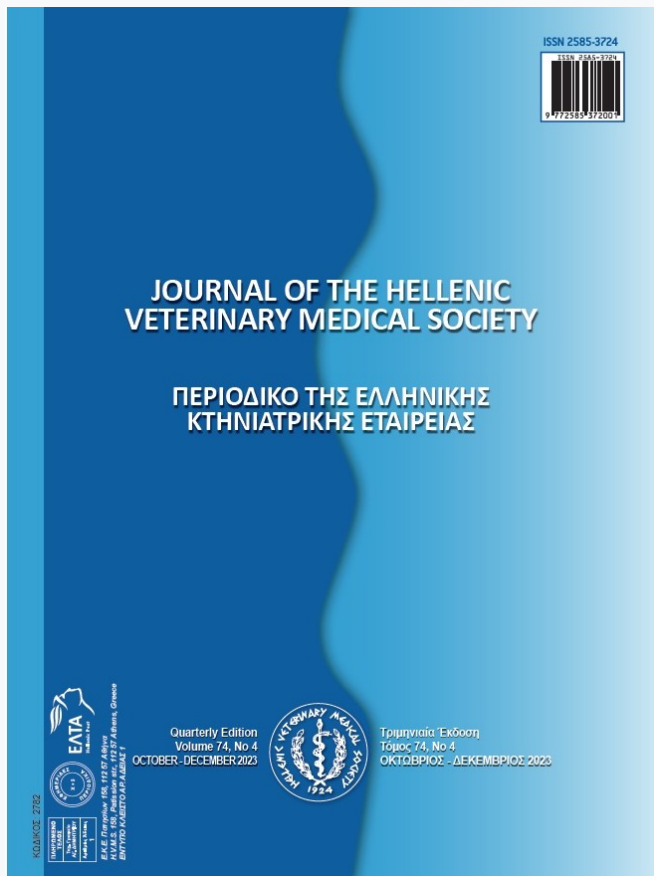


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## Hoof Overgrowth in Saanen Goats: A Study on Relationship Between Hoof Overgrowth, White Line Disease, Lameness and Body Condition

Z. Bozkan<sup>1</sup>, Z. Bilgen<sup>1</sup>, O. Bulut<sup>2</sup>, B. Kibar Kurt<sup>1</sup>, E. Gülendağ<sup>3</sup>, A. Belge<sup>1</sup>

<sup>1</sup>Department of Surgery, Faculty of Veterinary Medicine, University of Aydın Adnan Menderes, TR-09020 Aydın, Türkiye

<sup>2</sup>Department of Surgery, Faculty of Milas Veterinary Medicine, University of Muğla Sıtkı Koçman, TR-48200 Muğla, Türkiye

<sup>3</sup>Department of Biostatistics, Faculty of Veterinary Medicine, University of Siirt, TR-56100 Siirt, Türkiye

**ABSTRACT:** Hoof diseases are very common causes of lameness and hoof health, and it is very important factor for productivity and yield capacity in the small ruminants. This study was conducted in 97 Saanen goats, 12-18 months-old, and weighing 30-40 kg. Hoof overgrowth (HO), white line disease (WLD), lameness score (LS), and body conditions core (BCS) were scored using 3-point, 5-point, 4-point and 5-point scale systems, respectively. The hooves of all goats were evaluated for foot rot and interdigital dermatitis, toe granuloma/abscess and laminitis as absent or present and not found in any of the goats included in the study. A negative and significant relationships were found between the BCS and LS, HO and WLD scores. Mean HO was significantly lower only for the right fore claw, but there was statistically significant difference between all the four claws for WLD. Also, positive and highly significant relationship was found between HO and WLD. The incidence of HO between the fore and hind claws was not significantly different, but WLD in the hind claw was significantly higher than the fore claws. Consequently, in goats, lower BCS was associated with increase in the severity of LS, HO and WLD. Also, at a higher rate WLD was seen in the hind legs and, it has been demonstrated that HO may predispose to WLD.

**Keywords:** Saanen goats; claw; hoof overgrowth; white line disease; lameness; body condition;

*Corresponding Author:*

Zeynep Bozkan, Department of Surgery, Faculty of Veterinary Medicine, Adnan Menderes University, 09016, Aydın, Türkiye  
E-mail address: zbozkan@adu.edu.tr

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## INTRODUCTION

The main cause of lameness in small ruminants is foot and hoof diseases. Lameness can lead to great economic losses due to the reduced feed intake, reduced body weight, milk production and reproduction rates, and even early culling of animals (Oehm et al., 2019; Winter, 2011; Christodouloupoulos, 2009). In small ruminants, foot rot, interdigital dermatitis, white line disease, deep sepsis of the pedal joint (pedal joint abscess, septic pedal arthritis), toe granuloma, hoof overgrowing and hoof deformations are among the foot diseases encountered (Winter, 2011; Christodouloupoulos, 2009; Prado et al., 2022).

Interdigital dermatitis and footrot, which is more common in sheep and milder in goats, occur when the skin of the interdigital region is traumatized and infected by external effects such as faeces and mud (Olechnowicz and Jaśkowski, 2011; Kaler and Green, 2008; Winter, 2008). Deep sepsis of the pedal joint (pedal joint abscess, septic pedal arthritis) is a sporadic but serious problem that causes severe pain and, if not treated early and effectively, leads to claw deformity and chronic lameness. Toe Granuloma is the formation of a strawberry-like granulation tissue at the toe or base of the hoof, most frequently as a result of unqualified over trimming of the claw (Winter, 2011).

In farmed goats, the hoof overgrowth (HO) is a very common problem, affects more than half of the herds, as shown in many different studies (Hill et al., 1997; Anzuino et al., 2010; Ajuda et al., 2014; Hempstead et al., 2021). Because the goat claws are adapted to resist to abrasion on permanently hard, steep and dry ground, not in the farm environment (Zobel et al., 2019). White line disease (WLD) is very common in sheep and goats. It ranges from small discolored areas of the white line in the horn portion to a separated (shelly) hoof along the lateral hoof wall (Winter, 2011).

Healthy hooves play a crucial role in many ways, like as increasing productivity and yield capacity (Koluman and Göncü, 2016). However, although the progress of claw and foot diseases is similar, it has not been reported in goats as widely as in sheep and cattle (Smith and Sherman, 1994). The lack of systematic information on claw disorders in goats and the increase in dairy goat encouraged this study. The lack of systematic information on hoof diseases in goats and increase of the dairy goat breeding encouraged this study. Distribution and severity of the HO and WLD were investigated and their relationship with

the lameness score (LS) and body condition score (BCS) were evaluated in goats.

## MATERIAL AND METHODS

### Animal Studied

The study was conducted in 97 Saanen goats, aged 12-18 months, and weighing between 30-40 kg. The animals included in the study were all females which fed the same ration, housed on the same farm. Also, they were in the same period of the lactation since they gave birth at the same period. Information about the disease history was obtained from the owner and general health examinations of the animals were systematically performed. Animals with no history of health problems or no signs of disease were included in the study.

### Study design

The hooves of all goats were evaluated as absent or present in terms of foot rot and interdigital dermatitis, toe granuloma/abscess and laminitis.

HO was scored using 3-point scale as follows; appropriate hoof length and perfect shape of the wall area [0], moderately misshapen or overgrown hoof [1] and severely misshapen or overgrown hoof [2] (Foddai et al., 2012; Marcone et al., 2022). WLD was scored using a 5-point scale system as follows; healthy [0], discrete lesions with no separation along the white line [1], lesions with minor separation [2], lesions with moderate separation [3], lesions with major separation [4] (Winter and Arsenos, 2009). Each claw was evaluated individually in terms of hoof overgrowth and white line disease. Score for each foot was defined as the average of the two claws. Lameness was scored using a 4-point scale developed by Anzuino et al. (2010) as follows; the goat which places weight on all four limbs, moves forward freely with an even gait [0], the goat which has a definite limp on one or more legs, but bearing weight and moves forward freely [1], the goat which has some difficulty moving forward, severe limp, bearing little weight on one or more legs, may be a degree of goose-stepping [2]; the goat has some difficulty moving forward, not bearing weight on one or more legs, or may 'goose-step' high or walt on the knees [3].

Apart from these, the finding distribution ratio between the feet in terms of HO and WLD was also calculated and examined. This calculation was made proportionally by simply comparing the numbers.

BCS was evaluated a 5-point scoring system ranging from 1.0 to 5.0. A score of 1.0 is an extremely lean goat with no fat reserves and 5.0 is a very over-conditioned (obese) goat (Villaquiran et al., 2004).

### Statistical Analysis

The relationships between the parameters scored in the study were examined by using Spearman's Rank Correlation test. To compare the impaired or healthy condition of the fore and hind claws in terms of HO and WLD, the Mc-Nemar test was used. The mean HO and WLD scores were compared by using The Friedman test.  $p < 0.05$  was accepted as the statistical significance criterion. IBM SPSS Statistics Software Version 23 was used for all statistical analyzes.

### RESULTS

Foot rot and interdigital dermatitis, toe granuloma/abscess and laminitis were not found in any of the goats included in the study. In other words, none of the 97 goats included in the study had these problems.

Between BCS and LS (-0.203), HO (-0.331) and WLD (-0.356) scores a negative and significant relationship was found. Accordingly, BCS decreased with the increase in the severity of the disease in all 3 diseases (Table 1).

While no significant relationship was found between LS and HO and WLD, positive and highly significant relationship was found between HO and WLD (0.875) (Figure 1).

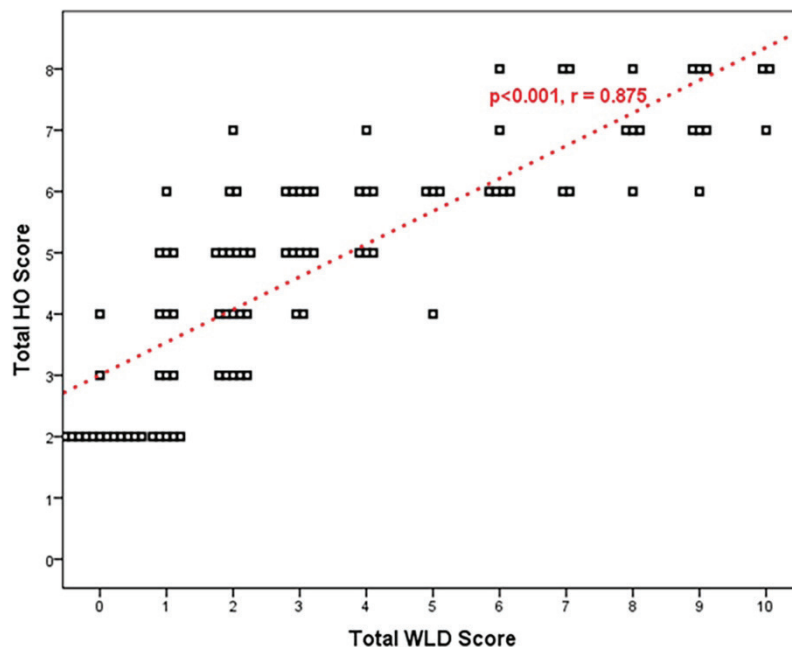
When the impaired and healthy conditions of the front and hind claws were compared in terms of HO; In only 6 cases, both fore claws were healthy, but at least one hind claw had HO. HO was observed in the hind claws of 96 of 97 goats (Figure 2). A goat with healthy hind claws had HO in one front claws, at least. No goat was found without HO in all 4 claws. No significant difference was found in the incidence of HO between the fore and hind claws (Table 2).

When the distribution of HO findings between the claws examined proportionally; 16 of 97 animals

**Table 1:** Relationship between BCS and LS, HO and WLD

	BCS	LS	Total HO	Total WLD
BCS	-			
LS	-0.203*	-		
Total HO	-0.331***	0.189	-	
Total WLD	-0.356***	0.268	0.875***	-

Spearman's rho p-value \*= $<0.05$  \*\*\*= $<0.001$



**Figure 1:** Relationship between HO and WLD



**Figure 2:** Hoof overgrowing of the score 1 on the fore leg (a) and score 2 on the hind leg (b)

**Table 2:** Impaired and healthy condition of the fore and hind claws in terms of HO (N=97)

		Hind Claws		Total	P
		Healthy	Impaired		
Fore Claws	Healthy	0	6	6	0.059
	Impaired	1	90	91	
	Total	1	96	97	

**Table 3:** Distribution of affected claw pairs in cases with HO in only two claws (N=16)

Fore Claws	Hind Claws	Right Side (Fore & Hind)	Left Side (Fore & Hind)	Left Fore- Right Hind	Right Fore- Left Hind
1 (6%)	3 (19%)	3 (19%)	4 (25%)	5 (31%)	0 (0%)

**Table 4:** Impaired and healthy condition of the fore and hind claws in terms of WLD (N=97)

		Hind Claws		Total	P
		Healthy	Impaired		
Fore Claws	Healthy	15	25	40	0.006
	Impaired	9	48	57	
	Total	24	73	97	

(16%) had HO in both claws and there was no case in which only one claw was affected. In other words, HO was observed in at least two claws in all animals in the study.

The number of cases where HO affected only the fore, hind, right and left claw pairs was 1 (6%), 3 (19%), 3 (19%) and 4 (25%) in these 16 cases, respectively. The number of cases affecting only the left fore-right hind and right fore-left hind cruciate claws were 5 (31%) and 0, respectively (Table 3).

In terms of WLD, when the front and hind paws of 97 goats were compared as impaired and healthy; Both front claws of 40 animals and both hind claws of 24 animals, all four claws of 15 animal were healthy,

the rest were impaired. WLD was detected in at least one of the fore and hind claws in 48 goats (Figure 3). Nine goats with healthy hind claws had WLD at least one fore claw, 25 goats with healthy fore claws had WLD in at least one hind claw. The WLD incidence in hind claws was statistically significantly higher than the fore claws ( $p=0.006$ ) (Table 4).

When the distribution of WLD findings between the feet was examined proportionally; the cases which only two claws affected were 27 (28%), and one claw were 16 (16%) (2 right fore 2, left fore 4, right hind 5, left hind 5). Among these 27 cases, the number of cases where WLD affected only fore, hind, right and left claw pairs were 3 (11%), 15 (56%), 2 (7%) and 3 (11%), respectively. The number of cases



**Figure 3:** WLD score 1, 2, 3 and 4 respectively from a to d

**Table 5:** Distribution of affected claw pairs in cases with WLD in only two claws (N=27)

Fore Claws	Hind Claws	Right Side (Fore & Hind)	Left Side (Fore & Hind)	Left Fore- Right Hind	Right Fore- Left Hind
3 (11%)	15 (56%)	2 (7%)	3 (11%)	4 (15%)	0 (0%)

**Table 6:** Comparison of the mean HO and WLD score for each claw

Scored Claw	HO		WLD	
	Mean±SE	Sum	Mean±SE	Sum
Right Fore	0.918±0.068 <sup>b</sup>	89	0.454±0.073 <sup>d</sup>	44
Left Fore	1.227±0.06 <sup>a</sup>	119	0.711±0.08 <sup>c</sup>	69
Right Hind	1.381±0.061 <sup>a</sup>	134	1.227±0.116 <sup>a</sup>	119
Left Hind	1.309±0.069 <sup>a</sup>	127	1.052±0.112 <sup>b</sup>	102

\*Differences between means indicated with different letters in the same column are significant ( $P < 0.001$ ).

in which only left fore-right hind and right fore-left hind crossed claws were affected were 4 (15%) and 0, respectively (Table 5).

In addition, when the scores for each claw were evaluated in terms of HO and WLD, it was seen that the total and average scores increased respectively right fore, left fore, left hind, right hind. The difference between the HO means was significantly lower for the right fore claw only ( $P < 0.001$ ). A statistically significant difference was found for WLD between four claws ( $P < 0.001$ ). (Table 6).

## DISCUSSION

This study was aimed to evaluate the relationship between lameness and body condition score of foot diseases encountered in Saanen goats raised on dairy farms. However, no foot problems were found in the goats included in the study, except for claw and white line disorders.

It is known that claw disorders are a common problem in goat farms (Ajuda et al., 2019). HO and WLD and horn separation are the top two of foot diseases that affect most goat populations (Hill et al., 1997; Hempstead et al., 2021). Goats' poor claw structure and increased claw size predispose to hoof lesions and affect the severity of lameness (Anzuino et al., 2010; Ajuda et al., 2019; Deeming et al., 2019). In addition, in goats, a significant relationship between horn separation and lameness was reported, although mild lesions on the white line were not associated with lameness (Hill et al., 1997). A relation between claw overgrowth and lameness in cattle (Oehm et al., 2019) and sheep (Winter et al., 2011) has been shown before. In the present study, no significant relationship was found between LS and HO or WLD. The absence of a significant relation may be based on the fact that the most severe WLD was seen in a small number of animals and that WLD may not cause lameness unless it is very severe as Hill et al. (1997) pointed out.

On the other hand, LS and HO and WLD were negatively correlated with BCS in our study. The effect of lameness on food intake, body weight and milk production has been reported in many farm animals (Oehm et al., 2019; Winter, 2011; Christodoulouopoulos, 2009). However, these studies investigated the effect of lameness from any reason on BCS, and no study was found that correlates hoof conformation or lameness with BCS in goats. There are some studies in cattle claiming that either low BCS (Oehm et al., 2019; Green et al., 2014; Randall et al., 2018) or both low and high BCS are associated with an increased risk of lameness (Kranepuhl et al., 2021). Also, there are studies reporting that there is a relationship between the claw conformation and BCS (Fabbri et al., 2020) and also there is not (Akin et al., 2021).

Hoof overgrowth (HO) in farm goats is a very common problem (Hill et al., 1997; Anzuino et al., 2010; Ajuda et al., 2014; Hempstead et al., 2021). In our study, no goats with 4 healthy claws were found. In other words, 100% of the animals had HO in at least one claw. Similarly, according to other studies examining the ratio of goats with HO in at least one claw in herds, it is seen that more than half of the herds are affected. Anzuino et al. (2010) and Hempstead et al. (2021) reported that the HO rate was 79% and 51.4%, respectively, in their studies on animal welfare in goat farms. In another study by Hill et al. (1997) on lameness and foot lesions, it was reported as 91%. Ajuda et al. (2014), on the other hand, found the HO rate to be 69% in their study investigating the effect of trimming on claw temperature.

In this study, the mean HO scores for each claw increased in order of right fore, left fore, left hind, right hind. But, the difference between the means was significantly lower only for only the right fore claw. Although the aforementioned studies generally evaluated the incidence of HO on a herd basis, did not examine which claw affected more commonly or more severely. Generally in cattle's, it is seen that the studies only are evaluated only hind claws, which is probably because those are more affected pairs, in terms of foot and claw disorders. (Fabbri et al., 2020; Akin et al., 2021).

The closest evaluation in studies on goats was made by Ajuda et al. (2019) on 152 claws of 34 goats. They investigated the role of claw deformation and size on goat lameness and evaluated the incidence of claw deformities between the claws. Claw deformation was found in at least one paw in 89% of 38 goats

and, 58% of 152 claws; 19% were front and 39% hind claws. In the present study, there was no significant difference in the incidence of disease between the fore and hind claws. In fact, the number of goats with two healthy fore claws (n:6) was higher than those with two healthy hind claws (n:1). Also, the number of goats with HO on the front paws only (n:1) was lower than the goats with only the hind paws (n:3). But these numbers include too few animals to draw any meaningful conclusions. It is known that up to 70% of the claw lesions occur on the hind legs in cattle. In cattle, this is thought to be due to the tendency of the weight distribution between the claws of the forelegs to be more equal than those of the hind legs (Newcomer and Chamorro, 2016). Unbalanced weight distribution may still be possible to cause a higher incidence of HO in the hind legs when the goats kept in farms because their claws adapted claws to resist constant abrasion on hard, steep and dry grounds, while there is no clear information about this.

WLD incidence in the hind claw was statistically significantly higher than in the fore claws ( $p=0.006$ ). Also, the goats with WLD in hind claws only (n:15) was higher than which has in fore claws only (n:3), but no statistical analysis was performed since they included very few animals. However, in another study, it was stated that the distribution of the white line lesions between the feet is no significantly different (Hill et al., 1997). Considering that horn separation was evaluated together with WLD in our study, our findings contradict with the finding of horn separation occurs independently of which claw is affected in the same study conducted by Hill et al. (1997). In this study, a positive correlation was observed between WLD and HO ( $r = 0.875$ ) and no correlation was found with LS. Also, mean WLD scores for each claw increased at the same rate as mean HO scores, and statistically significant differences were found for WLD between all four claws. In the study of Hill et al. (1997), horn separation was associated with a relative risk of lameness, although white line lesions were not found significantly associated with lameness. It has been previously reported that claw size is highly correlated with claw deformation in dairy goats (Ajuda et al., 2019). Furthermore, the long-term presence of overgrown claws can lead to chronically deformed morphology (Hill et al., 1997). However, it is stated that more information is needed about the effect and results of HO over time (Ajuda et al., 2019). There is no study examining the relationship between HO and WLD previously, according to the authors' knowl-

edge. However, while the exact etiology of white line disease has not been defined, so any method of prevention could be established (Winter et al., 2011). Although a limited number of animals have been studied, this study points to HO as an etiological factor for WLD, laying the groundwork for the generation of a preventative method.

## CONCLUSION

As a result, it was determined that there was a relationship between BCS and LS, HO and WLD in goats,

and although there was no difference between the legs in terms of HO predisposition, WLD was seen at a higher rate in the hind legs. More importantly, it has been demonstrated that HO may predispose to WLD. Thus, the idea has emerged that various measures effective for HO, particularly claw clipping, can also be used as a preventative against WLD.

## CONFLICTS OF INTEREST

The authors declare no financial or other conflicts related to this report.

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