Hungarian University of Agriculture and Life Sciences

POSSIBILITIES OF UTILIZATION OF THE ALPACAS (*VICUGNA PACOS*) IN HUNGARY

DOI: 10.54598/003830

PhD thesis

Andrea Prágai

Gödöllő
2023

The doctoral school

Name: Doctoral School of Animal Biotechnology and Animal Science

Science: Animal sciences

Head: Dr. Miklós Mézes
professor, member of the Hungarian Academy of Sciences
Hungarian University of Agriculture and Life Sciences,
Institute of Physiology and Animal Nutrition,
Department of Feed Safety

Supervisors: Dr. Ákos Bodnár
Associate Professor, Ph.D.
Hungarian University of Agriculture and Life Sciences,
Institute of Animal Sciences, Department of Animal Husbandry and Animal Welfare

Dr. Ferenc Pajor
Associate Professor, Ph.D.
Hungarian University of Agriculture and Life Sciences,
Institute of Animal Sciences, Department of Animal Husbandry and Animal Welfare

.....

Approval of the Head of the Doctoral School

.....

Approval of the Supervisor

.....

Approval of the Supervisor

1. RESEARCH BACKGROUND

1.1. Usability of alpacas in Hungary

Alpacas are kept and bred mainly for their wool, and also as show and companion animals (Conyngham, 2005). Alpaca meat is also good for consumption, including in South America (Altizio 1998, Pérez, 2000, Cristofanelli 2004, Morales 2006, Morante 2009) and in Australia (Smith, 2015).

In addition to their different porposes of use, there is no tradition of consuming alpaca milk in its homeland (Bonavia, 1996). However, the composition of milk has great importance, because young animals (cria) can double their weight in the first 60 days of their life (Van Shaun, 2006). Compared to the milk of llamas and other domesticated ruminants, only sheep milk can be very similar to the average milk protein values of alpacas, and the milk fat and lactose values are roughly similar to goats and cows' milk (Riek, 2006).

As in the case of other farm animals, it is also important for alpacas to achieve and maintain the ideal weight and nutritional status. At a veterinary clinic in Germany, it is becoming increasingly common for owners to notice too late that their alpacas are thin. It is recommended to carry out regular condition evaluations on the animals (Wagener et al., 2021). The body scoring system ranging from 1 to 5 points is used to examine the body condition (Masur et al., 2022). Many times, due to the large amount of wool or the advanced pregnancy, it is not possible to see what the condition of the alpacas really is. Therefore, it is better to carry out the evaluation after pruning (Bowman, 2006). During the condition evaluation, the scoring system ranges from 1 to 5. In this case, a score of 1 indicates very poor condition, and a score of 5 indicates obese alpacas. The ideal score is around 2.5-3.5 (Internet 27).

Farm animals are affected by various external factors, which can affect their health, development, and production (Gere et al., 2001). The body can respond to strong stimuli in different ways. This can be a specific response, for example in case of an infection. However, if there is no possibility of specific protection, the body reacts in a non-specific way. This is called stress. The causes of stress are stressors, which can be triggered by pain, weather, surgical intervention, pathogens, persistently hot or cold weather, etc. This triggers the release of ACTH (adrenocorticotropic hormone) (Rudas et al., 1995). In the case of alpacas, cortisol levels were mainly tested in blood. In 1977, Sumar et al. wrote, blood samples were also taken from fetuses and newborn alpacas. Cortisol was shown to be the main glucocorticoid in both cases. In the case of alpacas and llamas, the amount of cortisol metabolites increases in the blood plasma, serum, saliva and manure after various stressful situations (Smith et al., 1994, Grandon, 1997, Arias et al., 2015).

Alpacas produce about 680 kg of manure per year (Duey, 2003), which is emptied into one place (Reiner & Bryant, 1983, McGregor, 2002, Charry et al., 2003), which facilitates manure collection. The urine also goes to the fertilization site, so the organic matter gets into the soil and decomposes efficiently. Around the manure site approx. A significant micro fauna develops in a 1-meter area (Savory & Butterfield 1999). McGregor et al. (2010) investigated the accumulation of minerals at the manure site of alpacas. He found that, among other things, phosphorus, nitrogen and potassium were clearly accumulated in the soil. Very few publications have dealt with the NPK content of the alpaca's organic matter, but they seem contradictory: some authors gave the NPK ratio of alpaca as 1.5%, 0.2% and 1.1% (Internet 29). Brown (2008) measured 1.5 kg/t N, 3.7 kg/t P_2O_5 and 2.5 kg/t K_2O in the alpacas' organic manure with a dry matter content of 27.1%, while Stock et al (2019) reports different data (0.4% (4kg/t) N, 0.3% (3kg/t) P_2O_5 and 0.6% (6 kg/t) K_2O).

1. 2. Objectives

My objectives:

1. My goal was to record the body measurements of the mares and stallions of a domestic alpaca farm, compare them with international data, and evaluate their body conditions.

2. My goal was to detect infection of internal parasites (endoparasites) in several domestic alpaca farms (especially with regard to the possible presence of *Haemoncus contorctus*), and to determine the degree of parasite infection of farms.

3. My goal was to determine the cortisol concentration of the animals' saliva samples, and I also aimed to determine whether the shearing of alpacas couses stress for the animals, and how strong is this stress coused by shearing.

4. My goal was to determine the wool properties of the alpacas of a domestic alpaca farm and to determine the mineral content of the wool samples.

5. My goal was to determine the composition of the colostrum of alpaca mares.

6. One of my goals was to determine the NPK content of alpacas' organic manure and comparing it with literature data for other ruminants.

2. MATERIAL AND METHOD

2.1 Alpacas body size measurement

I measured the alpacas at the farm in Jobaháza, where huacaya-type animals are bred. 5 stallions, 7 mares and 2 young animals (under 2 years old) took part in the study. I took the body measurements based on Czub's (2010) study. The animals were placed on a straight pedestal so that they stood in the same way, the measurement was done with a measuring stick. The Kolmogorov-Smirnov test, F-test and independent samples t-test were used in statistical analysis.

2.2 Assessment of the condition of adult alpacas

The 5-score condition assessment was carried out in the summer. We examined 6 alpacas on the farm in Jobaháza, of which 2 were mares and 4 were stallions. Two university students also participated in the experiment. After learning about the judging rules, we judged 6 animals separately and independently. We examined the sternum and the groin from the back using an observational method. Using a tactile method, the part behind the ribs, in front of the pelvis, and the groin. The Mann-Whitney U-test was used in statistical analysis.

2.3. Examination of internal parasites, especially the red stomach worm

I collected faecal samples in different seasons in different farms (Békéscsaba, Jobaháza, Mezőtúr, Bábolna, Balassagyarmat, Tata). In 2014, in the spring, I took group samples from 6 animals (of mixed age), from 4 adult mares at Mezőtúr, from 4 adult mares and 2 adult stallions at Bábolna, from 2 adult mares at Balassagyarmat, from 8 adult mares and 4 adult stallions at Jobaháza, from 4 adult mares at Békéscsaba. In the fall of 2014, I collected samples in groups, in Bábolna separately from the mares and stallions, and in Békéscsaba from the mares. At Jobaháza, I managed to get individually sample from the stallions and mares. In the spring of 2015, I took individual samples from the Jobaház animals, for 6 mares and 4 stallions. I collected the samples in a stool container and then transported them to the lab in a cooler bag. The samples were examined at the Department of Parasitology and Zoology of the University of Veterinary Medicine by surface enrichment and microscopic methods. Based on the examination, no exact amount was established, only what parasite was found in the sample. The Chi^2-test was used in statistical analysis.

2.4. Examination of the stress effect of shearing on alpacas

During shearing in May 2014 and 2015, I took saliva samples from the alpacas using a Salivette® saliva sampling tube. The procedure is non-invasive and can be performed without cutting or stabbing. I placed the tampon directly under the tongue. In the case of cattle, 30 seconds is enough to saturate the tampon with saliva (Kovács et al., 2016). Alpacas have less saliva, so based on a preliminary measurement, I held the tampon in the animals' mouths for 60 seconds to soak it. As Wittek et al. (2017)'s method, I took several samples, the first one before shearing. The animals were in the barn, where they were usually herded for the night. I took the second sample during shearing, when the alpaca was on the shearing table. The third was immediately after shearing, when the animal was taken off the table. The last sample was taken 30 minutes after shearing. I transported the samples to the laboratory in a cooler bag, where cortisol was measured using the radioimmunoassay (RIA) methodology described by Csernus (1982), which was adapted for testing samples from farm animals to determine the concentration of glucocorticosteroids (Jurkovich et al., 2017). In 2015, I examined the same stock during shearing as in 2014. Compared to the previous year, however, I also took saliva samples from the animals the day before shearing, then that day before shearing, during, immediately after, and half an hour later. The following tests were applied: Kolmogorov-Smirnov test, Levene's test, multivariate General Linear Model (GLM) and Tukey test.

2.5. Examination of the properties and mineral content of alpacas' wool

2.5. *1. Examination of the most important properties of wool*

I carried out the tests at the alpaca farm in Jobaháza. I took individual wool samples from mares (n=12) and stallions (n=11), and then sent the samples for laboratory testing. In the further tests, I processed the data from the test reports of the submitted samples. During the study, I evaluated the effect of year and sex on wool properties (fiber length, fiber fineness, proportion of fibers thicker than 30 micrometers, amount of fiber curvature).

I collected the monthly average meteorological data for the region (average temperature, average humidity, average precipitation and average wind speed) from the Hungarian Meteorological Service, arranged in such a way that the month of wool shearing (May) was the first month, while the last month was the next shearing previous month (April), so the meteorological factors could be better matched with the growth of wool. I averaged annual data from the monthly data.

After that, I compared the meteorological data with the wool properties measured on both sexes (fiber length, fiber fineness, the proportion of fibers thicker than 30 micrometers, the amount of fiber curvature).

The fiber curvature: the size of the angle between the beginning and the end point on the 200 μm length of the curvature of the wool fiber is determined with an OFDA-100 measuring instrument. The Kolmogorov-Smirnov test, F-test, independent samples t-test, Levene's test, oneway ANOVA, Tukey test, Kruskal-Wallsi test, Pearson correlation, and multiple regression analyss with backward elimination were used in statistical analysis.

2.5.2. Determination of mineral content of wool samples

In May 2014, I took wool samples from two alpaca breeding farms, from 5 animals each, when the alpacas were sheared. Among the alpacas, there were 3 males and 7 females, adults in terms of their age (over 3 years old). Housing and feeding are essentially similar. They are provided with fodder and hay based on pasture. During the numbering of the samples, animals from farm "A" were given numbers from 1 to 5, and from farm "B" from 6 to 10. I took the wool from the side of the alpacas, stored it in an airtight ziplock bag, and then transported them to the laboratory. The samples were examined by HORIBA JOBIN YVON ACTIVA-M ICP-OES in the laboratory of the Department of Environmental Chemistry and Waste Management, Institute of Environmental Sciences, Hungarian University of Agricultural and Life Sciences. The results were evaluated using Microsoft Excel spreadsheet software and the GraphPad InStat program. The Kolmogorov-Smirnov test, F-test and independent samples t-test were used in statistical analysis.

2.6. Examination of alpacas' colostrum composition

I collected colostrum samples at the huacaya farm in Jobaháza. In 2013 and 2014, one mare's foal died, and it was possible to collect milk from the first- and second-day's milk. I stored the samples frozen. The samples were analyzed with a Delta Instruments LactoScope FTIR Advanced analyzer at the MATE Institute of Animal Husbandry Sciences, Department of Animal Husbandry Technology. The following tests were applied: Kolmogorov-Smirnov test, F-test and independent samples t-test.

2.7. NPK content of alpaca manure

I collected the manure samples from different farms, where the number of animals was 15-20 individuals. I collected one sample each season at the alpaca farm in Jobaháza and Békéscsaba. In winter, I collected another sample at an alpaca farm in Brno. I took the samples from the center of the faecal sludge produced that day, in the amount of 50 g. Delivery was in a cooler bag. I stored the samples frozen before the laboratory test. The dry matter and NPK content of

manure samples were determined by Hungarian Standards (N: MSZ-08-1783-6:1983, P: MSZ-08-1783-4:1983, K: MSZ 20135:1999 and dry matter: MSZ-08-1783-1:1983). The following statistical tests were applied: Kolmogorov-Smirnov test, F-test and independent samples t-test.

3. RESULTS AND DISCUSSION

3.1. Alpacas body size measurement

In the case of stallions, the average height at the withers was 85.6 cm. The depth of the chest is similar to what I measured, 38 cm on average. The circumference of the chest is 114 cm, which is larger compared to my measurements. In the case of mares, the average height at the withers was 86.6 cm, the circumference and width of the chest exceeded those of the withers. Chest depth and leg length were almost the same for both sexes. The width of chest (14.1 cm) was greater, while the head width (8 cm) and the stem of legs (10.8 cm) were lower in mares compared to stallions (10.4 cm, 9.8 cm and13.,2 cm).
Ponomareva (2019) measured an average withers height of 90 cm for mares, which is a little more than what I measured. In terms of his chest circumference (113 cm), he got a significantly higher result. The depth of the chest is 35 cm, which is similar to what I measured. Based on Tamburini's (2011) measurements, the average wither height of alpacas in the northern part of Italy is 85.6 ± 8.1 cm, which is similar to the data I measured. Comparing the average of the measurement data of all animals, we can conclude that the withers height, trunk length and stem circumference are similar to the measurement results that were measured in Poland (Czub et al., 2010). However, I found differences in the other measurement areas compared to the Polish stock. The average of chest depth and circumference is smaller than ours. Furthermore, a large difference can be observed in the width of the chest. The alpacas I measured have longer and wider heads. In addition to this, even the stem length was longer in our case.

3.2. Assessment of the condition of adult alpacas

Different people gave the same score to the condition of the animals in each case. The animals were in a condition suitable for our use. This is a good indication of the proper feeding of the animals. The two mares received adequate scores. However, one was in worse condition than the other, which is acceptable during the breastfeeding period (point 2). One of the males had an above average score (point 4), half a point above the limit. The condition of the other stallions was adequate and within the limit value. A difference can be measured between the two sexes condition scores, which is understandable due to the deviant optimal condition. Wagener et al. (2021) obtained an average score of 2.5 for mares (n=106) and 2.6 for stallions (n=87). He found difference between the average scores of the two sexes (mean scores of stallions and mares: 3.5 and 2.5), in favor of the male.

3.3. Examination of internal parasites, especially the red stomach worm

Among the samples taken in groups in the spring of 2014, the result was negative in Tata, Mezőtúr, Bábolna (in the case of mares), Balassagyarmat and Jobaháza (in the case of males). In Bábolna, *Trichostrongylida* eggs were found in the males, but it was not possible to determine exactly whether they came from large stomach worms. At Jobaháza, we were able to detect *Strongylida*-type eggs in the mares. In the case of samples collected in groups in the fall of 2014, *Nematodirus* eggs and lungworm (*Müllerius*) eggs were found in mares from Békéscsaba. The results of the samples collected in groups in Bábolna and individually in Jobaháza were also negative for mares and stallions. Contrary to the results of 2014, when *Strongylida*-type eggs were found, in the samples examined in 2015, *Trichostrongylida* eggs were found in all 6 mares and 4 stallions, and 2 of the mares even had *Nematodirus* eggs. The incidence rate of pathogenic worms this year was 100%, i.e. very significant.

3.4. Examination of the stress effect of shearing on alpacas

The average cortisol value of the saliva samples of the stallions was 2.79 nmol/l, mares was 2.47 nmol/l and all tested alpacas was 2.58 nmol/l. Which is a relatively low value and can be compared to the average value of an adult ruminant sheep (3.14 nmol/l, Pajor et al., 2010). On the other hand, Bonacic and Macdonald (2003) reported a value of 20.6 nmol/l for alpacas. During sampling, I found a significant effect on the animals' cortisol concentration. The cortisol content of the saliva samples were taken before shearing was 2.50 nmol/l and 30 minutes after shearing increased significantly (3.63 nmol/l). Similar to a previous study, the cortisol content of saliva samples showed an increase 20 minutes after shearing (Wittek et al., 2017).

3.5 Examination of the properties and mineral content of alpacas' wool

3.5. 1. Examination of the most important properties of wool

Average values of fiber fineness, fiber length, fiber curvature and ratio of fibers above of 30 μm of alpacas were 21.6 μm, 80mm, 40.9º and 7.3%. The relations between fiber fineness and ratio of fibers above of 30 μm, moreover fiber fineness and fiber curvature were r=0.96 and r=-0,58 ($P<0.05$).

During my research, I found that the fiber fineness and fiber curvature of alpaca wool were significantly influenced by the average annual temperature and the average annual precipitation among the meteorological factors (average annual temperature, average annual precipitation, average relative humidity, average

wind speed). As the average annual mean temperature and average annual precipitation increased, the diameter of the wool fibers thickened, and the values of the fiber curvature decreased in parallel. The fiber length was not significantly affected by meteorological factors. Based on the results of the investigation, it can be said that the areas with less rainfall and coolness are the most favorable for the production of thin fiber alpaca wool.

3.5.2. Determination of mineral content of wool samples

Average values of calcium, cupper, iron, and cink of alpacas during investigation were 1.69 g/kg, 10.65 mg/kg, 2.48 g/kg és 107.9 mg/kg. There was no significant difference the minerals of wool samples between stallions and mares. I didn't find any big differences in the measured parameters between the two farms, the alpacas showed different results on an individual basis. The Hungarian measurement data can fill in the gaps, supplemented by additional tests, they can help preserve the health of the alpacas, produce high-quality wool, and create optimal feeding, since minerals accumulate in the wool, thereby indicating the nutritional and health status of the animal.

3.6 Examination of alpacas' colostrum composition

The colostrum fat and protein content at first day were 1.75% and 10.24%, while these values were 3.99% and 8.13% in second day after parturition. Based on the results, it can be said that the composition of colostrum in domestic conditions was similar to foreign measurements, but at the same time, compared to literature data, the composition of colostrum differs from region to region.

3.7 NPK content of alpaca manure

During my tests, I found that the alpacas' manure has a significant NPK content (in dry matter: NPK values were 15 g/kg DM, 17.6 g/kg DM and 18.7 g/kg DM, and their ratio was 1:1.1:1.2). Compared to cattle manure, it contains more of all tested elements. Compared to the manure of the sheep, in terms of N and P, the manure of the alpaca contains more, while the sheep contains more of the K. Compared to llamas, there is less N, while there is more P in the alpaca's manure. I measured higher amounts of all three elements in the alpacas' manure during the summer grazing period than in the winter. However, in the case of phosphorus, I found no significant difference between the grazing and stable periods.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Alpacas body size measurement

It can be concluded that in the case of the animals I examined, the depth of the chest and the length of the stem were almost the same for both sexes. The average height at the withers, chest circumference and width of the mares exceeded those of the stallions. In the case of stallions, the body length, head length and width, as well as the stem circumference were larger compared to mares. The withers of European (Polish, Russian and Italian) alpaca herds are similar to the alpacas I measured. In the results measured in Poland, the depth of the chest was greater than what I measured. In the case of stem length, the results of alpacas measured in Hungary were higher compared to Poland. Taking body measurements can be one of the ways to assess the alpaca stock and judge its appearance. It can be used to filter out animals with a llama-like body structure (for example, the average height at the withers of adult alpacas cannot exceed 90 cm). These properties are undesirable, as they can impair the quality of the wool (the llama's wool is less fine).

4.2 Assessment of the condition of adult alpacas

Keeping alpacas in optimal condition is important as it can lead to health problems. A malnourished alpaca may miscarry and have little milk, but it may also indicate a parasitic infection. Overweight animals can be infertile and have a harder time bearing heat stress. Adequate condition before the breeding is the basic condition for alpacas to achieve favourable production indicators in the later period. That is why it is worth regularly assessing the condition of the alpacas in order to eliminate the resulting animal health and production problems.

4.3 Examination of internal parasites, especially the red stomach worm

One of the goals of my investigation is to establish, as in other countries, the infection of the domestic alpaca herd with stomach worms. In general, the alpaca farms in our country are slightly infected with worms, *Strongylida*-type eggs, *Trichostrongylida* eggs, and *Nematodirus* eggs were found in the manure samples I took. However, this can be significantly influenced by current meteorological effects (e.g. rainfall distribution, etc.). The infection is not only limited to one area, but also occurs in several parts of the country. In the sex distribution, it can be observed that both males and females are at risk. An important factor is keeping the pastures clean (deworming before the grazing season, changing pastures), separating them from cattle and small ruminants, and deworming

animals (mainly those imported from other countries). It is also recommended to detect the level of infection in the domestic herd and the possibilities of protection through questionnaire monitoring.

4.4 Examination of the stress effect of shearing on alpacas

From the tests, it can be concluded that shearing once a year is less stressful for the alpacas. I could not detect any significant differences between the mares and the stallions in the herd examined. I measured the highest cortisol concentration 30 minutes after the shearing, similar to previous studies. But this increased level (3.63 nmol/l) does not indicate a significant stress effect either. The development of unnecessary stress in alpacas can be prevented with appropriate treatment. For example, you should avoid unnecessary movements when grasping. It is also recommended to trim the teeth and nails while the animals are on the shearing table. This way, you have to disturb the animals less times a year by catching them.

4. 5 Examination of the properties and mineral content of alpacas' wool

4.5. 1. Examination of the most important properties of wool

There were no dignificant differences in alpacas' wool parameters as fiber fineness, fiber length, fiber curvature and ratio of fibers above of 30 μm between stallions and mares. In adition, the relation between fiber fineness and ratio of fibers above of 30 μm in alpacas.

During my tests, the fiber fineness and fiber curvature of alpacas' wool were significantly influenced by the average annual mean temperature and average annual precipitation among the meteorological factors examined (average annual temperature, average annual precipitation, average relative humidity, average wind speed). Accordingly, as the average annual mean temperature and the amount of average annual precipitation increase, the diameter of the wool fibers is expected to increase, and parallel to this, the fiber curvature values will also decrease. The evaluated meteorological factors had no significant effect on the fiber length. Based on the results of the study, the areas with less rainfall and coolness are the most favorable for the production of thin fiber wool for alpacas.

4.5.2. Determination of mineral content of wool samples

I didn't find any big differences in the measured parameters between the two farms, the alpacas showed different results on an individual basis. The domestic measurement data fills in the gaps, supplemented with additional tests, they can help preserve the health of the alpacas, produce high-quality wool, and create

optimal feeding, since minerals accumulate in the wool, thereby indicating the nutritional and health status of the animal. It is recommended for alpaca keepers to take a sample of the wool during shearing and have it tested for mineral content. It is practical to collect the samples during shearing, because then the sampling does not cause additional stress to the animals.

4.6 Examination of alpacas' colostrum composition

During breeding, it is important to know as much as possible about the composition of colostrum and normal milk due to the growth of young foals. During my investigation, I received data on the composition of the colostrum of alpaca mares. Based on my results, the composition of colostrum under domestic conditions was similar to foreign measurements on some nights. However, I also experienced deviations in different countries, compared to the data measured on the continent. Different feeding and environmental conditions may play a role in the different results. Further studies are needed regarding the composition of colostrum and normal milk.

4.7 NPK content of alpaca manure

During the tests, I found that the alpacas' manure has a significant NPK content. Compared to cattle manure, it contains more of all tested elements. Compared to the manure of the sheep, in terms of N and P, the manure of the alpaca contains more, while the sheep contains more of the K. Compared to llamas, there is less N, while there is more P in the alpaca's manure. I measured no differnces amounts of all three elements in the alpacas' manure during the summer grazing period than in the winter. However, in the case of potassium, I found slightly, but no significant difference between the grazing and stable periods. The farms are located in areas with different climates, so the contents of the forage fed may also differ, which may have influenced the composition of the alpacas' manure. Further studies are necessary to determine the values of bulk feeds. Due to its contents, alpaca manure can be advantageously used as an organic fertilizer under plants. Nevertheless, alpaca organic fertilizer pellets have already been sold abroad, and could also be sold in our country to growers of ornamental plants and horticulture.

5. NEW SCIENTIFIC RESULTS

1. I found that there is a detectable difference between the body sizes of mares and stallions. Mares have a wider chest, narrower head and thinner legs compared to stallions.

2. For the first time in our country, I carried out tests on internal parasites in alpaca herds, and found that infections with internal parasites – although differences can be detected between the farms – are currently small.

3. For the first time in Hungary, I investigated the cortisol content of alpacas' saliva when the animals were sheared. The method is suitable for determining the cortisol values of animals. The average cortisol value of the saliva samples of the tested alpacas before shearing was 2.50 nmol/l. I found that in the case of alpacas, shearing does not have a significant stress effect on the animals, 30 minutes after shearing the animals' cortisol values increased slightly (3.63 nmol/l). In addition, I found that the cortisol values of mares and stallions did not differ; the average cortisol value of the two sexes was 2.79 nmol/l (stallions) and 2.47 nmol/l (mares).

4. I found that the main wool properties of alpacas (fiber fineness, proportion of fibers over 30 μm in diameter, fiber length and fiber curvature) are not affected by sex. There is no significant difference between the values of mares (21.7 μm; 7.5 %; 8.2 cm; 40.70^{o}) and stallions (21.4 μm; 7.1 %; 7.8 cm; 41.10 ^{o}).

5. I found that in our country, the fiber fineness and fiber curvature of alpacas' wool were significantly influenced by the average annual temperature and average annual precipitation among the investigated meteorological factors (annual average temperature, annual average precipitation, annual average relative humidity and annual average wind speed). As the average annual temperature and the average annual precipitation increase, it is expected that the fineness of the fibers will increase and, in parallel, the curvature of the fibers will decrease. As a result, the less rainy and cooler areas are the most favorable for the production of high-quality alpaca wool. I found that the investigated meteorological factors have little effect on the development of the wool length of the alpacas.

6. For the first time in Hungary, I determined the content of calcium, copper, iron and zinc among the minerals in the wool of alpaca mares and stallions (mare: Ca: 1.7 g/kg, Cu: 10.9 mg/kg, Fe: 2, 85 g/kg, Zn: 107.2 mg/kg, stallion: Ca: 1.67 g/kg, Cu: 10.4 mg/kg, Fe: 2.11 g/kg, Zn: 108.6 mg/ kg). I found that there is no significant difference between the two sexes. In my study, the average mineral contents of alpaca wool were: 1.69 g/kg (calcium), 10.7 mg/kg (copper), 2.48 g/kg (iron) and 107.9 mg/kg (zinc).

7. For the first time in Hungary, I determined the average values of nitrogen, phosphorus and potassium of alpaca manure (N: 15 g/kg DM; P: 17.6 g/kg DM; K: 18.7 g/kg DM) and their ratio (1:1, 1:1,2).

LIST OF PUBLICATIONS

Scientific journal articles:

Referred publications with an impact factor

PRÁGAI A., KOVÁCS A. (2020): Stress of alpacas caused by shearing in Hungary. *BULGARIAN JOURNAL OF AGRICULTURAL SCIENCE*, *26*(1), 207–212.

Referred publications

PRÁGAI, A., & BODNÁR, Á. (2011): Alpakák viselkedésének néhány főbb jellemzője a Szegedi Vadasparkban (előzetes eredmények). *ANIMAL WELFARE ETOLÓGIA ÉS TARTÁSTECHNOLÓGIA,* 7(2), 165–179.

PRÁGAI, A., KISPÁL, T., KŐRÖSINÉ, M. A., & BODNÁR, Á. (2011): A gazdasági haszonállatként tartott alpaka jelentősége a Világ egyes országaiban. *ANIMAL WELFARE ETOLÓGIA ÉS TARTÁSTECHNOLÓGIA*, 7(Klnsz), 174–182.

PRÁGAI A., & KOVÁCS A. (2012): Az alpaka főbb fertőző betegségei. *ANIMAL WELFARE ETOLÓGIA ÉS TARTÁSTECHNOLÓGIA*, 8(2), 183–190.

PRÁGAI A., & KOVÁCS A. (2013): Az alpaka gyapjú felhasználási lehetőségei a gyapjúiparban. *ANIMAL WELFARE ETOLÓGIA ÉS TARTÁSTECHNOLÓGIA*, *9*(Klnsz), 310–314.

PRÁGAI A., & KOVÁCS A. (2013): Alpakák gyomorférgessége. *ANIMAL WELFARE ETOLÓGIA ÉS TARTÁSTECHNOLÓGIA*, 9(Klnsz), 305–309.

PRÁGAI A., & KOVÁCS A. (2013): Hungarian alpaca breeders. *ANIMAL WELFARE ETOLÓGIA ÉS TARTÁSTECHNOLÓGIA*, *9*(1), 54–60.

PRÁGAI, A., PAJOR, F., & BODNÁR, Á. (2020): Az alpakák vörös gyomorférgének (Haemonchus contortus) előfordulása magyarországi állományokban. *ACTA AGRONOMICA ÓVÁRIENSIS*, *61*(2), 25–40.

PRÁGAI, A., PAJOR, F., & BODNÁR, Á. (2022): ALPAKA SZERVESTRÁGYA NPK TARTALMA. *ACTA AGRONOMICA ÓVÁRIENSIS*, *63*(1), 4–14.

PRÁGAI, A., PAJOR, F., & BODNÁR, Á. (2021): Alpaka gyapjúminták mikro- és makroelemtartalma két magyarországi telepen. *ACTA AGRONOMICA ÓVÁRIENSIS*, *62*(1), 21–31.

Conference publication, announcements published in full:

PRÁGAI, A., KŐRÖSINÉ, M. A., PEKLI, J., VEPRIK, R., HUSZÁR, G., & BODNÁR, Á. (2010): Feed preferences and recipe alternatives for alpacas in a Hungarian zoo. In *5th European Symposium on South American Camelids and First European Meeting on Fibre Animals* (pp. 145–151).

PRÁGAI A., & KOVÁCS A. (2013): SOME HUNGARIAN BREEDER OF ALPACAS. In: University of Agriculture in Krakow In *II. International Conference of PhD Students* (pp. 9–15).

PRÁGAI A., & KOVÁCS A. (2013): ALPACA BREEDERS IN HUNGARY In: Falta, Daniel; Filipčík, Radek; Lichovníková, Martina (szerk.) Animal Breeding 2013, Brno, Csehország: Mendelova univerzita v Brne (2013) p.

PRÁGAI, A., & KOVÁCS, A. (2013): Alpakák kondíció bírálata. In *Állattenyésztés-tudományi Doktori Iskola, Szent István Egyetem, VII. Fórum* (pp. 110–113).

PRÁGAI A, KOVÁCS A, (2014): Alpacas body condition scoring in Jobahaza. In 20th Youth Scientific Forum (pp. 154–159).

PRÁGAI A, KOVÁCS A, (2014): Baber pole's worm in alpacas In: Falta, Daniel; Filipčík, Radek; Lichovníková, Martina (szerk.) Animal Breeding 2014., Brno, Csehország: Mendelova univerzita v Brne

PRÁGAI A, KOVÁCS A, (2015): Importance of alpacas condition scoring in Hungary In: MENDELOVA, UNIVERZITA V BRNĚ (szerk.) ANIMAL BREEDING 2015, Brno, Csehország: Mendelova univerzita v Brne (2015) pp. 68-72., 5 p.

NAGY, M. F., **PRÁGAI, A.**, PAJOR, F., & BODNÁR, Á. (2015): Előzetes adatok alpakák napi aktivitásához és viselkedéséhez egy hazai gazdaságban. In V. Gödöllői Állattenyésztési Tudományos Napok Nemzetközi Konferencia (pp. 27–27).

PRÁGAI, A.; PAJOR F.; KOVÁCS A. (2016): Some parameters of the alpaca's colostrum in Hungary In: Daniel, Falta; Milan, Vecera; Radek, Filipcik

(szerk.) Animal Breeding 2016, Brno, Csehország: Brno University of Technology (2016) pp. 101-105, 5 p.

PRÁGAI, A; KOVÁCS, A; Daniel, Falta (szerk.); Milan, Vecera (szerk.); Radek, Filipcik (szerk.) (2017): THERAPHY BY ALPACA IN HUNGARY, Brno, Csehország: Mendel University in Brno, 165 p.

PRÁGAI, A.; KOVÁCS, A.; PAJOR, F. (2018): ALPACAS BODY SIZE MEASUREMENTS IN HUNGARY, In: Daniel, Falta; Milan, Večeřa; Radek, Filipčík - Daniel, Falta; Milan, Večeřa; Radek, Filipčík (szerk.) Animal Breeding, Brno, Csehország: Mendel University in Brno (2018) pp. 85-88., 4 p.

Papers published as a summary in a conference publication:

PRÁGAI, A., KŐRÖSINÉ, M. A., PEKLI, J., VEPRIK, R., HUSZÁR, G., & BODNÁR, Á. (2010): Alpakák takarmánykedveltségi vizsgálata és javasolt évszakonkénti recepturájuk a Szegedi Vadasparkban. In Magyar Etológiai Társaság XII. Kongresszusa (pp. 23–23).

PRÁGAI, A., BODNÁR, Á., PEKLI, J., & VEPRIK, R. (2010): Újvilági tevefélék tartásának tapasztalatai eltérő környezeti körülmények között. In Erdei Ferenc V. Tudományos Konferencia (p. Poszter).

PRÁGAI, A., KISPÁL, T., KŐRÖSINÉ, M. A., & BODNÁR, Á. (2011): A gazdasági haszonállatként tartott alpaka jelentősége a Világ egyes országaiban. In III. Gödöllői Állattenyésztési Tudományos Napok (pp. 58–58).

PRÁGAI, A., VEPRIK, R., KÖRÖSINÉ, M. A., & BODNÁR, Á. (2011): Feed preference and general behaviour of alpacas in Szeged Zoo. AGRÁR- ÉS VIDÉKFEJLESZTÉSI SZEMLE, 6(Suppl. 1.), 526–526.

PRÁGAI, A.; KOVÁCS, A. (2014): Alpaca body condition scoring's importance in Hungary. In "II. Sustainable development in the Carpathian Basin" international conference – Book of Abstracts ("II. Fenntartható fejlődés a Kárpát-medencében" nemzetközi konferencia absztraktkötete) (p. 123).

Book Chapter (Scientific):

PRÁGAI A; MOLNÁR A K; PEKLI J; VEPRÓ R; HUSZÁR GY; BODNÁR Á, (2011): Feed preferences and recipe alternatives for alpacas in a Hungarian zoo. In Fibre production in South American Camelids and other fibre animals (pp. 177–186).

Knowledgeable journal article:

PRÁGAI, A. (2013): Alpaca breeding in Hungary. *ALPACA WORLD MAGAZINE*, *11*(2), 48–51.

PRÁGAI, A. (2017): Alpaka terápia. *KISTERMELŐK LAPJA*, *61*(3), 17–17.

Publications unrelated to the topic of the dissertation

Scientific journal article:

BODNÁR, Á., **PRÁGAI**, A., & KOVÁCS, A. (2012). A zebu (*Bos indicus*) és keresztezési lehetőségei: a santa gertrudis kialakulása és használata egyes helyi fajták javításában. *ANIMAL WELFARE ETOLÓGIA ÉS TARTÁSTECHNOLÓGIA*, 8(1), 118–126.

Book excerpt (Part of educational material):

PRÁGAI, A., & KOVÁCS, A. (2013). Házi húsfeldolgozás. In *Ökológiai gazdálkodás alapjai 2*. (p. 157).