

Sow Lateral Toe Growth and Lesion Presence on Hooves When Housed in Gestation Stalls

AK Johnson^{1*}, A Garcia²,
LA Karriker³ and KJ Stalder¹

Abstract

Background: Hoof quality is vital to reduce the risk of trauma or injury. The pig's hooves are susceptible to lesions, such as overgrowth, erosion, and cracks. The objectives of this study were to determine lateral toe growth and lesion severity and type when evaluating multi-parity sow hooves that were housed in gestation stalls over one month.

Methods and Findings: Thirty sows were obtained from the same farm, in their first to the fifth week of gestation, in good health and with no obvious lameness signs. Sows were selected for inclusion in this study based on parity (parity 1n=10; 158.8 Kg to 204.1 Kg BW; parity 2n=10; 181.4 Kg to 226.8 Kg BW; parity 3n=10; 204.1 Kg to 249.5 Kg BW) and (2) breed (Duroc; n=11; Cross [Duroc*Yorkshire] n=11; Yorkshire n=8). On the first day of the study, each lateral toe was marked using a paint marker at the coronary band and every seven days for the next four weeks, lateral toe growth and lesions were measured on all hooves, whilst sows stood. Hoof lesions on the medial and lateral toes, dew claws and plantar surface were recorded using the FeetFirst[®] guidelines; Zinpro. A new category was created called "any lesion". This was defined as summing all lesions for a category of interest for example breed. There were no differences in lateral toe growth between lateral toe pairs ($p=0.08$) for the same sow. There was a difference in lateral toe growth by sow breed, with Yorkshire sows' lateral toes growing more slowly when compared to Duroc and Crossbred (Duroc × Yorkshire) sows ($p<0.0001$). There was a difference by sow parity, with parity two sows' lateral toes growing the fastest, followed by parity one and three ($p<0.0001$). Regardless of parity and breed, lesion severity was predominantly scored level one (mild) with cracked wall vertical being the most common lesion type. When comparing foot pairs of the same sow, more lesions were observed on the front (61.7%) when compared to rear (46.7%) hooves. Parity two sows had the most lesions on their toes (hooves), and their toes grew more quickly, and thus new toe growth may not be as hard and could become more easily damaged.

Conclusions: It is suggested that caretakers carefully examine toe length and lesion presence at weaning for all sows, but particularly for parity two sows. This examination will result in a high-quality sow with sound hoof integrity being returning to the breeding herd. Additionally, working with the swine herd veterinarian can guide caretakers on how to manage longer toes or lesion presence throughout production. It is advised a good quality sow will have better performance, longevity and overall welfare.

Keywords: Sow; Hoof; Lateral toe-growth; Lesions

- 1 Department of Animal Science, Iowa State University, USA
- 2 Department of Animal and Food Sciences, Texas Tech University, USA
- 3 Swine Medicine Education Center, Veterinary Diagnostics and Production Animal Medicine, Iowa State University, USA

***Corresponding author:**

Anna Johnson

✉ johnsona@iastate.edu

Department of Animal Science, Iowa State University, USA

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Introduction

A sow has four hooves, with each hoof consisting of two toes

(a medial and lateral toe) with a corresponding dew claw [1]. Each toe includes a distal phalanx, which is covered with a horny

capsule that consists of a hard-outside wall, a sole of hard horn tissue (the anterior sole also known as the toe), a soft heel, and a narrow white line joining the wall and sole [2]. Horn quality is vital to reduce injury [2,3]. The pig's hoof has anatomical locations that are susceptible to lesions, such as overgrowth (toes, heel), erosion (heel), and cracks (heel, white line, sole/heel junction, toe wall). Lesion prevalence and severity are dependent on management and animal-related factors [1]. Pluym et al. [4] assessed 421 sows and observed 9.7% lameness prevalence. Furthermore, 99% had one or more toe lesions with overgrowth of the heel horn and cracks in the wall as the most prevalent lesions observed. Other studies agree that the heel and the wall horn are the most affected parts of the entire hoof [5]. Toe lesion prevalence afflicts 59% to 99% of the sow population [5-7] and lateral toes more severely affected with lesions [1,4]. The presence of toe lesions may be one etiology that can result in sows expressing lameness [8]. Severe lameness has considerable negative consequences for the sows' welfare and farm profitability. Severe lameness, defined as a sow's reduced weight bearing on one more limb, can have considerable negative consequences for animal welfare and farm profitability as it can result in culling 6% to 35%; or euthanasia [9,10]. Additionally, lameness of varying degrees may hinder a sow's locomotion, social and exploratory behaviors and negatively affect the ability to eat and/or drink [11-13]. Economic losses include caretaker time to move, monitor and treat lame sows, higher veterinary costs and negative impacts on reproduction, premature removal from the breeding herd [14,15] and loss of sow profit due to on-farm euthanasia or greater slaughter condemnation [16].

There has been a concerted effort to understand detrimental factors that affect sow hoof quality, wear, and overall health. Critical factors previously identified in the scientific literature are nutrition flooring type housing and parity [1,7,9,17-19]. Another important factor could be how quickly toes grow. Hanh et al. [20] reported in first lactation Holstein dairy cattle, that monthly hoof growth was 6.0 mm for front claws and 6.6 mm for rear claws and Glade and Salzman [21] reported that toe growth ranged between 5.7 mm and 8.4 mm per month in 5 to 12-year-old mixed bred horses. However, what remains unknown is how quickly sow toes grow and what lesion type and associated severity affects multi-parity sows when housed in gestation stalls. Therefore, the objectives of this study were to determine lateral toe growth and describe lesion severity and types that develop on sow hooves that were housed in gestation stalls over a one-month period.

Materials and Methods

Animals, management, and housing

The project was approved by the Iowa State University's Institutional Animal Care and Use Committee (log number; 7-08-6586-S). A total of 30 gestation stalls (each containing a sow) were used, and the stall was the experimental unit. Sows were selected for inclusion in this study based on parity (parity 1n=10; 158.8 Kg to 204.1 Kg BW; parity 2n=10; 181.4 Kg to 226.8 Kg BW; parity 3n=10; 204.1 Kg to 249.5 Kg BW) and breed (Duroc; n=11;

Cross [Duroc[®]Yorkshire] n=11; Yorkshire n=8). Sows ranged from their first to the fifth week of gestation. Sows were obtained from a single source farm. All sows underwent a physical examination (evaluation of integument, cardiovascular and respiratory system) prior to selection by a trained swine veterinarian and there was no evidence of standing lameness. The study was conducted at the Lauren Christian Swine Research facility in central Iowa. All sows were individually housed in stalls (2.1 m in length × 0.6 m wide × 1.1 m height; Eastern Iowa Pork Inc., Earlville, IA) during gestation. Concrete flooring (slat width 12.7 cm and slot opening 2.5 cm) was utilized under each stall, and manure fell into a holding pit that was 61 cm deep. Sows were fed a commercially available mash diet (1450 kcal per kg, 13% crude protein) at 6:00 A.M. that was formulated to meet or exceed their nutritional requirements [22]. The mash feed was provided in a water/feed combination trough (61 cm length × 33 cm width × 10 cm height) with a capacity of 8.2 kg per stall. Caretakers observed all sows twice daily, at 6:00 A.M. and 4:00 P.M. Large fans suspended from the ceiling regulated the environmental temperature and environmental measurements were recorded at 20 min intervals by two electronic recording devices (HOBO; Hobo Pro series, Janesville, WI) that were suspended 1 m from the ceiling, at an equal distance over the room. Over the trial, the average temperature was 24.5°C, relative humidity 71.8%, resulting in an average 73.3 Temperature Humidity Index [23].

Lateral toe growth

On the first day of the study, all sows were moved from a lying to standing posture. Each lateral toe was marked at the coronary band (defined as where the hair stopped growing on the leg and the toe growth began at the bottom of the pastern) along the entire frontal plane with a Fearing[®] paint marker (Digital Angel Corporation, Animal Applications Division, St. Paul, MN). Every seven days for the next four weeks, lateral toe growth was measured at the center of the coronary band on all hooves, whilst sows stood. A single researcher completed the task of measuring and recording lateral toe growth (the distance in mm between the initial mark and the coronary band) using a tape measure (Unique Bargains Yellow 1.5 m double sided soft plastics tape measure sewing rulers, Walmart, Ames, IA). The tape measure was divided into 1 mm increments.

Lesions

Hoof lesions on the medial and lateral toes, dewclaws and plantar surface (heel and sole) were collected using the FeetFirst guidelines [24] after the lateral toes had been measured (Table 1). Hoof lesions were collected from the medial and lateral toes, dewclaws and plantar surface (heel and sole). These anatomical areas were summed together to give lesions at the hoof level. A new category was created called "any lesion". This was defined as summing all lesions for a category of interest such as "breed".

Statistical analysis

Lateral toe growth was analyzed using mixed model methods

Table 1: Hoof lesions on the medial and lateral toes, dewclaws and plantar surface (heel and sole) were collected using the Feet first guidelines (Zinpro, 2008) after the lateral toes had been measured.

Measure	Mild	Moderate	Severe
Toe growth	one or more toes slightly longer than normal)	one or more toes significantly longer than normal	long toes that affect gait when walking
Dewclaws	slightly longer than normal	claws extend to the floor when the pig is standing	claw is torn and/or partially or completely missing
Heel overgrowth	slight overgrowth and/or erosion in soft heel tissue	numerous cracks with obvious overgrowth and erosion	large amount of erosion and overgrowth with cracks throughout
Heel sole crack	slight separation at the juncture	long separation at the juncture	long and deep separation at the juncture
White line	shallow and/or short separation along white line	long but shallow separation along white line	long separation along white line
Cracked wall horizontal	haemorrhage evident, short/shallow horizontal cracks in toe wall	long but shallow horizontal crack in toe wall	multiple or deep horizontal crack(s) in toe wall
Cracked wall vertical	short/shallow vertical crack in wall	long but shallow vertical crack in wall	multiple or deep vertical crack(s) in wall

(PROC MIXED; SAS Inst. Inc., Cary, NC) for parametric data. A complete randomized design with the model including the fixed effects of parity (1, 2, and 3) hoof location (front or rear), hoof side (left or right) and breed (Duroc, York, Cross). A repeated measure statement of week was used and a $p \leq 0.05$ was considered significant. The PDIF procedure was used to separate means when a fixed effect was a significant source of variation. Hoof lesion data will be presented descriptively as a number and percentage.

Results

Lateral toe growth

There were no differences in lateral toe growth between lateral toe pairs (front and rear $1.2 \text{ mm} \pm 0.04 \text{ mm}$; $p=0.98$) or for side (left 1.3 vs. right $1.2 \text{ mm} \pm 0.04 \text{ mm}$; $p=0.08$) for the same sow weekly. There was a difference in lateral toe growth by sow breed, with Yorkshire sows' lateral toes growing more slowly when compared to Duroc and Crossbred (Duroc \times Yorkshire) sows ($p<0.001$; **Figure 1**). There was a difference by sow parity, with parity two sows' lateral toes growing the fastest, followed by parity one and three ($p<0.001$; **Figure 2**).

Hoof lesions

Regardless of parity and breed, lesion severity was predominantly scored level one (mild) with cracked wall vertical being the most common lesion type. When reviewing lesion types, parity one sows showed a greater incidence of dew claw lesions (17.5%), compared to parities two and three (5%). Parity three sows had a greater incidence of cracked wall horizontal lesions (15%) compared to parities one and two (2.5% and 10%, respectively). However, cracked wall vertical lesion incidence was greater in parity two sows (30%) when compared to parities one and three sows (22.5% and 25%, respectively). For any lesion, there was a greater percentage recorded on the hooves of parity two sows (57.5%), compared to parity three and parity one sows (50% and 45%; **Table 2**). Duroc sows had a greater heel overgrowth and erosion (18.2%) percentage when compared to Crossbreds and

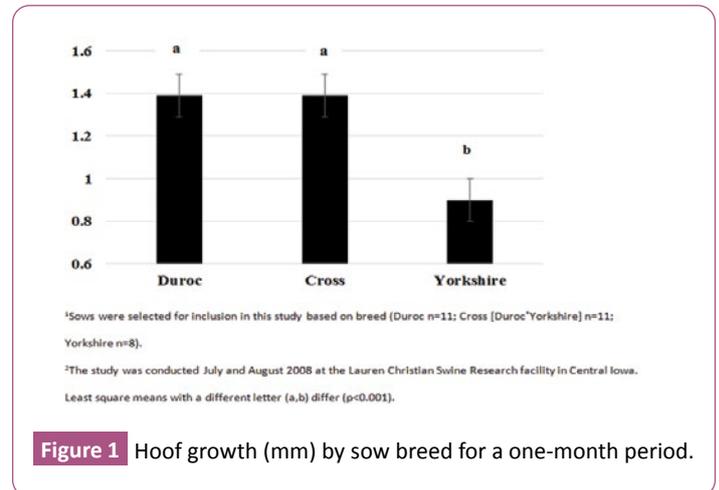


Figure 1 Hoof growth (mm) by sow breed for a one-month period.

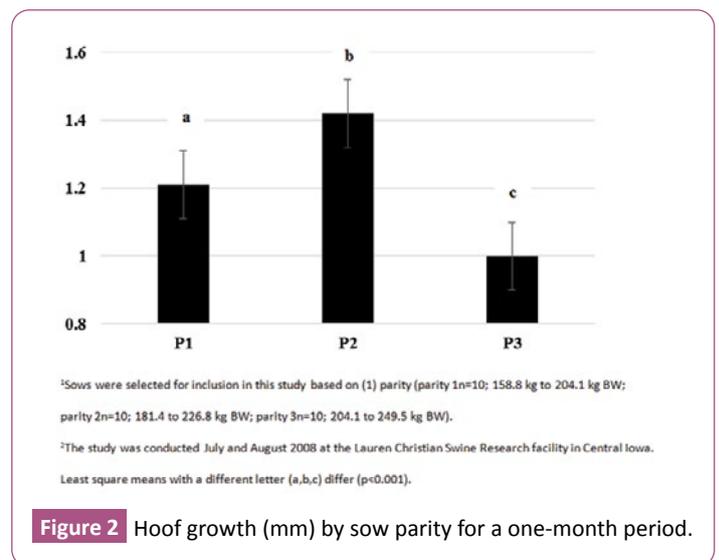


Figure 2 Hoof growth (mm) by sow parity for a one-month period.

Yorkshire sows (11.4% and 9.4%, respectively). Crossbred sows had greater cracked wall horizontal lesion percentage (13.6%) when compared to Duroc and Yorkshire sows (6.8% and 6.3%, respectively), but a lower dew claw lesion percentage (4.5%

Table 2: Number (percent) for any lesion, lesion severity and type by sow parity for a one-month period in purebred Yorkshire and Duroc sows and Crossbred Yorkshire × Duroc sows.

	Parity ¹		
	1 (n=10)	2 (n=10)	3 (n=10)
No. of hooves ²	40	40	40
Any lesion, (Number,%) ³	18 (45.0)	23 (57.5)	20 (50.0)
Lesion severity, (Number,%)			
One (mild)	13 (32.5)	19 (47.5)	16 (40.0)
Two (moderate)	5 (12.5)	3 (7.5)	4 (10.0)
Three (severe)	0	1 (2.5)	0
Lesion type, (Number,%)⁴			
Toe growth	0	4 (10.0)	1 (2.5)
Dew claw	7 (17.5)	2 (5.0)	2 (5.0)
Heel overgrowth and erosion	4 (10.0)	5 (12.5)	6 (15.0)
Heel-sole crack	1 (2.5)	3 (7.5)	4 (10.0)
White line	0	1 (2.5)	0
Cracked wall horizontal	1 (2.5)	4 (10.0)	6 (15.0)
Cracked wall vertical	9 (22.5)	12 (30.0)	10 (25.0)

¹Sows were selected for inclusion in this study based on (1) parity (parity 1n=10; 158.8 Kg to 204.1 Kg BW; parity 2n=10; 181.4 Kg to 226.8 Kg BW; parity 3n=10; 204.1 Kg to 249.5 Kg BW) and (2) breed (Duroc n=11; Cross [Duroc×Yorkshire] n=11; Yorkshire n=8); ²Hoof lesions on the medial and lateral toes, dewclaws and plantar surface (heel and sole) were collected using the Feet First guidelines (Zinpro, 2008). These anatomical areas were summed together to give lesions at the hoof level; ³A new category was created called “any lesion”. This was defined as summing all lesions for a category of interest for example breed; ⁴Hoof lesions on the medial and lateral toes, dewclaws and plantar surface (defined as the heel and sole) were collected when the lateral toe measurements occurred using the FeetFirst guidelines (Zinpro, 2008). Toe growth; mild (one or more toes slightly longer than normal), moderate (one or more toes significantly longer than normal) and severe (long toes that affect gait when walking). Dew claws; mild (slightly longer than normal), moderate (claws extend to the floor when the pig is standing) and severe (claw is torn and/or partially or completely missing). Heel overgrowth and erosion; mild (slight overgrowth and/or erosion in soft heel tissue), moderate (numerous cracks with obvious overgrowth and erosion), and severe (large amount of erosion and overgrowth with cracks throughout). Heel sole crack mild (slight separation at the juncture), moderate (long separation at the juncture) and severe (long and deep separation at the juncture). White line mild (shallow and/or short separation along white line), moderate (long but shallow separation along white line), and severe (long separation along white line). Cracked wall horizontal; mild (hemorrhage evident, short/shallow horizontal cracks in toe wall), moderate (long but shallow horizontal crack in toe wall), severe (multiple or deep horizontal crack(s) in toe wall. Cracked wall vertical; mild (short/shallow vertical crack in wall, moderate (long but shallow vertical crack in wall), severe (multiple or deep vertical crack(s) in wall; ⁵The study was conducted July and August 2008 at the Lauren Christian Swine Research facility in Central Iowa

Table 3: Number (percent) for any lesion, severity and type by sow breed (purebred Yorkshire and Duroc sows and Crossbred Yorkshire × Duroc sows) for a one-month period.

	Breed ¹			Foot pair	
	Duroc (n=11)	Cross (n=11)	Yorkshire (n=8)	Front (n=30)	Rear (n=30)
No. of hooves ²	44	44	32	60	60
Any lesion, (Number,%) ³	28 (63.6)	23 (52.3)	14 (43.8)	37 (61.7)	28 (46.7)
Lesion severity, (Number,%)					
One (mild)	24 (54.5)	17 (38.6)	10 (31.3)	26 (43.3)	25 (41.7)
Two (moderate)	4 (9.1)	6 (13.6)	3 (9.4)	11 (18.3)	2 (3.3)
Three (severe)	0	0	1 (3.1)	0	1 (1.7)
Lesion type, (Number,%)⁴					
Toe growth	0	1 (2.3)	4 (12.5)	3 (4.3)	2 (3.3)
Dew claw	5 (11.4)	2 (4.5)	4 (12.5)	5 (7.1)	6 (10.0)
Heel overgrowth and erosion	8 (18.2)	5 (11.4)	3 (9.4)	5 (7.1)	11 (18.3)
Heel-sole crack	3 (6.8)	4 (9.1)	1 (3.1)	2 (2.9)	6 (10.0)
White line	0	0	1 (3.1)	0	1 (1.7)
Cracked wall horizontal	3 (6.8)	6 (13.6)	2 (6.3)	8 (11.4)	3 (4.3)
Cracked wall vertical	16 (36.4)	12 (27.3)	6 (18.8)	24 (34.3)	10 (16.7)

¹Sows were selected for inclusion in this study based on (1) parity (parity 1n=10; 158.8 Kg to 204.1 Kg BW; parity 2n=10; 181.4 Kg to 226.8 Kg BW; parity 3n=10; 204.1 Kg to 249.5 Kg BW) and (2) breed (Duroc n=11; Cross [Duroc*Yorkshire] n=11; Yorkshire n=8); ²Hoof lesions on the medial and lateral toes, dewclaws and plantar surface (heel and sole) were collected using the Feet First guidelines (Zinpro, 2008). These anatomical areas were summed together to give lesions at the hoof level; ³A new category was created called "any lesion". This was defined as summing all lesions for a category of interest for example breed; ⁴Hoof lesions on the medial and lateral toes, dewclaws and plantar surface (defined as the heel and sole) were collected when the lateral toe measurements occurred using the Feet First guidelines (Zinpro, 2008). Toe growth; mild (one or more toes slightly longer than normal), moderate (one or more toes significantly longer than normal) and severe (long toes that affect gait when walking). Dew claws; mild (slightly longer than normal), moderate (claws extend to the floor when the pig is standing) and severe (claw is torn and/or partially or completely missing). Heel overgrowth and erosion; mild (slight overgrowth and/or erosion in soft heel tissue), moderate (numerous cracks with obvious overgrowth and erosion), and severe (large amount of erosion and overgrowth with cracks throughout). Heel sole crack mild (slight separation at the juncture), moderate (long separation at the juncture) and severe (long and deep separation at the juncture). White line mild (shallow and/or short separation along white line), moderate (long but shallow separation along white line), and severe (long separation along white line). Cracked wall horizontal; mild (haemorrhage evident, short/shallow horizontal cracks in toe wall), moderate (long but shallow horizontal crack in toe wall), severe (multiple or deep horizontal crack(s) in toe wall). Cracked wall vertical; mild (short/shallow vertical crack in wall), moderate (long but shallow vertical crack in wall), severe (multiple or deep vertical crack(s) in wall); ⁵The study was conducted July and August 2008 at the Lauren Christian Swine Research facility in Central Iowa.

compared to 11.4% and 12.5%, respectively). For any lesion, there was a greater percentage recorded on the hooves of Duroc sows (63.6%), compared to Crossbred and Yorkshire sows (52.3% and 44.8%). When comparing foot pairs, more lesions were observed on the front (61.7%) compared to rear (46.7%) hooves (**Table 3**).

Discussion

In a commercial study using crossbred gilts, van Amstel and Doherty [25] reported that mean toe horn growth was 11.6 mm per 55 days with a mean wear of 9.6 mm in crossbred gilts weighing 113 Kg to 150 Kg. The mean lateral toe growth varied (left hind lateral: +4.5 mm, right hind lateral: +3.6 mm; left front lateral: +3.1 mm; right front lateral: +2.5 mm). In the present study, there were no differences in toe growth rate between front and rear toes or for sow side. The toes from parity two sows grew more quickly when compared to the toes of parity one sows and parity three sows. Toe growth in the current study was 1.2 mm weekly, 0.2 mm less than the toe growth findings in gilts reported by van Amstel and Doherty [25]. If caretakers understood how quickly sow toes grow, be trained to assess toe length carefully and have management interventions, these efforts may extend the sow's productive life. Another interesting finding in the present study was that breed significantly affected toe growth with the lateral toes from Yorkshire sows growing more slowly when compared to the lateral toe growth observed from Duroc and Crossbred (Duroc × Yorkshire) sows. There is no scientific literature published that compares breed differences for toe growth in swine. Therefore, more work should be conducted in this area to determine if breed differences are repeatable and biologically relevant.

The relatively high prevalence of toe lesions may be linked to pigs being predominately housed on concrete floors [1,26]. When pigs are housed on slatted floors an increased risk of sole and heel erosions have been reported and these lesion prevalences are higher compared to pigs housed on solid floors with straw bedding [27]. Floor quality such as rough and sharp edges, abrasiveness, slipperiness and slat width play a role in the development of toe

lesions and bursitis [28]. Additionally, high stocking density, poor hygiene [27], unstable social groups, and intrinsic factors such as toe size, variation of pig weight relative to toe size, nutritional and genetic factors play an important role in toe lesion development [29]. In this study, parity one sows had a greater dew claw lesion incidence when compared to the dew claws from parity two and three sows. Injuries to dew claws may be due to younger sows with small feet getting their dew claws stuck in between the concrete slats. Dew claws are highly innervated; thus, such injuries are hypothesized to be very painful [4]. Additional research needs to focus on dew claw health and pain in these younger animals. Cracked vertical walls were the most common lesion type among all three parities. This finding agrees with previous reports in the scientific literature where sows had one or more toe lesions with cracked vertical walls as the most prevalent lesion [4,5]. Finally, in agreement with Knauer et al. [6] a larger percentage of lesions were located on the front toes (52% vs. 40%) when compared to the rear toes. Enokida et al. [8] found within-toe and between-toe variability in lesion occurrence and these may be related to postural differences. We can only speculate that these postural differences may be due to flooring, manure pooling, or possibly other environmental factors [30].

Conclusion

In conclusion, it was previously reported that in farrow-to-finish operations that sows need to remain in the breeding herd until parity three to financially "breakeven" and in a breed-to-wean operation, sows need to remain in the herd for four parities to reach the "breakeven" point. Yet, in the U.S. the reported average herd parity of culled sows ranges from 3.1 to 3.7, with locomotion or feet and leg problems representing major culling reasons. In the present study, parity two sows had the most lesion on their toes (hooves), and their toes grew more quickly. It could be hypothesized that the new toe growth is not as hard and can become more easily damaged. However, additional work is needed to better understand the underlying physiological, genetic and nutritional factors that affect sow toe growth and the formation of lesions.

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