Evaluating the correlation between hoof overgrowth, foot diseases, lameness, and body condition in Murcia-Granada, Anglo-Nubian, and Boer goats

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SUMMARY

Hoof deformities-a common problem faced on goat farms- are considered to lead to various foot diseases. The aim of this study is to evaluate the correlation between hoof size and deformation, lameness score, body condition score, and white line disease in goats. Goats from the Murcia-Granada, Anglo-Nubian, and Boer breeds, aged between 1-4 years and weighing 26-61 kg, were used as the study material. Care was taken to ensure that the goats had the same care and feeding conditions. The assessment was performed using various scoring systems. It was determined that 79.51% of the goats had overgrown hooves. The Boer breed had the highest score for overgrown hooves, followed by the Anglo-Nubian and Murcia-Granada breeds. The Anglo-Nubian goats had higher scores for white line disease than the other breeds. It was also observed that lameness worsened as hooves were overgrown in the Boer and Murcia-Granada goat breeds, and body condition scores dropped in the Boer breed as their hooves overgrew. Consequently, it was observed that hoof overgrowth and deformation can cause many negative effects in goats. The most important way to eliminate these problems is considered to implement regular hoof care in accordance with the standards.

KEY WORDS

Goat; Hoof overgrowth; White line disease; Lameness; Body condition.

INTRODUCTION

In recent years, goat farming has become more and more popular due to the increasing number of studies on the benefits of goat milk and dairy products for human health. To meet the growing demand for goat milk and dairy products, it is necessary to maximise the yield and improve the genetic structure of the animals, as well as their nutritional and breeding conditions. This can be achieved by housing goats in intensive production systems where their genetic potential has been greatly improved (1). The change of habitat for goats in intensive production systems leads to many foot health problems, including overgrowth and deformations in their hooves (2, 3). From this point of view, goats are thought to have difficulties in adapting to man-made housing systems (4).

Hoof has a complex structure that has a significant impact on the overall health and fertility of animals. Healthy hooves contribute to the economic value of animals by improving their overall health and fertility (5). A previous study showed that irregular hoof wear in goats can lead to malformations and structural changes in the hooves (6). These malformations impair the mobility and musculoskeletal structure of the animals, as well as make them susceptible to infectious agents by raising the risk of mechanical injury (7). Therefore, it is recommended that the hooves of goats be trimmed at least 2-3 times a year for hoof care. Thus, it has been reported that irregular and painful hoof growth and many accompanying problems would be eliminated (4).

Poor hoof structure leads to increasing of hoof lesions and the development of lameness (8, 9). Lameness that develops in small ruminants impairs animal welfare and leads to a reduction in milk yield and fertility performance. This results in the slaughter of animals (10, 11). From this point of view, it is important to evaluate the hoof structure correctly in order to identify animals at risk (9).

The related studies have emphasised that overgrown hooves have been identified at the rate of 60.5–95.5% in dairy goat farms and foot diseases are one of the most significant health and welfare problems (3, 12, 13). These diseases include rot, hairy scab, interdigital dermatitis (ID), contagious ovine digital dermatitis (CODD), white line disease (WLD), pododermatitis, foot-founder, purulent-necrotic inflammation of the corium ungulae, and septic foot arthritis (14). WLD is quite prevalent in sheep and goats and differs according to the degree of separation of the white line. Although small separations are usu-

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ally not crucial, they are important as they lead to acute lameness and different foot diseases, as well as the effects produced by the ground in progressive cases. The disease can be treated through regular, careful trimming of the lesioned part (14, 15).

Hoof conformation can be assessed using objective measurements and subjective scoring. Both assessments present positive and negative aspects. Although the accurate and repeatable nature of objective measurements provides superior assessments compared to subjective scoring, objective measurements may bring along subjective judgments of the researcher (9, 16). Subjective assessments include visual assessments to determine a categorical score (8, 17). The advantages of subjective assessment include the ability to assess quickly and easily, the lack of need for equipment, and the ability to assess a large number of animals in a short period of time. Therefore, farms use it more frequently (9).

The increasing number of goat farms in Turkiye brings along problems related to the adaptation of goats to intensive farming. This study aimed to raise awareness about hoof care and contribute to improving productivity in goat breeding by comparing overgrown hooves, foot conformation, foot diseases, and body condition scores (BCS) in Murcia-Granada (M-G), Anglo-Nubian (A-N), and Boer (B) goat breeds.

MATERIALS AND METHODS

Material

The study material consisted of 83 goats from M-G, A-N, and B breeds with the same care and feeding conditions at the Directorate of Animal Breeding, Genetic Application, and Research Centre of Siirt University. The goats were aged from 1-4 years and had a live weight of 26-61 kg. Animals were subjected to detailed general health examinations and those without any other health problems other than foot diseases were included in the study.

Method

Screening for Foot Diseases

Detailed clinical examinations (inspection, palpation), including all four feet of the goats were performed on the same day for all three goat breeds. During the examinations, each hoof was assessed for the presence or absence of diseases such as sole necrosis, foot rot, digital dermatitis, toe granuloma or abscess, hoof deformation, and WLD. Furthermore, a 5-point scoring system used by Winter and Arsenos (18) was used for WLD. This system assigned a score as follows: completely healthy hoof [0], hoof with prominent lesions without separation along the white line [1], hoof with mild separation and prominent lesions [2], hoof with moderate separation and prominent lesions [3], and hoof with major separation and prominent lesions [4]. In this scoring, the single-foot score was determined by averaging both hooves.

Assessment of Overgrown Hooves

A three-point scoring system used by Marcone et al. (19) was used for scoring hoof overgrowth (HO): appropriate HO and perfect shape of the wall area [0], moderately deformed or overgrown hoof [1], and severely deformed or overgrown hoof [2]. In this scoring, the single-foot score was determined by averaging both hooves.

Assessment of Lameness

A four-point scoring system developed by Anzuino et al. (3) was used to assess lameness: a goat with a smooth gait and able to bear weight on all four extremities as [0] point, a goat having pronounced lameness in one or more extremities, but being able to bear weight and gait freely as [1] point, a goat with difficult forward gait, severe lameness, ability to bear less weight on one or more extremities, and ability to duck gait to a certain extent as [2] points, and a goat having a significantly difficult gait but being unable to bear weight on one or more extremities, or being to do a high duck gait or jump on its knees as [3] points.

Assessment of Body Condition Score

A 5-point scoring system reported by Villaquiran et al. (20) was used to assess BCS. Accordingly, a score of 1.0 was rated as an extremely lean goat with no fat reserves, and a score of 5.0 was rated as a highly conditioned (obese) goat. After the scoring procedures were completed, each hoof was brought to normal levels by performing the necessary trimming procedures.

Statistical Analysis

The Spearman's rank correlation test was used to analyse the correlations between the scored parameters. Mc-Nemar's test was used to compare the impaired or healthy anterior and posterior hooves in terms of the hoof overgrowth and WLD. The mean HO and WLD scores were compared using Friedman's test. The Mann-Whitney U test analysed the correlation of lame-

Table 1 - Analysis of the correlation of lameness, hoof overgrowth, White Line disease, and body condition scores, with foot rot.

				Mann Whitney	
	Foot Rot	N	Mean rank	U	p
LS	Available	56	51.06	248.500	0.000
	None	27	23.20		
HO	Available	56	47.57	444.000	0.002
	None	27	30.44		
WLD	Available	56	42.38	734.500	0.796
	None	27	41.20		
BCS	Available	56	43.02	699.000	0.558
	None	27	39.89		

LS: Lameness, BCS: Body condition score, HO: Hoof overgrowth, WLD: White Line Disease

Table 2 - Correlation between body condition score and lameness, hoof overgrowth, and white line disease according to breeds.

Variables	Breeds A-N LS	BCS	HO	WLD	B LS	BCS	HO	WLD	M-G LS	BCS	HO	WLD
LS	-				-				-			
BCS	0.141	-			-0.236	-			-0.271	-		
HO	0.324	0.304	-		0.402*	-0.375*	-		0.409*	-0.217	-	
WLD	0.183	0.025	0.302	-	-0.101	0.547**	-0.035	-	0.063	0.075	0.047	-

Spearman's rho p-value *=<0.05 **=<0.01
A-N: Anglo-Nubian, B: Boer, M-G: Murcia-Granada, LS: Lameness, BCS: Body condition score, HO: Hoof overgrowth, WLD: White Line Disease

ness (LS), HO, WLD, and BCS, with foot rot disease. The Kruskal-Wallis H test was used to compare the LS, HO, and WLD scores in terms of breeds. The value of $p<0.05$ was accepted as the statistical significance level, and all analyses were done using the statistical package programme.

RESULTS

In the assessment of foot diseases, sole necrosis was identified in 28 (33.73%) of 83 goats. Five goats had the disease in their right fore foot, ten in their left fore foot, eight in their right hind foot, and sixteen in their left hind foot. Hoof deformation was detected in 28 (33.73%) of the goats. 25 of them had the deformation on the right fore, 24 on the left fore, 18 on the right hind, and 20 on the left hind. In 35 goats, foot rot disease was determined. 21 lesions were observed in the right fore foot, 25 in the left fore foot, 26 in the right hind foot, and 27 in the left hind foot. Any diseases such as digital dermatitis, toe granuloma, or abscess were not observed in the goats.

According to the Mann-Whitney U test, there was a statistically significant difference between the breeds for LS and HO ($p<0.05$). The mean ranks revealed that goats with foot rot had higher LS and HO (Table 1).

No statistically significant difference was found between the parameters scored in A-N breeds. In the Boer (B) breed, there was a significant positive correlation between HO and LS ($p=0.402$) and a significant negative correlation between HO and BCS ($p=-0.375$). Accordingly, as HO increased, LS also increased. BCS dropped as HO increased. There was a significant positive correlation ($p=0.547$) between WLD and BCS in the B breed. There was a significant positive correlation ($p=0.409$) between HO and LS in the Murcia-Granada breed. As HO increased, LS also increased (Table 2).

Table 2 shows the comparison of healthy and unhealthy fore and hind hooves of 83 goats according to breeds for HO. 18 of the goats (n=83) had healthy two fore hooves, and 17 animals had healthy two hind hooves. 17 of these goats had four healthy hooves. No significant difference was found between the fore and hind hooves in terms of incidence of HO (Table 3).

When the distribution of HO findings between the hooves was analysed proportionally, the number of cases in which only two hooves were impaired was found to be 4.82%, and no cases in which only one hoof was impaired were observed. The cases in which only two hooves were impaired were observed in the hind hoof and right hoof pairs (Table 3). Breed analysis revealed that the M-G breed had impaired right and left hind hoof pairs, while the A-N and B breeds had only impaired right hoof pairs (Table 4).

In terms of WLD, the fore and hind hooves of 83 goats were compared as healthy and impaired according to breeds and Table 4 shows the results. When only the fore hooves of 83 goats were

Table 3 - Impaired and healthy condition of fore and hind hooves for HO (n=83).

Breeds A-N			Hind Hooves Healthy	Impaired	Total	p
A-N	Fore Hooves	Healthy	2	0	2	
		Impaired	0	23	23	1.000
		Total	2	23	25	
	Fore Hooves	Healthy	4	0	4	
		Impaired	0	28	28	1.000
		Total	4	28	32	
M-G	Fore Hooves	Healthy	11	1	12	
		Impaired	0	14	14	1.000
		Total	11	15	26	
General	Fore Hooves	Healthy	17	1	18	
		Impaired	0	65	65	1.000
		Total	17	66	83	

A-N: Anglo- Nubian, B: Boer, M-G: Murcia-Granada

Table 4 - Distribution of impaired hoof pairs in cases with HO in only two hooves (n=4).

Fore Hooves	Hind Hooves	Right Side (Fore&Hind)	Left Side (Fore&Hind)	Left Fore-Right Hind	Right Fore-Left Hind
0 (0%)	1 (25.00%)	3 (75.00%)	0 (%)	0 (0%)	0 (0%)

assessed, both fore hooves of 60 animals were healthy, and when only the hind hooves were assessed, both hind hooves of 64 animals were healthy. All four hooves on 54 of these goats were healthy. No significant difference was found in the incidence of WLD between the fore and hind hooves (Table 5).

Upon proportional analysis of the distribution of the WLD findings among the hooves, it was found that only two hooves were impaired in thirteen cases (15.66%), while only one hoof (right fore 1, left fore 5, right hind 2, left hind 1) was impaired in nine cases (10.84%). Among these thirteen cases, only the fore, hind, right, and left hoof pairs were impaired in three (23.08%), three (23.08%), three (23.08%), and two (15.38%), respectively. The number of cases in which only left fore-right hind and right fore-left hind cross hooves were impaired was 0 and 2 (15.38%), respectively (Table 5). When analysed according to breeds, the number of cases in the A-N breed in which right fore-right hind cross hooves were impaired was 2, the number of cases in which only fore hoof pairs were impaired was 3, and the number of cases in which only hind hoof pairs were impaired was 1. In the B breed, the number of cases in which only left fore-right hind cross hoof pairs were impaired was 2, the number of cases in which only hind hoof pairs were impaired was 2, and the number of cases in which only right hoof pairs were impaired was 1. The number of cases in which only right hoof pairs were impaired in the M-G breed was 2 (Table 6).

Furthermore, Table 7 presents the means of HO and WLD for each hoof by breed. All breeds showed no statistically significant difference between the four hooves in terms of HO and WLD mean scores.

According to the Kruskal-Wallis test, a statistically significant difference was found between the breeds for HO and WLD ($p<0.05$). According to the mean ranks, the highest HO score was found in the B breed, and the highest WLD score was found in the A-Nubian breed. The Mann-Whitney U test was run on the pairwise combinations of the breeds to identify which groups differed. While the A-N breed goats had higher HO scores than the M-G breed, the B-breed goats had higher HO scores than the A-N and M-G breeds. The A-N breed goats had higher WLD scores than the B and M-G breeds.

DISCUSSION

Hoof disorders appear to be a highly prevalent common problem in goat farms (13). It is predicted that this condition can cause many foot diseases (14). In this sense, HO, hoof deformation, WLD, and horn separation are the most prevalent foot-related issues in goats (14, 21). There are studies indicating that

Table 5 - Healthy or impaired fore and hind hooves for white line disease (n=83).

Breeds A-N			Hind Hooves Healthy	Impaired	Total	p
A-N	Fore Hooves	Healthy	2	0	2	
		Impaired	0	23	23	1.000
		Total	2	23	25	
B	Fore Hooves	Healthy	11	1	12	
		Impaired	6	7	13	0.125
		Total	17	8	25	
	Fore Hooves	Healthy	23	4	27	
		Impaired	1	4	5	0.375
		Total	24	8	32	
M-G	Fore Hooves	Healthy	20	1	21	
		Impaired	3	2	5	0.625
		Total	23	3	26	
General	Fore Hooves	Healthy	54	6	60	
		Impaired	10	13	23	0.454
		Total	64	19	83	

A-N: Anglo- Nubian, B: Boer, M-G: Murcia-Granada

Table 6 - Distribution of impaired pairs of cases with white line disease in only two hooves (n = 13).

Fore Hooves	Hind Hooves	Right Side (Fore&Hind)	Left Side (Fore&Hind)	Left Fore-Right Hind	Right Fore-Left Hind
3 (23.08%)	3 (23.08%)	3 (23.08%)	2 (15.38%)	0 (0%)	2 (15.38%)

Table 7 - Comparison of mean scores of hoof overgrowth and white line disease for each hoof.

Breeds	Scored Hoof	HO Mean±SE	HO Sum	WLD Mean±SE	WLD Sum
A-N	Right Fore	1.16±0.554	29	0.240±0.459	6
	Left Fore	1.08±0.702	27	0.300±0.433	7.5
	Right Hind	1.24±0.597	31	0.160±0.345	4
	Left Hind	1.16±0.746	29	0.160±0.278	4
B	Right Fore	1.50±0.718	48	0.047±0.148	1.5
	Left Fore	1.47±0.761	47	0.047±0.195	1.5
	Right Hind	1.50±0.718	48	0.109±0.276	3.5
	Left Hind	1.47±0.761	47	0.109±0.330	3.5
M-G	Right Fore	0.580±0.578	15	0.038±0.135	1
	Left Fore	0.580±0.578	15	0.019±0.098	0.5
	Right Hind	0.620±0.571	16	0.038±0.135	1
	Left Hind	0.580±0.578	15	0.019±0.098	0.5
General	Right Fore	1.11±0.733	92	0.102±0.290	8.5
	Left Fore	1.07±0.777	89	0.114±0.295	8.5
	Right Hind	1.14±0.735	95	0.102±0.268	9.5
	Left Hind	1.10±0.790	91	0.096±0.264	8.0

A-N: Anglo-Nubian, B: Boer, M-G: Murcia-Granada, BCS: Body condition score, HO: Hoof overgrowth, WLD: White Line Disease

HO is correlated with lameness in sheep (20) and goats (3, 9, 13). A study conducted by Hill et al., (12) in goats demonstrated a significant correlation between horn separation and lameness, while in their study, Bozkan et al., (14) found that there was no significant correlation between LS and HO or WLD. They attributed this to the theory that white line lesions may not cause lameness unless they are serious, as pointed out by Hill et al. (12) and Bozkan et al. (14). This study on three different goat breeds showed that there was a difference between lameness and HO and WLD. Accordingly, while there was no statistically significant difference between these parameters in the A-N breed, a significant positive correlation was found between the HO and LS in the B (p=0.402) and M-G (p=0.409) breeds. Accordingly, as HO increased, LS also increased. A comparison of goat breeds suggests that the A-N breed had less sensitivity to hoof growth than the B and M-G breeds, but it is believed that the number of goats should be increased in order to make a clear statement.

Numerous studies (15, 22, 23) have indicated the impact of lameness on nutrition, meat, and milk production in livestock. Some studies have reported that lameness is correlated with low body condition scores in cattle (22, 24, 25). Some studies reported that increased lameness dropped BCS, while some others reported that lameness increased BCS (26). Besides, some researchers reported a correlation between hoof shape and BCS (27), while others reported that they could not determine this correlation (28). A study conducted by Bozkan et al., (14) in goats showed that LS, HO, and WLD were negatively correlated with BCS. This study showed a significant negative correlation between HO and BCS (p = -0.375) only in the B breed. Accordingly, it was determined that as HO increased, BCS also dropped. This result is compatible with the results of Bozkan et al., (14) only for the B breed. Furthermore, unlike Bozkan et al., (14), a significant positive correlation (p=0.547) was found between WLD and BCS in the B breed, while no significant difference was found in other breeds. This suggested that it was correlated with the WLD score, as reported in the literature (12). Studies conducted on goat farms have reported that the rate of animals with overgrown hooves varies between 50% and 100% (1, 3, 12, 14, 21). The study revealed that 66 out of 83 goats had overgrown hooves. In other words, the rate of the goats with overgrown hooves was 79.51%. Moreover, a statistically significant difference was found between the breeds for HO incidence. Accordingly, the B breed had the highest HO scores, followed by the A-N and M-G breeds, respectively. However, since the goats were recently collected from different farms and

Table 8 - Results of the Kruskal-Wallis h-test to determine whether or not LS, HO, and WLD scores differed according to breeds.

	Breed	N	Mean rank	Sd	X^2	p	Significant difference
LS	A-N	25	37.52				
	B	32	48.23	2	4.434	0.109	-
	M-G	36	38.63				
HO	A-N	25	43.12				1.3
	B	32	54.02	2	21.077	0.000	
	M-G	26	26.13				2.1-2.3
WLD	A-N	25	52.16				
	B	32	39.72	2	10.504	0.005	1.2-1.3
	M-G	26	35.04				

A-N: Anglo-Nubian, B: Boer, M-G: Murcia-Granada, BCS: Body condition score, HO: Hoof overgrowth, WLD: White Line Disease

brought to the farm where the study was carried out, and therefore standard hoof care was not provided to all of them, it was concluded that this would not be sufficient to draw a definite conclusion about the breed.

There are studies reporting that HO and deformation encountered in goat farms are more common in the hind feet (12, 13). Ajuda et al. (13) reported that the prevalence of deformation involving the hind feet was approximately 20% higher than the deformation rate in the forefoot. In their study, Bozkan et al. (14) reported that only the number of deformations in the right forefoot was lower than the others, while there was no significant difference between the hindfoot and forefoot. This study found no significant difference between the forefoot and hindfoot in terms of incidence of HO.

This study showed a statistically significant difference between breeds for WLD. WLD scores from high to low were determined in A-N, B, and M-G breeds, respectively. No significant difference was found between the fore and hind hooves in terms of incidence of WLD. When compared by breeds, 3 cases were identified in the A-N breed with only the fore hoof pairs, 1 case with only the hind hoof pairs, and 2 cases with only the hind hoof pairs in the B breed. No cases in which only the fore or hind feet were impaired were identified in the M-G breed. Parallel to the present study, there are studies indicating that the distribution of white line lesions between the feet showed no significant difference (29), and the incidence of WLD is statistically significantly higher in the hind hooves than in the fore hooves (14).

While sole necrosis, hoof deformation, foot rot, and WLD were identified during the screening of foot diseases in the study, no diseases such as digital dermatitis, toe granuloma, or abscess were identified. Kaler et al. (8) reported that goats with infectious diseases such as foot rot were correlated with a higher risk of lameness. The presence of a significant positive correlation between lameness and HO scores in goats with foot rot in this study corroborates the study by Kaler et al. (8).

CONCLUSIONS

The present study showed that there was a worsening in lameness with overgrown hooves in the B and M-G goat breeds. BCS decreased with overgrown hooves in the B breed. The present study found that 79.51% of goats had a high rate of HO. Moreover, the B breed had the highest scores in HO, followed by the A-N and M-G breeds. The A-N breed goats had higher WLD scores than the B breed and M-G breeds. Consequently, HO and deformation were effective on many parameters.

This finding suggests that regular hoof care can help goats achieve hoof health standards and improve their fertility potential.

Ethical approval

This study was approved with the decision of the Local Ethics Committee of Animal Experiments at Siirt University, dated 30/04/2024, and numbered 2024/04/19.

Author contributions

Ali Gulaydin: Conceptualization, formal analysis, investigation, data collection, data curation, drafting manuscript, critical revisions, writing original draft. **Nihat Sindak:** Data curation, critical revisions, writing original draft. **Mustafa Baris Akgul:** Data curation, drafting manuscript, critical revisions, writing original draft. **Onur Yildirim:** Investigation, data collection, data curation. **Maruf Yilmaz:** Investigation, data collection, data curation. **Muzzemil Hattap Soysal:** Investigation, data collection, data curation.

Conflict of interest statement

The authors declare that there is no conflict of interest.

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