Effects of lameness on productivity and longevity for sows in pen gestation

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Summary

Objective: To determine the impact of lameness on sow productivity and longevity and evaluate the effects of housing management on the removal of lame sows in herds using pen gestation.

Materials and methods: Retrospective production records and information on housing methods were collected from 23 farms using pen gestation and analyzed for the removal of 214,254 sows from 2014 through 2020. Statistical analyses were performed to evaluate differences in longevity, productivity, and the impact of housing methods.

Results: Lameness was the third most reported cause of removal for sows in the study (13.7%). Sows culled for lameness spent significantly fewer days in the herd ($P < .001$), resulting in fewer litters ($P < .001$). The odds of removal for lameness were increased by several farm level factors including using dynamic groups and decreasing square footage ($P < .05$).

Implications: Lameness is one of the top 3 reasons reported for sow removal and those sows are costly as they leave the herd earlier, are less productive, and are more likely to die or be euthanized versus culled. Housing methods play a role in the odds of removal for lameness and should be further investigated.

Keywords: swine, lameness, survival analysis, welfare, group housing

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Resumen - Efectos de la cojera en la productividad y la longevidad de las cerdas en gestación en corrales

Objetivo: Determinar el impacto de las cojeras en la productividad y longevidad de las cerdas y evaluar los efectos del manejo del alojamiento en la eliminación de las cojeras en hatos con gestación en corrales.

Materiales y métodos: Se recopilaron registros de producción retrospectivos e información sobre los métodos de alojamiento de 23 granjas que utilizan la gestación en corrales y se analizaron para la eliminación de 214,254 cerdas desde 2014 hasta 2020. Se realizaron análisis estadísticos para evaluar las diferencias en la longevidad, la productividad y el impacto del sistema de alojamiento.

Resultados: En el estudio, la cojera fue la tercera causa más reportada de desecho de las cerdas (13.7%). Las cerdas descartadas por cojera pasaron significativamente menos días en la piara ($P < .001$), lo que resultó en menos camadas ($P < .001$). Las probabilidades de eliminación por cojera aumentaron por varios factores a nivel de granja, incluido el uso de grupos dinámicos y la disminución de los pies cuadrados ($P < .05$).

Implicaciones: La cojera es una de las 3 razones principales reportadas de desecho de las cerdas, estas cerdas son costosas ya que se retiran de la piara antes de tiempo, son menos productivas y es más probable que mueran o sean sacrificadas en lugar de ser desechadas. Los métodos de alojamiento juegan un papel en las probabilidades de ser desechadas por cojera y deben investigarse más a fondo.

Résumé - Effets de la boiterie sur la productivité et la longévité des truies en gestation en enclos

Objectif: Déterminer l'impact de la boiterie sur la productivité et la longévité des truies et évaluer les effets de la gestion du logement sur le retrait des truies avec boiterie dans les troupeaux utilisant la gestation en enclos.

Matériels et méthodes: Rétrospectivement, les dossiers de production et des informations sur les méthodes de logement ont été recueillis auprès de 23 fermes utilisant la gestation en enclos et analysés pour le retrait de 214,254 truies de 2014 à 2020. Des analyses statistiques ont été effectuées pour évaluer les différences de longévité, de productivité et l'impact des méthodes de logement.

Résultats: La boiterie était la troisième cause de retrait la plus signalée chez les truies dans l'étude (13.7%). Les truies réformées pour boiterie ont passé beaucoup moins de jours dans le troupeau ($P < .001$), ce qui a entraîné moins de portées ($P < .001$). Les probabilités d'élimination pour boiterie ont été augmentées par plusieurs facteurs au niveau de la ferme, notamment l'utilisation de groupes dynamiques et la diminution de la superficie en pieds carrés ($P < .05$).

Implications: La boiterie est l'une des trois principales raisons signalées pour le retrait des truies et ces truies sont coûteuses car elles quittent le troupeau plus tôt, sont moins productives et sont plus susceptibles de mourir ou d'être euthanasiées que réformées. Les méthodes de logement jouent un rôle dans les probabilités de retrait pour boiterie et devraient faire l'objet d'étude supplémentaires.

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Lameness is a serious welfare and economic issue on sow farms and gains importance as the use of pen gestation increases. Cross-sectional studies have detected the prevalence of lameness in sows in pen gestation between 4.5% and 16.9% and the National Animal Health Monitoring System reported that 15.2% of all sows culled in the United States, are culled for lameness.[1-3] Given the prevalence of lameness, it is not surprising that lameness can be costly for swine farmers and has been shown to result in increased labor needed to manage lame sows[4] and higher veterinary costs for treatment.[4,5] Lameness has been associated with decreased reproductive performance due to premature removal of sows from the herd[5,6] and reduced salvage value attributed to on-farm euthanasia.[4,7]

Engblom et al[8,9] conducted large scale studies of sow removal reasons for 21 herds in Sweden, all using pen gestation,[8] and examined survival time[9] finding that lameness accounted for 8.6% of removals[8] and that lameness as a removal reason was more common in younger animals.[9] Anil et al[6,10] collected records from 11 farms in Canada using gestation stalls and found that the risk of removal for lameness varied by time in the production cycle and the productivity of the sow.[10] They later examined survival time for 674 animals and found that lame sows had fewer piglets due to less time in the herd.[6] Studies that examine the number of sows and gilts removed for lameness, as well as the impact on their lifetime productivity, in US herds using pen gestation is lacking.

When sows are housed in groups during gestation, there are a multitude of options for managing feeding and mixing, thus bringing a unique challenge to understanding the impact of these housing management strategies on lameness. Previous studies have identified that feeding method, group size, space allowance, group structure (dynamic or static), and time of group formation (immediately post breeding or 28 to 35 days post breeding) influences animal-animal aggression which may lead to stress, injuries, and lameness for animals housed in pen gestation.[11,12] In a study of 8 Belgian pig herds, Pluym et al[4] found that there was no difference in the percentage of lame sows in farms using electronic sow feeders (ESF) compared to farms using free access stalls. Having a larger area and a higher stocking density, both increased the risk of lameness for sows on English sow farms.[1] There is limited research that evaluates the associations between housing management strategies and removal of sows for lameness in pen gestation in US herds. Understanding the link between group housing methods and lameness could help producers understand how much they can invest in alterations to housing management as well as make decisions on the best housing and management strategies for pen gestation.

The first objective of the present study was to examine retrospective data to determine the effects of lameness on sow productivity and longevity in herds using pen gestation. We predict that in comparison to other removal reasons, lameness will be associated with sows spending less time in the herd, ultimately producing fewer litters. Additionally, we hypothesize that lame sows are more likely to be involuntarily removed (death or euthanasia) from the herd compared to non-lame sows. Secondly, we examined the effects of feeding method, group size, space allowance, group structure, and time of group formation on the odds of removal for lameness. We hypothesize that lame sows fed with an ESF, housed in dynamic pens, contained in smaller groups, with less space allowance, and mixed immediately post breeding are more likely to be removed for lameness compared to other housing practices.

Animal care and use

Production records were used for this study, so no Institutional Animal Care and Use Committee approval was needed. This retrospective study was carried out using production records from commercial farms certified in the Pork Quality Assurance Plus program. The program guidelines directed animal care on the farms and the study was conducted without changing animal care routines.

Materials and methods

Experimental design

Retrospective data from 23 farms using pen gestation were examined for the removal of 214,254 sows from June 2014 through July 2020. Farms were enrolled in the study if they removed at least parity 2 animals and recorded reasons for at least 80% of removals. Farms shared the feeding method, timing of group formation, group structure, square meters per sow, group size, and farm size for each farm included in the study. Management techniques differed for gilts compared to sows on 4 farms so gilt removals on those farms were categorized by the management factors in place for gilts. Housing management techniques are given in Table 1. There were 3 different feeding systems represented in the data: ESF (n = 16), small pens using drop feeding (n = 6), and free access feeding stalls (n = 1). Farmers were also asked to submit production records that included sow identification number, entry date, removal date, removal parity, removal type, and removal reason. Total lifetime parameters for the number of litters, piglets born, piglets born alive, and piglets weaned were included in the production records.

Removal types included transfer, cull, euthanasia, and death with 96% of all removals accompanied by a reason for their removal. All sows identified as transfers were dropped from the study (n = 14). Removal reasons were broadly grouped into the following categories: age, body condition and structure, disease, lameness, injury other than lameness, reproduction, sudden death, prolapse, and other. The category of age combined any reasons that an animal was removed from the herd due to age (eg, old age and high parity). The category of body condition and structure included reasons of body size, off feed, poor condition, poor structure, and unthrifty. The category of disease included specific infectious diseases (eg, erysipelas, influenza, *Glaesserella parasuis,* porcine reproductive and respiratory syndrome, and *Streptococcus suis*), infections (eg, discharge, mastitis, cutaneous infection, urinary infection, vaginal discharge, and abscess in the body cavity), health conditions (eg, heart attack/failure, constipation, ileitis, twisted gut, stomach ulcer, scours, respiratory disease, post-farrowing illness, hemorrhage, heat stress/trauma, and cancer), and depopulation. The category of lameness combined any reasons representing locomotor problems (eg, lame, nonambulatory, unsound, joint problem/infection, bad legs, downer, hooves, chronically lame, swollen extremities, and septic from severe infection of the leg) since reasons for the removal of the sow were recorded by herd personnel and were not necessarily based on diagnosis as determined by a veterinarian or necropsy.[10] The category of injury other than lameness included reasons of abscess, accident, rupture, hernia, injury, ulcer, udder trauma, nonhealing shoulder sore, and broken back. The

Table 1: Housing description from 23 farms* using pen gestation that shared retrospective data for the removal of 214,254 sows from June 2014 through July 2020

Feeding method	Time of group formation	Group structure: Dynamic, No. of farms (No. of removals)	Group structure: Static, No. of farms (No. of removals)	Range of space allowance, m^2/sow, (median [IQR])	Range of group size, No. of sows, (median [IQR])	Range of farm size, No. sows, (median [IQR])
Electronic sow feeding (n = 16)†	Immediately post breeding	3 (17,789)	6 (68,046)	1.45-2.04 (1.86 [0.13])	66-290 (130 [98])	2400-6300 (255 [2600])
	28-35 d post breeding	4 (13,667)	12 (57,389)			
Drop feeding (n = 6)	28-35 d post breeding	0	6 (50,261)	1.58-1.86 (1.83 [0])	10-20 (10 [2])	250-5600 (5150 [1775])

* Farms were enrolled in the study if removing at least parity 2 animals and recording reasons for at least 80% of removals. One participating farm used free access stalls and is not included in this table to preserve anonymity.

† On some farms, gilts were housed in a different group structure than the sows, so farms may be included in both group structure types.

category of reproduction combined any reasons involving poor reproductive performance or productivity (eg, farrowing difficulty/dystocia, open, unable to conceive, no estrus, poor milker, poor mothering, abortion, low born alive/total born, low weaned, low weaning average, low born alive average, poor litter sizes, small/weak pigs, abnormal pigs, and dead/mummified litter). The category of sudden death included animals that were found dead. The category of prolapse combined rectal prolapse, uterine prolapse, and vaginal prolapse. Reasons that did not appropriately fit under a specific category and accounted for less than 1% of total removal reasons were categorized as other. The other category included reasons of poor underline, behavior, inventory adjustment, market conditions/taxes, testing, and genetics.

Piglet mortality rate was determined by the differences between the piglets born alive per litter and the piglets weaned per litter and represents the number of piglets that died per litter. The time in the herd for each sow was determined as the interval between the entry date and the removal date. Nonproductive days were calculated as the total number of days in the herd minus the total number of gestation and lactation days. The proportion of nonproductive days was calculated as the total nonproductive days divided by the number of days a sow remained in the herd. Removal type was condensed to a binary variable of voluntary (sows were culled) and involuntary (sows were euthanized or died).

Statistical analyses

Statistical analyses were performed using Stata IC v.16. Sows were categorized as lame or non-lame based on whether they were removed for lameness or another reason. The sow was treated as the statistical unit for all analysis and $P < .05$ was treated as significant. Production measures including total litters, piglets born alive per litter, piglets weaned per litter, piglet mortality rate, and proportion of nonproductive days were analyzed with mixed effect linear regression models. Each model included removal for lameness and year of removal as factor variables as fixed effects. Farm served as the random effect. Survival time for sows reported as removed for lameness compared to sows removed for other reasons was analyzed using a mixed effect survival analysis model with an exponential distribution. Lameness and farm were included as factor variables as fixed effects and year was included as a random effect. Removal type was examined using a mixed effect logistic regression model. Lameness and year were included as factor variables as fixed effects and farm was included as a random effect. Housing management factors were analyzed for their impact on the odds of a sow being removed for lameness using a mixed effect logistic regression model with feeding system, timing of mixing, pen structure, and year included as factor variables and standard deviation of group size and square meters per sow included as continuous variables. Farm was included as a random effect.

Results

Productivity and longevity

In this study of 214,254 sow removals, 29,334 (13.7%) were reported as removed for lameness, the third most reported removal reason behind reproduction (114,961 sows, 53.7%) and age (30,809 sows, 14.4%). Lame animals were significantly less productive compared to non-lame sows (Table 2). Lame sows spent significantly fewer days in the herd (mean [SE] = 323.1 [18.7]) compared to sows removed for other reasons (489.2 [28.2]; $P < .0001$; Figure 1). The odds of being removed involuntarily were significantly higher for lame sows compared to non-lame sows (odds ratio = 10.6; 95% CI, 10.3-10.9; $P < .001$).

Housing management

Feeding method did not have a significant effect on the odds of removal for lameness ($P = .51$). Odds ratios associated with housing management are provided in Table 3 where dynamic groups increased odds of removal for lameness and increasing group size and increasing square footage decreased odds of removal for lameness.

Discussion

In this production data from 23 US sow herds, we found that lameness was the third most common reason reported for removal from the herd. This is higher than reported by Engblom et al[8] who found that lameness was the fifth most common reason for removal from Swedish herds preceded by reproductive

Table 2: Least squares means (SE) of productivity of sows from 23 farms using pen gestation removed for lameness (n = 29,344) compared to sows removed for other reasons (n = 114,961)

	Lame	Non-lame*	*P***
Total litters†	1.8 (.22)	3.0 (.27)	< .001
Piglets born alive/litter‡	12.9 (.15)	12.9 (.13)	.29
Piglets weaned/litter	10.3 (.29)	10.8 (.25)	< .001
Piglet mortality rate§	2.6 (.19)	2.2 (.19)	< .001
Proportion nonproductive days¶	0.49 (.04)	0.40 (.04)	< .001

* Removed for reasons other than lameness such as age, body condition and structure, disease, injury other than lameness, reproduction, sudden death, prolapse, and other.

† Total litters for a sow for their lifetime.

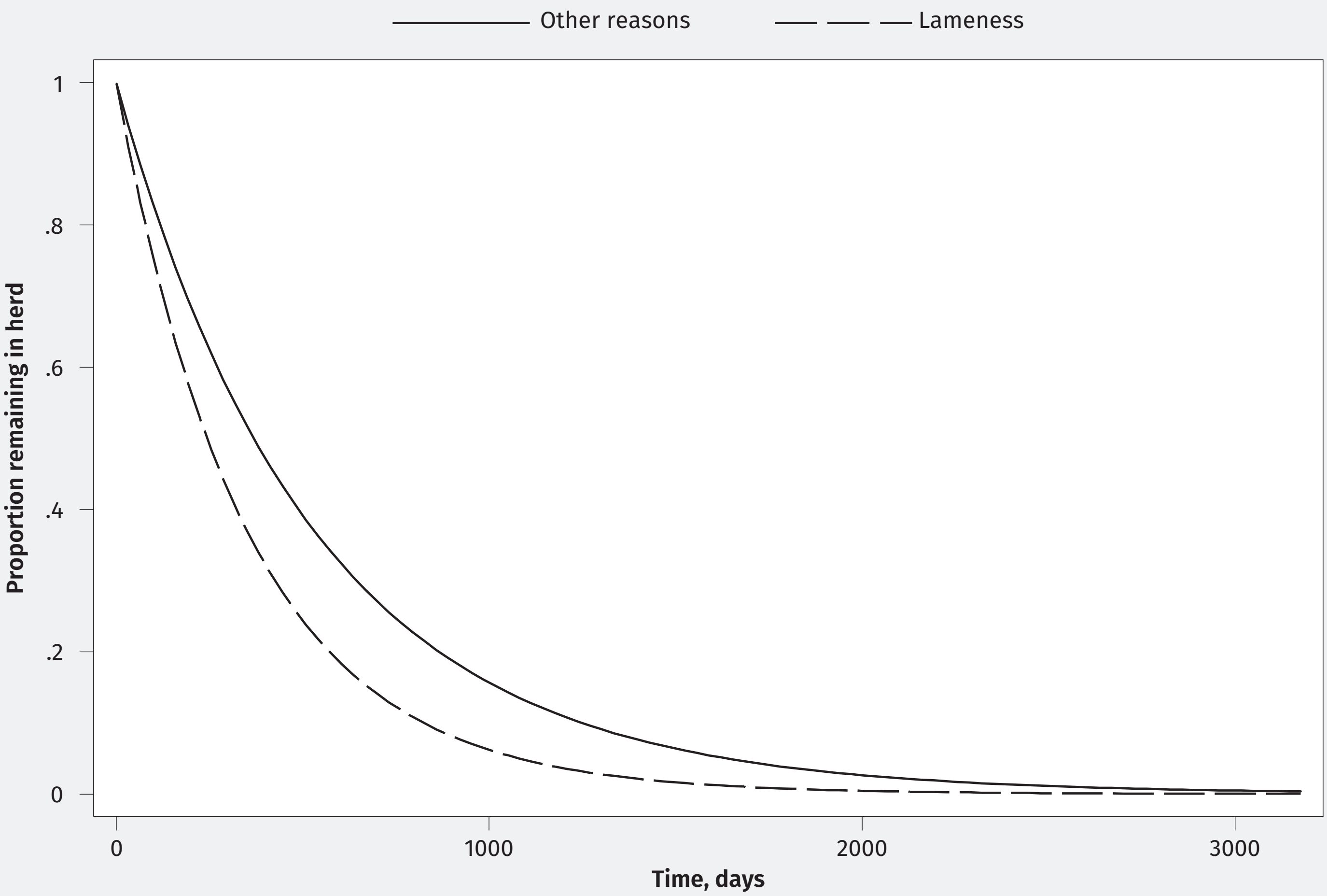
‡ Piglets that were not mummified or stillborn when born.

§ Number of piglets that died/litter calculated by number born alive minus number weaned.

¶ Days the sow is neither pregnant nor nursing a litter as a proportion of her days in the herd.

** Significance was determined by mixed effect linear regression models for each production outcome. Each model included removal for lameness and year of removal as factor variables as fixed effects. Farm served as the random effect.

Figure 1: The predicted time to removal from the herd for sows removed for lameness (n = 29,344) and sows removed for other reasons (n = 114,961) for 23 farms using pen gestation that shared entry dates and removal dates. Day zero is the day that the sow entered the herd. Sows removed for lameness spent significantly fewer days (323 d) in the herd compared to sows removed for other reasons (489 d; *P* < .001).



reasons, age, udder issues, and low productivity, which could be attributable to different farm practices or genetics. Our results showed a smaller number of removals for lameness than several other US-based studies. A case study on a large US farm conducted by Sanz et al[13] found that lameness was responsible for the majority of animal removals with 23.4% of the animals dying or being removed for locomotor issues during their study period. Irwin et al[14] found that the largest contributor to sow mortality during their study was locomotor issues, which was responsible for 44% of the mortalities across 6 different farms. Our results may undercount lameness, as a sow may have been lame but removed for another primary reason such as reproduction. In the context of these case studies, our results confirm that in US herds specifically, locomotor issues are a significant percentage of sow removals.

Sows removed for lameness in our study spent significantly less time in the herd compared to sows removed for other reasons. This is similar to other studies that have looked at reasons for sow removal. In Engblom et al[9] they found that lameness posed the greatest risk in determining when gilts left the herd compared to other parities. Likewise, Anil et al[10] found that the percent removed for lameness was highest in parity 0 and parity 1 sows compared to sows that were parity 2 or greater. This is of concern because when lame sows are removed before they attain their expected life in the herd, the economic performance of the herd can be adversely affected.[10] When a sow remains in the breeding herd for fewer parities, the animal is likely to produce fewer piglets in her lifetime compared to a sow that remained in the breeding herd for a longer period. Lame sows in this study did have fewer litters producing 1.8 litters in their lifetime while non-lame sows produced 3 litters. This reduces the opportunity for a sow to be sufficiently productive and for a farmer to achieve a profit from the investment in that animal since sows reach peak production between the third and sixth parity and do not produce a profit for the farmer until their third parity.[15]

Not only did sows removed for lameness generate fewer total litters in their lifetime, but the proportion of nonproductive days were higher for such sows compared to sows removed for other reasons. There was no difference in the piglets born alive per litter for sows removed for lameness however, there were fewer piglets weaned per litter and a higher piglet mortality rate compared to sows removed for other reasons. These results are similar to the higher preweaning piglet losses reported by Anil et al.[6] This decrease in number of litters may be related to pain caused by lameness creating stress, which has a negative influence on sow reproductive performance through inhibition of ovulation or by hindering the expression of estrus behavior.[16] The pain of lameness may also affect the piglet mortality rate as it may influence the ability of a sow to make postural changes within a farrowing crate or lead to uncontrolled lying-down behavior and consequently may cause death of baby pigs as a result of crushing.[5,6]

Another impact increasing the cost of lameness is the cost associated with losing the salvage value of the sow when she is removed involuntarily. The data collected in this study indicate that the odds of being removed involuntarily were significantly higher for lame sows compared to non-lame sows. Kirk et al[7] similarly found that the largest cause of euthanasia in Danish herds was related to musculoskeletal and locomotor issues. In the case study by Sanz et al,[13] 38.5% of the animals removed from breeding were removed for locomotor reasons and 59.1% of those were euthanized. In gestation, 64% were removed for locomotor reasons and 56.8% of those were euthanized[13] supporting the conclusion of our data that lameness is even more costly for farmers as it results in animals being disposed of on the farm.

Certain housing and feeding methods may predispose herds to increased locomotor issues. In our data, the feeding method did not impact the odds of removal for lameness when comparing sows fed with ESF to those using drop feeding and free access feeding stalls. Though studies of sow removals are rare, studies of lameness prevalence are more common, and we would expect an association between the two. A comparative study that assessed individual feeding methods concluded that group-housed sows fed using ESF and trickle systems had higher incidences of locomotion disorders and hoof lesions compared with sows fed in free access stalls.[17] Though Zurbrigg and Blackwell[18] did not analyze the feeding system in their study of 4 farms, the farm using the ESF feeding method did have the highest percentage of lameness, which is in contrast to our study. Like our study, a study of 8 Belgian herds found the prevalence of lameness was not different between the sows fed with ESF compared to the sows housed in free access stalls.[4] Different feeding systems on the same farm, though challenging, would be a way to isolate the impact of the feeding system in future work while controlling for other factors.

The results of this study indicated that increasing group size in farms decreased the odds of removal for lameness. The literature shows mixed results on the impact of group size on aggression in sows. In some studies, aggression does

Table 3: Odds of removal for lameness associated with housing management factors for 23 farms that shared housing management information*

	Odds ratio	SE	*P*	95% CI
Dynamic vs static	1.37	0.08	< .001	1.22-1.54
Immediately post breeding vs 28-35 d post breeding	1.59	0.66	.27	0.71-3.60
m^2/sow	0.26	0.02	.02	0.08-0.80
SD of group size	0.74	0.03	< .001	0.68-0.81

* Results are presented as the odds ratio generated from a mixed effect logistic regression model which included the standard deviation of group size, feeding type, time of group formation (immediately post breeding or 28-35 days post breeding), and group structure (static or dynamic) as factor variables and square meters as a continuous variable.

not increase with increasing group size as shown in a study by Turner et al[19] where inter-sow aggression decreased in larger groups. However, other studies show an increase in lesions as group size increases[20] indicating more aggression. Like many aspects of housing, there are other factors, such as mixing strategy, which may influence aggression. It is also worth noting that many of these studies have not looked at the impact of group size specifically on lameness.

There was a decrease in the odds of being removed for lameness with increasing square footage. This idea is in contrast to the findings of Salak-Johnson et al[21] where an increase in square meters increased lameness in small static groups. In other studies, decreasing space allowance led to more agonistic interactions when ESF were being used[22] and lesion scores increased when space allowance was decreased when using feeding stalls.[23] Such lesions and aggressive interactions could correlate with an increased odds of lameness. Space allowance on the study farms included here only varied from 1.45 to 2.04 m^2/sow which is not a wide range and less than the square meters mandated in the European Union.[24]

Group structure also had an impact on the odds of removal on farms using ESF where sows in dynamic pens had 1.4 times greater odds of removal for lameness compared to sows in static groups. Group structure influences animal behavior and thus may influence the occurrence of lameness. A review by Bench et al[25] described static groups as more consistent compared to dynamic groups as mixing only occurs once and then stable subgroups can form. Bos et al[26] compared prevalence, incidence, and mean scores of lameness in static versus dynamic group housed sows at different stages of gestation and found that static groups demonstrated lower lameness scores at the end of gestation when compared to dynamic groups. Anil et al[27] similarly detected that pregnant sows housed in dynamic systems with ESF had a significantly higher total injury score which could lead to an increase in lameness. These increases in aggression and lameness in dynamic groups are consistent with our findings of increased odds of removal for lameness in farms with such groups.

The timing of group formation is yet another aspect of sow housing that could be expected to influence the amount of lameness in a herd. Unlike our study, where time of mixing did not have an effect, Strawford et al[28] found fewer aggressive encounters occurred at the feeder when sows were mixed later in gestation. Like our study however, Knox et al[29] found there was no difference in the amount of leg inflammation in sows that were mixed between 7- and 35-days post weaning. The research is therefore equivocal on whether timing of mixing has an impact on the odds of lameness in pen gestated sows.

Our data is a sample of US herds using pen gestation that shared records for a large number of sow removals. As sows may not be correctly categorized by farm staff as to the reason for their removal[10] and sows may be removed for multiple reasons that were not captured in our data, we may be undercounting lameness by looking only at removal reasons. Associations between housing types and lameness are challenging as the relationships are not necessarily casual and should be considered carefully within each production system. More research is needed to investigate the direct relationship between housing management strategies and the risk of removing lame sows in US herds using pen gestation. The impact of group size on lameness is difficult to assess since it is related to the feeding methodology and thus isolating group size as its own factor to understand the association with the risk of removal for lameness is important. Additional studies are needed to determine whether time of mixing has an impact on the risk of removal for lame sows since there have been conflicting results from previous research. Based on the information provided by the farms in this study, housing systems and mixing methods that promote the formation of stable groups may have an impact on decreasing odds of removal for lameness. These data indicate the importance of lameness as a reason for removal and highlights the cost of lameness due to its impact on productivity and the removal of younger animals from the herd. Ultimately, understanding the link between housing methods and lameness removals and the high costs associated with lameness could help producers make decisions on best housing strategies for pen gestation and how much they can invest in alterations to housing management.

Implications

Under the conditions of this study:

- Lameness was the third most commonly reported cause of sow removal.
- Lame sows were removed earlier, less productive, and more likely removed by death or euthanasia.
- More work is needed to assess impacts of housing methods on risk of lameness.

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Conflict of interest

None reported.

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