) in Chak'us llamas, a synonymous SNP (c.300C>T) in the vicuña, a deletion of one nucleotide (c.351delC) and an insertion of 12 nucleotides (c.348\_349insGCCATATAACAT) present only in Chak'us llamas. The insertion present in llamas causes a short protein of 119 amino acids that affects the FGF5 gene and would cause long fleece growth. In the case of the c.499C>T mutation that causes a premature stop codon at amino acid position 168, it would have implications for fleece length in alpacas. Without changes in the FGF5 gene, fiber growth is not stimulated, which is what occurs with the vicuña, guanaco and llamas of the K'ara breed that present a complete length of the gene (270 amino acids). These results reveal that, if the FGF5 gene is functional, the animals will have a short fiber growth and if there are mutations that affect the FGF5 gene, the animals will have a higher fiber growth as occurs in alpacas of the Huacaya and Suri breeds, as well as in llamas of the Chak'u breed.

## Genetic diversity in alpaca *LALBA* promoter affects pGL3-luciferase expression

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$\alpha$ -lactalbumin ( $\alpha$ -La), encoded by *LALBA* gene, is a  $\text{Ca}^{2+}$ -binding whey-protein. The key function of this protein is to facilitate lactose synthesis by the galactosyltransferase component of the enzyme system, serving as a regulatory subunit. However, other biological functions have been demonstrated. For instance, it plays central roles in immune modulation, cell growth regulation, antimicrobial activity, etc. Gene promoters have transcription factor (TF) binding sites necessary for the regulation of gene expression. Mutations in the promoters have been reported to modify the transcription rates or the mRNA stability, thus affecting the protein yield. This study aims to sequence the alpaca *LALBA* promoter, identify putative TFs and detect genetic diversity affecting gene expression.

A DNA fragment (800bp) spanning the gene promoter until the complete exon 1 was amplified by PCR using 20 alpaca DNA samples. Primers for PCR amplification and Sanger sequencing were 5'-TGCACACTTTTCCAGTTCTCTGTTC-3' and 5'-ACATTCAGCCAGAGTGATGCCTC-3'. Multiple alignments and SNP discovery were accomplished by DNAsis software, whereas Transfact 7.0 was used for the TF sites search. Three independent gene reporter assays were achieved by pGL3 specific constructs to test luciferase expression (Promega) in HEK293T cells. Data elaboration was performed using JASP software ( $p < 0.05$ , student's t-test).

*LALBA* promoter and the exon 1 were sequenced in 20 alpacas. TF binding sites analysis evidenced at least 16 putative consensus sequences, including e.g. three C/EBP $\alpha$ , three Sp1, and one NF-1. Seven polymorphic sites were found. One SNP (g.15C>G) was found in the signal peptide coding region, but it is a silent mutation. The other six SNPs were detected in the promoter (g.-553A>G, g.-428C>T, g.-308C>G, g.-236A>T, g.-73C>G, g.-51A>G). The SNP g.-553A>G creates a putative binding site for the TF Sp1. This motif is a well-known enhancer element for the basal expression of many genes, including milk protein genes.

To assess the effect of this SNP on the *LALBA* promoter activity, we amplified and cloned a DNA region of 178bp in the pGL3-basic vector, upstream the reporter gene, from four homozygous individuals (two g.-553AA and two g.-553GG). The two different constructs (g.553A and g.553G), with the pGL3 vector as a control were used to transiently transfect HEK293T cells. After 48h, the reporter activity of the variants was measured using the luciferase assay system. The G variant of this SNP enhances the promoter activity of the alpaca *LALBA* ( $p < 0.01$ ). Therefore, we suppose an effective role of this binding site in the expression of the  $\alpha$ -La in alpaca milk that, consequently, may affect the functional protein roles.

## **Evaluation of the hybridization and introgression between llamas and alpacas in Bolivian populations using “Y” chromosome and mitochondrial molecular markers**

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Traditional llama's and alpaca's husbandry is an important economic activity in the Bolivian highlands. While alpaca fiber is more demanded for its higher quality, llamas are raised for consumption and marketing of their meat. In several regions, farmers raise both species, sometimes in mixed herds, where interspecific mating could affect the productive characteristics of fiber and meat. Genetic and genomic studies have shown the presence of introgression and hybridization in the populations and genomes of domestic camelids, especially in alpacas. This information generates confusion about phylogenetic relationships and potential origin of domestic South American camelids. The application of sex-linked markers (mitochondrial and Y chromosome) allows inferring about the direction of hybridization between related species. The objective of this study was to evaluate the hybridization between llamas and alpacas, inferred through the use of markers of the "Y" chromosome (DBY intron fragment) and mitochondrial (D-Loop fragment) in three populations with possible presence of mixed raising. Three haplotypes were identified in the DBY intron and 28 in the D-Loop region. With DBY marker; we found 4,3% of introgression in llamas and 1,3% in alpacas, whereas with mitochondrial DNA marker; the level of introgression was of 4,48% in llamas and 58,88% in alpacas. Despite in Catacora farmers are more focus in producing alpaca fiber, we found more extended introgression in the mitochondrial sequence (81,25%) than other populations, that could suggest a previous and extended hybridization in alpacas populations. In regard to the directionality of genetic flow, this was higher between female llamas and male alpacas. The asymmetric pattern of the paternal vs. maternal genetic flow, frequently observed among the alpaca populations of the study regions, could be related to the breeding management of camelids males, the adaptive hybridization in alpacas and other effects of the natural selection. Another explanation of the direction of the flow could be discussed around the origin and domestication process of alpacas. If we assume the theory that llamas were domesticated from guanaco and alpacas from a cross between llamas and vicuñas, considering a mate between male vicuñas and female llamas, this patron of hybridization could be supported. Finally, the use of a single marker of the “Y” chromosome limits the interpretation of the results at phylogenetic level, therefore, genomics studies of domestic camelids, will allow a better characterization of this phenomenon.

## Session 2. Breeding and genetics

### Resuming wool: a strategy for active conservation of an Italian Merino-type sheep breed

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Italy has a relevant genetic repertoire of fine-wool Merino-type sheep breeds, including Gentile di Puglia, Sopravissana and Merinizzata Italiana. Similarly to other European Merino-type sheep breeds, they have experienced, mainly in the second half of the last century, a significant size contraction, paralleled by a drop in the commercial interest for wool. New interest in natural and sustainable textile products has recently emerged, bringing wool back into the spotlight for its unique properties, being naturally durable, dirt-, odour- and fire-resistant, anti-static, breathable, water-repellent, renewable, and bio-degradable. Genetic improvement of wool traits through traditional breeding methods based on phenotype recording is well documented, mainly in large sheep wool countries, and the most notable results have been achieved for traits with high heritability, like fleece weight and fiber diameter. Most studies on Italian sheep wool quality attributes dates back to the 1950s and 1960s and they possibly do not reflect anymore the current situation, given the poor attention in selectively breeding for wool traits during the last decades. Since collecting reliable and representative individual phenotypes is the basis for an effective selection process, by focusing on the Gentile di Puglia breed, we started collecting, in a single flock in the province of Foggia (Apulia, Southern Italy), wool samples from adult animals registered to the ASSONAPA herd-book (106 ewes and 16 rams). Wool sampling was performed in the dorsal region, halfway between the last rib and the crest of the ileum, using a standard shear for normal shearing. For each sample, we assessed the average fiber diameter using the greasy wool staples analyzed in a Fibrelux® instrument, recently made available at the laboratory of the regional breeder association (ARA Puglia). The mean fiber diameter per animal was  $26.27 \pm 1.25$  micron in ewes and  $26.01 \pm 1.03$  micron in rams. The mean variability coefficients were 4.87 and 3.98 in ewes and rams, respectively. The results show that the Gentile di Puglia retains the Merino-type wool characteristics, though falling in the larger micron ranges expected for these sheep stock, thus highlighting that there may be room for selective improvement in this sheep breed. Once validated using the IWTO-approved OFDA methodology, we will extend the Fibrelux® analysis to additional samples from different Gentile di Puglia flocks, also including fiber length measurements, in order to get an overall picture and start assessing phenotypic correlations among wool traits. **ACKNOWLEDGEMENTS:** Letizia Temerario was supported by PhD Program 2020 FSC - Piano Stralcio "R&I 2015-2017", University of Bari, Italy. The work was partially supported by the Dept. Research, Innovation and Institutional Capacity of the Apulia region ("Woolly" Project).

## **The Sopravissana sheep: three centuries of resilience, meat, fiber and far more**

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The Sopravissana is the only descendant of the process of selection of merino sheep in the Pontifical State, wanted by Pope Pius VI and started in 1792 with the purchase of a flock of Spanish merinos operated by the Jesuit Gonzalo Adorno Hinojosa with the aim of providing improved rams to all the "masserie" of the State.

At that time, wool was the main product of sheep and the crossing with Merinos was used to increase the amount of fleece and improved the quality of the yarn.

Some families of sheep breeders from Visso, in particular the Piscini, continued the selection process culminating in 1942 with the establishment of a breed called precisely "Sopravissana". The agricultural and industrial conversion of the Agro Romano, has made this territory unavailable to the seasonal stationing of sheep, causing the abandonment of transhumance, with a drastic reduction of the heads; a new productive selection towards quantitative traits, with the increasing in the production of the milk has strongly penalized the Sopravissana, only because it produces less quantity of milk, ignoring its best quality. In fact, its products, in addition to the high quality of the wool, are "romanesco" cheese, and lamb named "abbacchio"; all of these have their own characteristics and can therefore be recognised for their real uniqueness.

The relaunch of this breed, necessary to restore the economy of Valnerina territory strongly affected by the earthquake of 30 October 2016, can be based on short and sustainable supply chains of meat and wool, directed to new markets and new production realities.

An example is offered by Fiber Art, in strong expansion, in which textile material, wool, becomes an artistic tool and a language of contemporary art.

In addition, the recovery of the traditional semi-wild breeding system of Sopravissana, in its natural environment is reflected in the quality of its production.

Appreciation for products must also be translated into the social recognition of the work of producers, who are often denied not only a fair remuneration, but also the dignity of their efforts.

## The wool quality of Jezersko-Solčava and Improved Jezersko-Solčava sheep in Slovenia

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The aim of the study was to determine the wool quality traits of local Jezersko-Solčava (JS) and Improved Jezersko-Solčava (JSR) sheep breeds in Slovenia. JS originate from the ancient Zaupeel sheep improved with the Bergamasca and the extinct Paduan sheep. JSR was developed later when a part of JS population was improved with Romanov sheep, with the aim to enlarge the litter size. Fleece samples belonged to 88 young JS (45) and JSR (43) rams included in the performance test for growth in the year 2020. Rams were selected from different flocks throughout the country according to the breeding program. Fleece samples were taken from the left side of the body at the end of the test period when all rams were sheared with Bowen technique at the average age of 249.38 days. The fleeces weight (FW) were recorded as well. Samples were sent in the laboratory of AAFT ([www.aaft.com.au](http://www.aaft.com.au)) in Finland where fibre diameter (FD), comfort factor (CF), spin fineness (SF), staple length (SL) and fibre curvature (FC) were determined. In JS, the average FW was  $1.58 \pm 0.39$  kg, FD was  $30.17 \pm 2.65$   $\mu\text{m}$ , CF was  $56.32 \pm 15.12\%$ , SF was  $29.87 \pm 2.69$   $\mu\text{m}$ , SL was  $81.11 \pm 14.53$  mm and FC was  $49.00 \pm 7.92$  degrees/mm. In JSR, the average FW was  $1.49 \pm 0.31$  kg, FD was  $26.67 \pm 2.05$   $\mu\text{m}$ , CF was  $76.23 \pm 11.22\%$ , SF was  $26.50 \pm 2.26$   $\mu\text{m}$ , SL was  $79.76 \pm 12.97$  mm and FC was  $47.98 \pm 8.08$  degrees/mm. The MIXED procedure (SAS/STAT) considered fixed effect of the breed, age at shearing fitted as linear regression and the flock of origin as a random effect. The effect of the breed significantly affected the FD, CF and SF. The effect of age significantly affected only the FW, which increased with the age of the ram at shearing. The random effect of the flock of origin contributed a relatively large part of the phenotypic variance for fleece weight (0.30). The FD and SF were lower in JSR ( $26.70 \pm 0.37$   $\mu\text{m}$ ;  $26.53 \pm 0.39$   $\mu\text{m}$ ) compared to JS ( $30.15 \pm 0.36$   $\mu\text{m}$ ;  $29.85 \pm 0.38$   $\mu\text{m}$ ), respectively. Consequently, comfort factor was higher in JSR ( $75.99 \pm 2.08\%$ ) compared to JS ( $56.54 \pm 2.01\%$ ). The results confirmed that improving JS population with Romanov sheep which started 40 years ago have not decreased the studied wool quality traits of the JSR breed.

## **Improving a black alpaca breeding program using colourimeter values for male selection**

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In recent years, consumers have been more interested in using eco-friendly garments. The alpaca textile industry does not escape this trend, where products based on natural colours such as black would not need to be dyed, reducing the use of chemical products. So there is an economic interest to increase the number of alpacas with uniform black coat colour. Using colourimetry in testing the fibre colour will help implement a sound black alpaca breeding program. Colourimeter values as L\*(lightness), a\*(red/green axis), b\*(yellow/blue axis) values were recorded from 1,254 Dark Brown Black (DBB) and Black (B) alpacas of the Pacamarca Research Station. The model included the following effects: year in 4 levels (2018 to 2021), sex in 2 levels (male and female), coat colour in 2 levels (DBB and B). The means of the colorimeter parameters were: DBB= 18.47, 1.48 and 1.08, B=17.59, 0.79 and -0.03 for L\*, a\* and b\*, respectively. No significant difference was found for sex and year. However, a significant difference was found in the coat colour. In addition, a factorial analysis was carried out, including year and coat colour, finding that the interaction of both effects was significant. In 2018 the Black Alpaca Program started by classifying DBB and B females and B males by visual appraisal. As a result, only 40% of the offspring could be classified as B. To increase the number of black offspring, the selection of males was refined using the L\* and b\* values, where lower L\* values and negative b\* values are indicators of black fibre. Therefore, in 2021 the same females had 79% black offspring. Also, a phenotypic trend for decreasing L\*, a\* and b\* values was observed in the offspring: year 2019= 20.80, 1.38 and 1.59; year 2020= 17.72, 0.97 and 0.37; year 2021= 17.14, 0.72 and -0.13 for L\*, a\* and b\* respectively. In sum, the use of colourimeter values helped to form a more uniform black alpaca herd.

## Polymorphisms in *MC1R* and *ASIP* genes associated with color phenotypes in alpaca huacaya

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The wide phenotypic diversity in alpacas results from human selection by color phenotypes that favored the fixation of main alleles in *MC1R* and *ASIP* genes. In this context, the objectives of this study were: to characterize the fiber color by colorimetry and identify the main polymorphisms in *MC1R* and *ASIP* genes associated with black and brown alpacas. Fiber and blood samples of 98 alpacas were obtained from Pacamarca Research Station; and 9 vicuñas from Abancay province were considered as reference for this study (Peru). Fleece color phenotypes were determined by colorimetry using Chroma Meter CR-210. DNA was extracted from 200  $\mu$ L of EDTA anticoagulated blood using the commercial kit (Quick-DNA™ Miniprep Plus Kit). Polymerase chain reaction (PCR) primers were designed to amplify *MC1R* and *ASIP* genes following Daverio et al. (2016). For all PCR products purification we used exo-sap method, with enzyme ExoASP-IT® (usb). The purified amplicons were sequenced by the Sanger method at MacroGen Inc using the original PCR forward and reverse primers. Complete *MC1R* and *ASIP* coding sequences for each animal were obtained and analyzed using Geneious Software Version 11.1.5. The *CIE L\*a\*b\** system,  $L^*$  = lightness showed low values in eumelanic alpacas (black and black-brown) and high values in white, pheomelanic brown alpacas and vicuñas. Coding sequence of *MC1R* (CDS) consisted of 954bp and encoded a 317 amino acid protein. Inside of CDS a heterozygous deletion *c.224\_227del* and nine SNPs were observed; 5 non synonymous SNPs: *c.82A>G*, *c.259G>A*, *c.376G>A*, *c.587T>C*, *c.901C>T* (p.T28A, p.M87V, p.G126S, p.F196S, p.R301C, respectively) and 4 synonymous SNPs: *c.126C>T*, *c.354C>T*, *c.618G>A*, *c.933A>G*. Two non-synonymous polymorphisms (*c.292C>T* and *c.353G>A*) and a 57bp deletion (*c.325\_381del*) were identified within exon 4 of *ASIP* gene. The five non synonymous SNPs at *MC1R* and the mutations at *ASIP* define the recessive genotypes (*ASIP*) together with the dominant genotypes at *MC1R* (*EEaa*) in black and black-brown alpacas, heterozygote genotypes for both genes (*EeAa*) was observed in brown, dark brown and black alpacas. The wild genotype ( $E^+E^+A^+A^+$ ) was observed in white, brown alpaca and vicuña. The nine vicuñas have the wild allele without deletion in *MC1R* and *ASIP* genes. In sum, there is more than one genotype for black and brown phenotypes. Likewise, for each genotype described we also observed black and brown phenotypes; then it would be explained by the epistatic interaction between *MC1R* and *ASIP* genes.

## Genome sequencing of the four camelid species of the new world

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Understanding the changes that occur at the genetic level in camelids allows us to have a deeper understanding of how these changes allow the differences at the phenotypic level of the four species of camelids of the new world. In this work we have sequenced the complete genome of 16 alpacas (8 of the Huacaya breed and 8 of the Suri breed) of white, brown, black and Light fawn fleece, 6 llamas (4 of the K'ara breed and 2 of the Chak'u breed), one vicuña and one guanaco with an effective mapping depth that is between 45.7068 X and 62.4944 X, the GC content is 39.67 %. The mapping rate of the samples varies between 99.6 % and 99.79 %. We found an average of  $10.42 \times 10^6$  SNPs (the lowest in vicuña with  $9.74 \times 10^6$  SNPs and the highest in a llama of the Chak'u race with  $10.89 \times 10^6$  SNPs). For InDel the animal with the highest rate of homozygous InDel is a two-color Chak'u llama (74.16%) and the one with the lowest percentage is the vicuña sample (73.49%). As for inversions a K'ara llama has the largest number (2,195) and the smallest is a thick brown alpaca (1,417). Regarding intrachromosomal translocations (ITX), the highest number was found in the sample of a guanaco (8,864) and the lowest number in a thick brown alpaca (6,167). For interchromosomal translocations (CTX) the highest number was obtained by a thick white suri alpaca (70.038) and the lowest by a thick brown alpaca (58.134). Finally, as for CNVs the highest number of losses was found in a K'ara llama (127), the lowest number of losses in a fine white alpaca (86), the highest number of gains in a thick white suri alpaca (79) and the lowest number in a fine white suri alpaca (59). The number of SNPs found will be the basis for a future SNP microarray to identify genes of interest in both domestic and wild camelids. At the same time, we are the first group to find CNVs and SVs (Structural variants such as inversions and translocations, which by affecting one or more genes in greater size would have a very important role in traits of interest for camelids of the new world.

### **Session 3. health and reproduction**

#### **Candidatus mycoplasma haemolamae - a first idea of prevalence in german llama and alpaca flocks**

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Candidatus Mycoplasma haemolamae (CMh) is a hemotroph mycoplasma species. The disease causes chronic to acute infections in llama and alpaca flocks world-wide. A few studies already showed alarming prevalence of up to 29% in European countries. In addition, the population of New World camelids sharply rose without emerging disease control by the state vets over the past two decades in Middle European countries. Consequently, one has to expect an increasing prevalence of CMh infections in German llama and alpaca flocks. Therefore, our working group started a prevalence study in a small number of llama and alpaca farms in Germany. The results will give a first estimation of the real prevalence of CMh in German New World camelid flocks, although a small sample size was only available to investigate. This prevalence data will support the establishment of prevention strategies to protect uninfected flocks from infection with CMh. Prevalence data and data about the spread velocity within single flocks will be provided in the presentation.

## **Reproductive management of llama and alpaca flocks in Germany - results from a survey among animal owners**

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In recent years, breeding of New World camelids (NWC) became very popular in Germany. Good practice of reproductive management is required to receive healthy animals without behavioural disorders. Further, the diverse kinds of purposes place high demands on NWC for example such as private or touristic trekking tours and pet-faciliated therapy. However, it can be assumed that the rapidly increasing NWC population, together with a lack of knowledge, has resulted in over-demand on the owners. Therefore, our working group conducted a survey to assess the current reproductive management practice. The survey was addressed to NWC owners from all over Germany. Results will be provided in the presentation. Topics will include selection criteria of stallions, pregnancy diagnostics and birth and cria management.

## **Effects of photoperiod on cashmere shedding synchronization and its mechanism in hanshan white cashmere goats**

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This paper mainly studied on cashmere shedding synchronization and cashmere growth in Hanshan White Cashmere (HWC) goats treated by different length of photoperiod in Telogen (from January 30 to April 20. 100 female 2 years old (second shearing) goats were divided randomly in two groups A) and B) each of 50 goats, group A will be bred in traditional way, group B will be subjected at Light Control Activity (LCA) to 15h totally. All the goats were collected the following samples every month, skin samples, fibre samples, blood samples. Finally, the outcombed trials was carried in 6 sampling areas of each goats. The level of melatonin in plasma of goats in A group were higher than that of in B group, but the prolactin and IGF-I was greatly increased. Compared with the A group, the combing amount of each part was slightly increased. The cashmere quality was no difference in the diameter and CV of the two groups, but the combing strength and combing time are both reduced in group B. The hair follicle activity in the B groups was significantly lower than that in the natural light groups.

## Session 4. Nutrition

### Nutritional biology and energy expenditure in South American camelids

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South American camelids (SAC) are ruminating animals and thus share certain physiological and nutritional features of ruminants. However, SAC also have many distinct nutritional and physiological differences compared to ruminants, e.g. glucose metabolism, forestomach physiology, urea metabolism etc. Furthermore, SAC are generally more efficient in digesting lower nutritional quality feeds, compared to ruminant species, reflecting an adaptation to harsh and adverse environmental conditions. While there are some studies on the nutrition in SAC, less information is available on the early life stages (i.e. suckling young) and the daily energy expenditure in adult SAC. Thus, this talk will highlight some aspects of the nutritional demands in suckling young and the daily energy expenditure in adult animals.

In several studies milk intake in suckling llama crias and output in lactating dams was measured using an isotope dilution technique. Compared to different ruminant species, the milk production in llamas appears to lie between small to medium sized wild and domestic ruminants, i.e. 2-3 kg per day. Extrapolating energy intake data shows that the maintenance energy requirement for suckling llamas is around  $310 \text{ kJ/kg BW}^{0.83}$  per day. In lactating dams calculating the required metabolizable energy intakes for lactation from milk output data and gross energy content of milk revealed that with increasing lactation stage, metabolizable energy requirements per day for lactation decreased but remained constant per kg milk output.

Daily energy expenditure in free ranging female non-lactating SAC were measured using the doubly labelled water technique, in a temperate environment (Germany) and in their natural high-altitude Andean habitat (Peru). The method involves the enrichment of the body water with both stable oxygen and hydrogen isotopes. The difference between the elimination rates of hydrogen and oxygen isotopes is used to estimate the CO<sub>2</sub> production, which together with the respiration quotient yields the O<sub>2</sub> production and thus an estimate of the daily energy expenditure. The studies showed that llamas kept at the Andean high plateau have an exceptionally low energy expenditure compared to ruminant species, thus providing evidence for their adaptation to the harsh Andean climatic conditions and low-quality food supply. Contrarily, alpacas have comparable daily energy expenditures to similar sized ruminant species and thus a relative higher daily energy expenditure compared to llamas, which might be due to their additional metabolic requirements for fine fibre production.

## Effect of dietary protein on postpartum reproductive performance in alpacas

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The role of nutrition, especially the roles of energy and protein status, on reproductive performance of production animals has been well researched. Comparatively, a true paucity of information in the literature is available relative to nutritional mediation of reproductive performance in llamas and alpacas. Following seasonal patterns of feed availability in South America, adverse effects of nutritional deprivation on reproductive performance is well recognized, suggesting similar nutrition-reproduction interrelationships. The objective of this study was to determine the effect of dietary protein content during late pregnancy on alpaca reproductive performance. A total of 48 mature female alpacas were randomly assigned to one of three prepartum diets differing only in their crude protein content (80, 110 and 140 g/kg dry matter) from 30 days prior to calving through 45 days postcalving. Dietary protein was modified by inclusion of urea to the basal diet. Animals were housed in individual pens to determine intake. Body weight (BW) and dry matter intake (DMI) were repeatedly measured. Blood was collected at days -7, 0 and 7 relative to calving (day=0) for urea nitrogen (BUN) concentration. Reproductive performance was evaluated via blood progesterone concentrations and ultrasound imaging of ovarian structures. Data within study were analyzed by ANOVA for repeated measures and t-test mean comparisons. There was no effect of treatment on body weight throughout the study (initial BW  $69.5 \pm 4.1$  kg). Dietary treatment influenced BUN concentration. At day 7, mean BUN was  $14.1 \pm 2.6$ ,  $17.5 \pm 3.8$ , and  $24.0 \pm 4.1$  mg/dL in low, medium, and high protein groups, respectively ( $P < 0.05$ ). Prepartum DMI ( $1.58 \pm 0.7$ ,  $1.69 \pm 0.5$ ,  $1.75 \pm 0.8$  kg/d) increased ( $P < 0.05$ ) linearly with dietary treatment, respectively. Postpartum intake (kg/d) was not different between medium ( $1.72 \pm 0.7$ ) and high ( $1.77 \pm 0.7$ ) protein groups and both were greater ( $P < 0.05$ ) than low ( $1.64 \pm 0.7$ ) protein alpacas. Both low and high protein group alpacas had impaired ( $P < 0.05$ ) pregnancy (56.2% and 37.5%) outcomes and lower progesterone (4.2 and 4.1 ng/mL) at 30 d compared to the medium (75.0%, 6.0 ng/mL) protein group. A higher rate of embryonic mortality (50%) and endometritis (43.7%) was observed for the high protein group. A lower ( $P < 0.05$ ) ovulation rate was found in low (71.4%) protein compared to medium (93.7%) or high (93.7%) protein group alpacas. These results suggest alpacas show similar negative effects of low or excess dietary protein on reproductive performance identified in dairy cattle.

## Blood calcium-phosphorus product as a proxy for vitamin d status in camelids

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The study objective was to retrospectively investigate potential for using the product of blood calcium and phosphorus concentrations (CaxP) as a proxy measure of camelid vitamin D status. Blood concentrations of Ca, P, and vitamin D (n=1188) determined in previous camelid vitamin D research studies and a clinical case of herd vitamin D intoxication were used to generate CaxP values relative to the animal's measured vitamin D concentration relative to potential vitamin D toxicity or deficiency. Data were subjected to analysis of variance with fixed model effects of CaxP, study (n=6), age category (n=3), gender, and their two-way interactions. Year and season were used as covariates. Age categories were crias (0-12 mos.), tuis (12-24 mos), and adults (>24 mos). Threshold values were determined using receiver operator curve analysis. Phosphorus concentration was more highly correlated (r=.96) to CaxP than was Ca concentration (r=.23-.45) across groups. Vitamin D concentration was influenced by all model effects and analysis was separated by age category and vitamin D exposure (low vs. high). CaxP was not affected by vitamin D but was influenced by age category (P < .05) and vitamin D x age interaction (P < .05) in low vitamin D. In contrast, CaxP was influenced (P < .05) by vitamin D in high exposed animals. Least squared mean (LSM) CaxP was 79.1 ± 15.0, 63.9 ± 15, and 47.3 ± 15 mg<sup>2</sup>/dL<sup>2</sup> (all P < .05) for low exposure crias, tuis, and adults, respectively. For animals exposed to high vitamin D, LSM CaxP was 110.6 ± 26.3, 66.4 ± 7.2, and 55.8 ± 3.0 mg<sup>2</sup>/dL<sup>2</sup> for crias, tuis, and adults, respectively. In both cria and tuis age groups a CaxP ≤ 50 mg<sup>2</sup>/dL<sup>2</sup> was associated with lower serum vitamin D concentration 56.9 ± 26.8 vs 132.6 ± 8.2 nmol/L (P < .05) and 78.3 ± 25.1 vs 184.1 ± 13.2 nmol/L (P < .05), respectively. Within the adult age group, a CaxP ≥ 60 mg<sup>2</sup>/dL<sup>2</sup> was associated with high vitamin D exposure (P < .05). Mean CaxP for adults injected with a single high vitamin D dose or exposed to a chronic high dose were 56.6 ± 2.3 and 57.5 ± 2.3 mg<sup>2</sup>/dL<sup>2</sup>, which was lower (P<.05) than healthy adults (48.1 ± 3.1 mg<sup>2</sup>/dL<sup>2</sup>) or orally supplemented adults (47.6 ± 4.1 mg<sup>2</sup>/dL<sup>2</sup>). Study findings suggest the product of serum Ca and P concentrations (mg/dL) can be used to define potential vitamin D toxicity (>60 mg<sup>2</sup>/dL<sup>2</sup>) llamas and alpacas and may be useful for vitamin D deficiency (< 50 mg<sup>2</sup>/dL<sup>2</sup>) in crias.

## **Effects of dietary supplementation with n-carbamylglutamate on maternal endometrium and fetal development during early pregnancy in inner Mongolia white cashmere goats**

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This study investigated the effects of dietary supplementation with N-carbamylglutamate (NCG) on maternal endometrium and fetal development during early pregnancy of Inner Mongolia White Cashmere Goats. Forty-eight pregnant Inner Mongolia White Cashmere Goats (average age three years old, average lactation parity 2, and average body weight  $43.81 \pm 2.66$  kg) were randomly allocated to three groups: a basal diet (Control group, n = 16), a basal diet plus 0.30 g NCG/d (NCG1 Group, n = 16), and a basal diet plus 0.40 g NCG/d (NCG2 Group, n = 16). All of the does were housed in individual pens and the NCG treatment was conducted from day 0 to day 90 of pregnancy. At day 17 and 90 of pregnancy, six representative pregnant does in each group were slaughtered. The current study results demonstrated that maternal NCG administration during early pregnancy effectively increased the arginine family of amino acids and the glucogenic amino acids concentrations, and promoted the mRNA expression of OPN,  $\alpha v$  and  $\beta 3$  integrins and endometrial development of Inner Mongolia White Cashmere Goats. The supplementation improved the fetal BAT stores and the mRNA expression of UCP-1 and BMP7, thereby helping to the fetal early development.

## **Effects of dietary phosphorus on puberty and reproductive performance in female alpacas**

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Phosphorus (P) is considered the first-limiting mineral in extensive pastoral systems such as the situation in the Peruvian Altiplano for alpaca production. Study objectives were to determine dietary P effect on growing female alpacas relative to puberty and reproductive performance. The study was completed in the communal cooperative "San Pedro de Racco" located in Simón Bolívar district, Cerro de Pasco region between September and March. Weaned female alpacas (n=48) with an average age of 8 months and live weight of  $25.25 \pm 1.62$  kg were used in the trial. Alpacas were randomly assigned to one of three diets differing in P concentration (1.6 Low, 2.5 Med, and 3.4 g/kg High). Animals were housed in individual pens to measure individual dry matter intakes (DMI). Food and water were provided ad libitum. Body condition score (BCS) assessment was performed on a scale of 1 to 5 (1=thin and 5=obese). Body weight (BW) was determined with an electronic platform balance at a frequency of 15 days. Serum inorganic P concentrations were determined by colorimetry every 30 days. Ultrasonography was used to monitor follicular growth, ovulation, and pregnancy status. Puberty was defined by first ovulation. Blood progesterone was determined following ovulation and breeding. Data were subjected to ANOVA for repeated measures with main effects of treatment, time, and their interaction. Serum P increased with dietary treatment, though there were no difference between Med and High groups. Increasing dietary P resulted in increased BW, BCS, and DMI with Low group values lower ( $P < .05$ ) compared to Med and High groups. Puberty was displayed starting in October (n=1) through April (n=3) with most occurring in December (n=14) and January (n=11). Assuming a similar final mature BW of 62 kg, alpaca females achieved puberty between 46.5 and 57.2% of mature BW with the majority occurring at 54-55%. Puberty was not achieved by 14 months in 4 Low and 1 Med alpacas. Ovulation percent was lowest in Low (77.7%) compared to Med (91.6%) and High (86.6%) groups. Pregnancy success was highest in High (10/16, 62.5%) compared to Med (7/16, 43.8%) and Low (4/16, 25%) groups. Blood progesterone concentration at d 13 postovulation was higher ( $P < .05$ ) in High ( $5.3 \pm 4$  ng/mL) compared to Med ( $4.4 \pm 6$  ng/mL) and Low ( $4.2 \pm 6$  ng/mL) group alpacas. Results suggest dietary P less than 2.5 g/kg may not adequately support good growth, but 3.4 g/kg may improve reproductive performance in alpacas.

## **Interaction between vicuñas and sheeps in the Reserva Nacional Pampa Galeras , Peru**

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The high mountain extends over 3800 masl and is home to camelids, which are a source of diverse benefits linked to the production of fiber and food security for high Andean families. The vicuña is relevant due to the fineness of its fiber. The Reserva Nacional Pampa Galeras (RNPG) has been home to vicuñas since ancient times; in addition, domestic animals coexist with vicuñas in the highland. The objective of this study is to analyze the effect of the presence of sheeps on the temporal stability of vicuña populations under a system dynamics approach. To reach this purpose, we raise a socio-ecological model that considers the main relationships of the highland ecosystem and four scenarios that consider perturbations in the variables associated with ovines (sheep consumption and time spent in the RNPG) and changes in precipitation (permanent rains with different intensity, rains with pulses of maximum and minimum in intervals of ten years, and random rainfall). The results indicate that sheep have no direct influence on vicuña populations, given that the vicuña population in all scenarios tends to be self-regulating. The ovine population shows a heterogeneous concentration in the reserve and its permanence is temporary and associated with the rainy season, which suggests that the farming families access the reserve to use marginally the pastures during the dry season, while the farming families do not use the reserve's pastures during the rainy season. In the scenario under permanent low rainfall, the growth rates of vicuñas are negative; but in a permanent rainy season, the growth rates of vicuñas become positive. The behavior of the sheep shows an inverse behavior with respect to vicuñas. In a scenario with pulses of intense rainfall, it is evident that the vicuña population would grow in the first decade, but without exceeding 3,000 vicuñas; and then, in the following decades, the population would stabilize, incorporating recurring oscillations that would not be pronounced until the end of the horizon of the model. In the climatic eventuality, it would appear that the vicuña population not only tends to decrease but also shows oscillations, the intensity of which decreases over the proposed horizon. Meanwhile, in scenarios of a scarcity of precipitation pulses, the behavior of the vicuña population shows oscillations, the intensity of which decreases as the proposed horizon progresses. Finally, in the scenario under random precipitation, the behavior of the vicuña population shows an accumulation in the class whose class mark is 3159 vicuñas for year 30. In a context of random precipitation, the farming families that access the reserve have it as a survival strategy, reduce the size or accept the low meat content of their sheep flocks, as an effort to conserve "insurance" to face difficult times.

## Session 5. Fibre metrology

### Development of a novel device to determinate incidence medullation of white alpaca fiber

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The natural presence of medullated fibers within alpaca fleeces is an important characteristic for textile industry, because they affect the quality of fabrics and garments (McGregor, 2006). A high incidence of medullated fibers reduce quality and price of alpaca fibers; therefore, is conveniently to decrease incidence of medullation, specifically of strongly and continuously medullated fibers. Currently, projection microscope method (PM) is applied to determinate incidence of medullated fibers, but it is expensive, laborious, time-consuming and non-practical (Czaplicki, 2012). For these reasons, this research was carried out in order to development a device that determinates the incidence of non-medullated, fragmented, un-continuous, continuous, and strongly medullated fibers (NM, FM, UM, CM, and SM, respectively), on automatically and fast way using artificial intelligence (AI) technology. This device is composed of four sub systems: electronical, mechanical, optical and informatic. An AI-based model was developed and it was incorporated within in the AI-based software. This software installed in a computer, contains the controls to configure and make use of the system. It also served as the orchestrator between the electronic system, the optical system and the AI engine. The results of incidence of NM, FM, UM, CM and SM in 4810 fibers were compared with PM, and two-proportion z-test was used to statistical analysis. The device develop was named Smart Fiber Medullometer (S-Fiber Med), and it is portable, because it weighs only 2.8 kg, and is easily transportable in a small backpack. The S-Fiber Med scanning snippets of fiber sample prepared on slides covered with coverslip according to IWTO-8-11 (IWTO, 2017). During scanning, it captures thousands of fiber images and they are processed with AI-based software to identify NM, FM, UM, CM and SM fibers. The S-Fiber Med identifies  $1736.95 \pm 109.88$  fibers/sample in about 40 seconds/sample. The device assesses the medullation of white, beige and light fawn fibers only, because its AI-based software needs to identify fiber images that show the different types of medullas. At z-test was found none significantly difference between PM and S-Fiber Med when proportions of NM, FM, UM, CM and SM fibers were compared (p-values: 0.47, 0.37, 0.54, 0.66 and 0.32, respectively). It is concluded that S-Fiber Med identify fibers according medullation in practical way, and it could be utilized at the animal production, textile industry and fiber market with practical purposes. Also, its use could be extended to mohair, cashmere, wool and other fibers.

## **Development of a software based an artificial intelligence to determine density fiber on skin alpacas**

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The fiber and hair-duct density (FDen and DDen) are important features of skin that are related with the production, and quality of alpaca fibers (Nagorcka, 1995), and they can be new selection criteria within a program of animal selection. However, their measure should be practical, fast, and low-cost. Currently, the device called Fiber Den measures fiber and hair-duct from the skin, but the counting of fiber and ducts is semi-automatic. The procedure takes about ten minutes per animal (Quispe y Quispe, 2019) and it is laborious. For this problem, the research was carried out in order to develop software that is capable of determining the fiber and hair-duct density in an automatic and practical way. Initially, 289 photographs from mid-side shaved skin (area: 5 x 5 cm<sup>2</sup>) of Huacaya alpacas were taken with the Fiber Den microscope. Then, 1087 ducts and 3042 fibers (from 50 photographs taken randomly) were labeled using the VGG Image Annotator software. Mask RCNN101 with its set of weights trained with "COCO" data set was used to construct the neural network. Then, the training of an artificial intelligence model based on Detectron2 (AI-based software) was carried out, using the fibers and ducts labeled. For validation, 70 photographs were used to measure fiber density with AI-based software, and by manual counting (MacC). The t-test and Pearson correlation ( $r$ ) were used to compare and relate the results of both methods. As a first result, the AI-based software was developed, and it identifies fibers and ducts in photographs of shaven skin, and its process takes 5 secs per photo. Also, the AI-based software shows fiber and hair-ducts density per mm<sup>2</sup>. At comparison between methods found no significantly difference ( $p$ -value $<0.01$ ), and there is high, direct, and significative relations were found ( $r=0.95$ ). It is concluded that AI-based software has the potential to obtain FDen and DDen objectively and automatically, and it is a non-invasive procedure, inexpensive, and is carried out whitin a short period of time. Therefore, it is a practical method, and FDen and DDen can become new selection criteria for the genetic improvement of fibers in quality and quantity, in animal species that produce fibers or wool, since it is known that FDen is directly related to the weight of fleece (D'arcy, 1990) and inversely with the average diameter of the fibers (Quispe y Quispe, 2018).

## Community-based vicuña (*vicugna vicugna*) fleece collection in the arid puna of Argentina

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Innovation in production techniques for desert environments, including vicuña, is strategic for the communities inhabiting Argentine Puna, and it represents an opportunity for development, since industrial capacity is available. However, insufficient information about the relationship between quality and textile processing affects the proposals for innovation, which are essential to add local value. The objective of this work was to characterize the variability in both quantity and quality of vicuña fiber obtained by shearing in Argentine Puna, in the context of sustainable management presented by different aboriginal communities in Yavi district, Jujuy province. Samples were taken during shearing (n=150) in locations at an altitude <3814 masl (LOW, n=5) and >4222 masl (HIGH, n=4). The following were recorded: sex, age, body weight (BW, kg), greasy fleece weight (GFW, g) and staple length (SL, mm). The following were determined: mean fiber diameter (MFD,  $\mu\text{m}$ ), mean diameter of down fibers (DDO,  $\mu\text{m}$ ), mean diameter of hair (DHA,  $\mu\text{m}$ ), comfort factor (COF, %), proportion of down fibers (PWB, %) and mean fiber curvature (CRV,  $^{\circ}/\text{mm}$ ). Altitude significantly affected BW and SL; location affected all the other quality variables and GFW was affected by sex. Animals in HIGH locations turned out to be lighter than those in LOW locations (38.6 vs. 41.6 kg,  $P<0.01$ ). Average GFW was 228 g, being LOW locations more variable and those HIGH more homogeneous to each other. Females produced lighter fleeces than males (216 vs. 244 g,  $P<0.01$ ). In LOW locations SL was greater than in HIGH locations (42.4 vs. 38.8 mm,  $P<0.05$ ). MFD, DDO and DHA, COF, PWB and CRV presented averages of 13  $\mu\text{m}$ , 12.6  $\mu\text{m}$ , 53  $\mu\text{m}$ , 99.1%, 87.0% y 87  $^{\circ}/\text{mm}$ , respectively. Differences found among sampling locations were significant for all quality variables studied and they could present implications for the textile processing.

## **Establishment of camel wool chain in Iran with the aim of improving the livelihood of camel owners**

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There are problems in all stages of production, harvesting, marketing, collection, marketing and sale of camel wool, which prevent farmers from using its profits. Our idea is to improve these processes with the aim of increasing farmers' incomes through livestock fiber products. Camel wool is a rare and valuable product in today's world, but camel wool produced in Iran is not well exploited due to a number of existing problems. In this plan, the existing issues and problems will be solved so that flawless products will reach the hands of the interested parties. Due to a series of special features and characteristics of camel wool production, produced without chemicals and insecticides, this product has many customers. Economic importance and justification of the Idea is help to sustainable livestock and camel farming in the regions of camel production in Iran. Increase their revenue. Reduce migration and marginalization problems. There is no accurate report on the purchase and sale prices of camel wool and its statistics. For example, it is declared that the center of South Khorasan, this province has 29,800 camels, which produce an average of 150 to 180 tons of wool per year, but there are few people who use this product to make usable equipment. Camel wool is soft and does not stretch or "pill" when knitted (it does not form little balls of fuzz on its surface). Unlike sheep's wool, it does not cause allergies. It keeps the wearer warm when the weather is cold, and pleasantly cool when it is warm. It has a range of earthy natural colours, from white, cream, beige, brown to black, and is ideal for dyeing.

The practical steps and actions taken by our team in order to achieve the desired technology and the obtained results: All stages of production, processing and collection of camel wool are reviewed. The quantitative and qualitative characteristics of the produced wool are measured and the product is presented to the market by determining the specifications. Existing defects are identified and their solutions are taught to farmers. The value of camel wool is rediscovered.

Describe the remaining process and methods for achieving the final product and its commercialization:

Check the status and estimate the existing quantity and current production status. Doing reform. Find the nodes of the production process and finding solution for them. Marketing based on product quality. Creating a sustainable value chain from farmer to consumer.

The expected applications of the idea:

Rediscover the value of camel wool for ranchers and create the perfect production and sales chain based on the local camel owners association or camel owners cooperative. Camel farmers are applicants. Private companies will buy the product.

## Session 6. Behavior and animal welfare

### Drinking behavior in llamas (*Lama glama*) offered fresh and saline water

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In the last decades, the risk of water salinization due to climate change increased, leading to potential health risks for livestock, especially in arid and semi-arid regions such as the Andes, the habitat of wild and domesticated South American camelids. The aims of our study were to analyse the drinking behaviour of llamas (*Lama glama*) and to identify their behavioural adaptation strategies when confronted with different options of saline water. Twelve adult female llamas with an average body weight (BW) of  $140 \text{ kg} \pm 20.6 \text{ kg}$  were kept under controlled conditions in individual pens. After a control phase (1 week), providing only fresh water in two buckets, a pairwise preference test was conducted for 3 weeks by offering the choice between one bucket with fresh water and another with stepwise increasing NaCl concentration (0.25, 0.5, 0.75, 1.0, 1.25, or 1.5%). Chopped hay, water and a mineral lick were provided for *ad libitum* intake. Extensive 24h video recordings were used to evaluate the duration and frequency of drinking behaviour. Records were kept on body weight, body condition, feed, water and Na intake. Dry matter intake, total water and Na intakes increased during the choice test ( $P < 0.001$ ). When only fresh water was offered (control phase), the llamas ingested  $59.5 \pm 5.3 \text{ g/kg}^{0.82}$  drinking water per day, increasing to  $70.9 \pm 5.3 \text{ g/kg}^{0.82}$  during the pairwise preference test. In parallel, drinking frequency increased from 3.7 to 5.17 drinking events, and total time spent drinking from 162.2 to 237.6 s (control vs preference test), respectively. However, the duration of a single drinking event and the diurnal drinking rhythm of drinking remained unchanged during the experiment. Daily total Na intakes averaged  $0.04 \pm 0.02 \text{ (g/kg}^{0.75})$  during the control phase and increased by more than four times to  $0.19 \pm 0.02 \text{ (g/kg}^{0.75})$  in the pairwise preference test. The llamas showed a weak preference for saline water with 0.5 to 0.75% NaCl, and rejected water from 1.25% NaCl. The llamas demonstrated an extraordinary capacity to differentiate between saline water concentrations in the choice experiment, similar to that of goat breeds adapted to arid zones.

## **Assessing animal welfare risk in fibre-producing animals applying the five domains framework**

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To obtain a better understanding of the risks that arise with the husbandry of fibre-producing animals, we deep-dived into an evaluation of 16 textile certifications for sheep, goat, and alpaca wools, and down and leather. After an initial assessment that aimed to evaluate the extent to which these certifications prevented most cruel practices, we investigated the animal welfare requirements for each certification and how well these requirements held against the Five Domains of Animal Welfare (Mellor et al., 2020).

To obtain a risk assessment result for each of the certifications, we adapted the Welfare Quality<sup>®</sup> assessment protocols (WQ) from actual animal-based parameters (e.g., “Body Condition Score”) into questions of whether such measures were taken into consideration within the Animal Welfare requirements of the standard on which a certification is based (e.g., “Is the BCS of the animals regularly monitored and are the workers knowledgeable in assessing it?”). The answers to these questions, known as our single measures, then guided us to a score for each of the 12 provisions. These provision scores were then aggregated into a score for the respective domains, using a Choquet integral with expert-determined weights. Finally, the scores of the respective domains were combined overall into a score for each standard as the “Mental State” score.

Unfortunately, only one of the standards which we reviewed reached a score in the “Acceptable” animal welfare category, while the rest fell into the “Poor” and “Very poor” animal welfare categories. In general, standards have not prohibited most cruel practices of fibre animal husbandry and have not demanded sufficient requirements regarding the animals’ physical environment and behavioural interactions, while also lagging behind in nutrition and health. Our findings show that further work is needed when it comes to improving animal welfare within the textile industry, should it depend only on the minimum requirements outlined by the certifications. While we are aware that many farmers may go beyond the bare minimum that is required from them, this is both not always the case nor is it the objective of this project. To evaluate the actual welfare states of the animals in fibre production, further research is needed to apply the animal welfare assessment protocols to actual farms.

## **Does the usual keeping of male South American camelids conform with the law of animal welfare?**

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Usually, male alpacas and llamas of different ages are kept in groups between 2 and 30 or more animals, in pastures and stables of different sizes, all bordered by fences. Adult male alpacas and llamas behave strongly territorially. To avoid serious injuries in ranking fights it is tradition until now to cut all 6 permanent fighting teeth at the age of 3 to 5 years. At this age the dental pulp of the fighting teeth is wide and reaches to the tip of the tooth. By amputating the teeth the pulpa with its vessels and nerves is exposed. This causes permanent sensitive and painful teeth. From an animal welfare point of view this way of keeping them is not acceptable.

A territorially behavior does not exist in geldings who were castrated before the increased production of testosterone, i.e. at the age of about one year. Caused by the low testosterone the fighting teeth are very small and erupt later, similar to the fighting teeth of females. Therefore the ranking fights are not so serious compared to the fights of intact males.

Since the majority of male alpacas and llamas are used as companion animals it could be more in line with animal welfare to castrate them early and keep only those as intact males which should be used for breeding. Each breeding male should than have a “private territory” near the “private territories” of other breeding males.

In the presentation the problem and possible solutions will be explained with photos, radiographs and sketches.

## Stress in alpacas: physiological and behavioral responses during the shearing procedure

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Alpacas are primarily raised for fiber production, which involves regular shearing. The shearing process induces stress caused by social isolation, handling, restraint and shearing itself. Stress can be measured through physiological and behavioral parameters. Therefore, the aim of this experiment was to evaluate the stress reaction of alpacas by assessing core and peripheral body temperature as well as stress-indicating behaviors (e.g., vocalization, defense behavior). For this purpose, 42 female alpacas were either subjected to a ‘Shear’ (handled and shorn, n=32) or ‘Sham’ (handled but not shorn, n=10) treatment. To assess changes in the peripheral body temperature, infrared images were taken of the eyes (right and left) and nose (right nostril, left nostril, flew). Additionally, rectal temperature was measured to study how changes in core and peripheral temperature cohere. In both groups, temperatures were taken at five different measurement time points: before (‘Pre’), during (‘Start’, ‘Mid’, ‘End’) and after shearing/sham-shearing (‘Post’). To capture stress-indicating behaviors during shearing/sham-shearing, videos were recorded and analyzed for the different phases. Large individual differences were found in the temperature patterns. Mixed effects models revealed a significant increase in right eye temperature followed by a decrease in both groups ( $p_{\text{time point}}=0.018$ ). Nostril and flew temperature consistently decreased as a first reaction to shearing/sham-shearing ( $p_{\text{time point}}<0.07$ ). Rectal temperature stayed rather stable over the whole process, but it was higher in the ‘Shear’ (LSM=38.0°C) compared to the ‘Sham’ group (37.8°C,  $p_{\text{group}}=0.04$ ). Frequency of screams ( $p_{\text{group*phase}}<0.001$ ), time spent screaming ( $p_{\text{group*phase}}=0.003$ ) and defense behaviors ( $p_{\text{group*phase}}=0.007$ ) first increased in the ‘Shear’ group and decreased after the middle of shearing, while the contrary was observed in the ‘Sham’ group with more stress-indicating behaviors before and after sham-shearing and less during the middle part. Rectal and peripheral temperature correlated only weakly and associations between temperature changes of the right nostril and flew and scream frequency were also weak, indicating a slight increase in temperature with more screams. In sum, it can be assumed that the shearing/sham-shearing process (capture, handling, restraint) induces stress which is reflected in the overall frequency of stress-indicating behaviors. Core body temperature and peripheral temperature react differently in the course of shearing/sham-shearing and do not correlate well. The unclear pattern of physiological responses indicates that using core or peripheral body temperatures as a single measure of stress may not reveal valid conclusions. An important question for future studies should be how to reduce stress for alpacas during handling and shearing.

## Relationship between coat colour and temperature measurements along the alpaca fibre

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In the South American Andes alpacas are raised at an altitude between 3,500 and 5,000m. Alpaca is one of the few economically productive species under these conditions. They are characterized by a wide range of coat colors, which can be grouped into 9 basic colors: White (W), LFY, LFX, LFZ (Light Fawn Intensity X, Y, Z), Light Brown (LB), Dark Brown (DB), Dark Brown Black (DBB), Black (B) and Gray (G). The coat color can influence the thermoregulation of alpacas, since color has an important effect on the reflectance of solar radiation. Therefore, the present work aims to evaluate the effect of coat color on thermoregulation at noon in sunny days. From 18 animals (2 per coat color) over a period of 15 days a total of 540 temperature records were taken from the mid side on two points along the fiber: 1) medium point - MP of fiber length, and 2) fleece base – FB (contact with the skin). Temperature was taken with an infrared thermographic camera at a distance of 1m. All measurements were taken at the Pacamarca Research Station at an altitude of 4100m. The statistical model included the effect of coat color (9 levels) and fiber length and fiber diameter as covariates. The coat color temperatures in the MP were: 30.62, 31.11, 33.01, 31.14, 31.18, 31.73, 30.01, 33.01, 30.62 °C, and the temperatures in the FB were: 33.34, 33.31, 34.77, 33.81, 34.42, 33.78, 33.78, 35.64, 34.04 °C for W, LFX, LFY, LFZ, LB, DB, DBB, B and G respectively. A significant difference was found for FB among colors. The temperature in the MP is lower and more homogeneous compared to FB. Likewise, significant differences were found for both covariates fiber diameter and fiber length in the FB. It seems that the fiber diameter, fiber length and coat color play an important role in heat isolation in alpacas.

## **Set up wool collection centres in Europe for upgrading the value of fleeces**

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Currently the market value of greasy wool is very low and remains dependent on the world market and the economic situation. Wool is, however, an interesting livestock product both from an economic point of view and for the promotion of European sheep breeds. Consumers are increasingly demanding natural finished products, with guaranteed origin and traceability. In recent years, wool recovery initiatives have multiplied in Europe. Breeders and groups of breeders are looking for processing circuits adapted to their raw materials in order to then be able to market quality finished products. But breeders have very little knowledge about fleeces and their qualities, about the right conditions for sorting wool during shearing, about existing processing companies. The *ATELIER-Laines d'Europe* association, involved in the development of European wool for more than 30 years, proposes the creation of wool collection and sorting centres. These would make it possible to receive batches of wool, sort them according to the qualities required and organize the necessary logistics. But these centres would also be places of advice and training for breeders wishing to make use of their fleeces: basic notions of wool, organisation of shearing places, knowledge of sorting fleeces, information on textile transformation cycles, support for projects.

The presentation will give examples of such existing structures in France, Italy, Austria and Great Britain.

## **Ways to improve the profitability of sheep farming with rare indigenous sheep breeds**

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The main goal is the preservation of rare indigenous sheep breeds by using their typical and natural coloured wool in traditional and modern ways. In addition, we are raising the profitability of sheep farming and wool production by reducing costs and enabling the achievement of higher prices for sustainable wool products. Processing natural coloured wool from rare indigenous sheep breeds into healthy and long-lasting garments started as a project idea 15 years ago by the breeders themselves. In this mindset, the value chain integrates all actors involved in the production of traditional and modern wool products. From the sheep breeders to the small local handcraft companies – in the end bringing sustainable woollen products directly to the consumers from "sheep to shop", increase the income of the sheep farmers and preserve biodiversity.

When we started our project, the renewable research wool was regarded as waste and had no use. Shearing their sheep causes costs for sheep breeders instead of increase their income and in most cases is only done for animal welfare reasons.

Instead of throwing away an eco-friendly and sustainable fibre, we found use for the wool of our indigenous sheep breeds thereby avoiding microplastic pollution since wool is compared to synthetical fibre re-useable and 100% biodegradable.

By selling our high-quality woollen products directly from "sheep to shop", the whole value chain is maxed out, increase the income of the breeders, supporting preservation of rare indigenous sheep breeds and maintaining and sustaining biodiversity and cultural heritage.

Another benefit, 5% of the weight of wool is pure organic carbon. When stored in wool, there is less carbon in the atmosphere and this mitigates climate change.

The project has contributed to agriculture and landscape conservation as well as to the promotion of endangered sheep breeds and the preservation of their genetic diversity.

For over 15 years, we've proved that it's possible to give back value to European wool and to put it back on the map. That it's possible to develop an action plan that supports sheep production, local manufactories and handcrafts, process sustainable products, create a brand and sell the products at profit directly to the consumers and support the local trade.

Instead of throwing a sustainable and renewable natural fibre away, our project supports a re-valorisation of the renewable resource wool and demonstrates ways to exploit its commercial potential.

## Can Alpacas and Vicuñas Save the Planet?

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Global warming is the world's single greatest threat to the planet. Today, over 34 billion tons of CO<sub>2</sub> is emitted annually. This article aims to showcase the environmental sustainability of South American camelid fibers in the fashion industry, and the indigenous group that has been their caretakers for the last 7,000 years.

By tying together the goals of the most recent COP26 conference and the desire for fashion brands to be viewed as sustainable and eco-friendly, the author dives into the natural habitat of South American camelids (mainly Alpaca and Vicuña) and the carbon sequestration ability of their ecosystem.

During the discussion of true fiber sustainability, the industrial process of South American camelid fiber is examined. The author compares the production process of alpaca and vicuña fiber to the most used alternatives: cashmere, cotton and polyester.

The factors being examined in the determination of sustainability include the following: habitat and ecosystem impact, carbon sequestration vs carbon emission, energy consumption and efficiency,

From a production and processing perspective, it seems that camelid fiber is the most environmentally friendly example of sustainable textile manufacturing and highlights close to net zero waste being created in the process.

While discussing the smoke and mirrors behind the fashion industry's "eco-friendly and sustainable" act, the author dives into the most obvious choice that companies hesitate on due to cost: South American camelids. He demonstrates the efficiency, environment friendly, socially just practices during the production and manufacturing of alpaca products.

The argument for alpaca and vicuña fiber compared to the more commonly "eco-friendly due to greenwashing" textiles have both positive environmental impacts as well as positive social justice impacts. By using the indigenous Quechua people from the Peruvian highlands as the example of model pastoralists for a "greener world," the author illustrates how these alpaca shepherds have created a duplicatable model for holistic pasture management and water conservation, all while unknowingly creating one of the world's largest carbon sinks.

Fashion brands who want true "eco-friendly" branding behind their name should look to protect and replicate the ecosystem created by the indigenous alpaca herders in South America. This means protecting both the natural habitat the camelids dwell and the way of life for the indigenous suppliers.

## **Picotani Water Project**

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Water conservation and global warming are the current hot topics of discussion. With companies standing behind initiatives that boasts a “greener way” or “eco-friendly” the author, Dale, takes us on a journey to 15,000 feet elevation in the Andean highlands of Peru. Here, he introduces the community of Picotani. Through his wife’s work as an alpaca breeder in their home of Boulder, CO Dale connected with the non-profit organization Quechua Benefit. It began as a glimpse into the programs and services that Quechua Benefit provided for communities like Picotani, providing and supporting education, economic empowerment, and preventative medicine for the benefit of the community.

Fast forward to present day, the community asked for help with a water project. At first, it was assumed it was regarding the town’s drinking water, but through a few more meetings, the community was asking for a water project for their vicuña habitats during the dry season. Dale presents an in-depth blueprint of the science and construction of this water project and its economic benefit and impact for a community like Picotani.