Reproductive profile and lifetime efficiency of female pigs by culling reason in high-performing commercial breeding herds

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Summary

Objectives: To compare lifetime efficiency and by-parity reproductive performance of female pigs categorized by culling reason or herd productivity group.

Materials and methods: Lifetime records were analyzed for 62,775 females in 101 Japanese commercial herds. Culling reasons were categorized into four groups. Three herd groups were based on the upper and lower 25th percentiles of pigs weaned per mated female per year: high-, intermediate-, and low-performing herds. Annualized lifetime pigs born alive (PBA) was calculated as the sum of PBA in the sow's lifetime ÷ female life-days × 365 days. Multilevel linear mixed-effects models were performed to compare measurements by subgroups.

Results: Females culled for "reproductive failure" had 7.5 pigs fewer annualized lifetime PBA and 43.0 more lifetime nonproductive days than those culled for "high parity" ($P < .01$). Females culled for reproductive failure in high-performing herds had 34.7 fewer lifetime nonproductive days than those in low-performing herds ($P < .01$), but lifetime PBA was similar to those in the other herd groups. Females culled for reproductive failure had a longer weaning-to-first-mating interval and lower farrowing percentage from parity 1 to 4 than those culled for "high parity" ($P < .01$), but PBA values were similar to those in other parity groups. Females culled for "locomotor problems" had 0.3 pigs more annualized lifetime PBA than those culled for reproductive failure ($P < .01$).

Implications: It is critical to decrease nonproductive days in each parity of females with reproductive problems in order to increase sow lifetime efficiency.

Keywords: swine, lameness, longevity, reproductive failure, well-being

Received: August 13, 2010
Accepted: December 13, 2010

Resumen - Perfil reproductivo y eficiencia de vida de hembras con relación al motivo de desecho en hatos comerciales de alto rendimiento

Objetivos: Comparar la eficiencia de vida y el comportamiento reproductivo por parto de hembras categorizados por motivo de desecho y grupo de productividad en el hato.

Materiales y métodos: Se analizaron los registros de vida de 62,775 hembras en 101 hatos comerciales japoneses. Los motivos de desecho se clasificaron en cuatro grupos. Se establecieron tres grupos de hatos basándose en el 25avo percentil, alto y bajo, de cerdos destetados por hembra servida por año: hatos con rendimiento alto, intermedio, y bajo. Se calculó la producción anualizada de cerdos nacidos vivos (PBA por sus siglas en inglés) como la suma de PBA en la vida de la hembra ÷ los días de vida de la hembra × 365 días. Para comparar las medidas por subgrupos se corrieron modelos mixtos lineares de niveles múltiples.

Resultados: Las hembras desechadas debido a "falla reproductiva" tuvieron 7.5 cerdos menos en su PBA de vida anualizada y 43.0 días no productivos extras que aquellas desechadas por "alta paridad" ($P < .01$). Las hembras desechadas por falla reproductiva en hatos de alto rendimiento tuvieron 34.7 días no productivos menos de vida total que aquellas en hatos de bajo rendimiento ($P < .01$), pero los PBA de vida fueron similares al de aquellas en otros grupos de hatos. Las hembras desechadas por falla reproductiva tuvieron un intervalo más largo de destete a primer servicio y un porcentaje de fertilidad más bajo en las paridades 1 a 4 que aquellas sacrificadas por "alta paridad" ($P < .01$), pero los valores de PBA fueron similares a los de los otros grupos de paridad. Las hembras desechadas por "problemas motrices" tuvieron 0.3 cerdos más en sus PBA de vida anualizada que aquellas desechadas por falla reproductiva ($P < .01$).

Implicaciones: Es crítico disminuir los días no productivos en cada parto de hembras con problemas reproductivos para incrementar la eficiencia de vida de la hembra.

Résumé - Profil de reproduction et efficience durant leur durée de vie des porcs femelles selon les motifs de réforme dans des troupeaux reproducteurs commerciaux de haute performance

Objectifs: Comparer l'efficience durant leur durée de vie et les performances reproductives par parité de porcs femelles catégorisés par motif de réforme ou groupe de productivité du troupeau.

Matériels et méthodes: Les données provenant de 62,775 femelles dans 101 troupeaux commerciaux japonais ont été analysées. Les motifs de réforme ont été catégorisés en quatre groupes. Trois groupes de troupeaux étaient basés sur les 25e percentiles supérieur et inférieur des porcs sevrés par femelle accouplée par année: élevé, intermédiaire, et faible. Le nombre annualisé de porcs nés vivants (PBA) était calculé en prenant la somme de PBA au cours de la vie de la truie ÷ durée de vie de la femelle × 365 jours. Des modèles linéaires multi-niveaux à effets mixtes ont été réalisés afin de comparer les mesures par sous-groupes.

Résultats: Les femelles réformées pour "troubles de reproduction" avaient 7.5 PBA

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This article is available online at http://www.aasv.org/shap.html.

Sasaki Y, Koketsu Y. Reproductive profile and lifetime efficiency of female pigs by culling reason in high-performing commercial breeding herds. *J Swine Health Prod.* 2011;19(5):284–291.

annualisés de moins et 43.0 jours supplémentaires de non-productivité pour la durée de leur vie que celles réformées pour “parité élevée” (*P* < .01). Les femelles réformées pour troubles de reproduction dans les troupeaux à haute-performance avaient 34.7 jours de moins de non-productivité pour la durée de leur vie que celles dans les troupeaux à pauvre performance (*P* < .01), mais le PBA pour la durée de la vie était similaire à ceux des autres groupes. Les femelles réformées pour troubles de reproduction avaient un intervalle sevrage-première saillie plus long et un pourcentage de mise-bas plus bas de la parité 1 à la parité 4 que celles réformées pour “haute parité” (*P* < .01), mais les valeurs de PBA étaient similaires à celles des autres groupes de parité. Les femelles réformées pour “problèmes locomoteurs” avaient 0.3 PBA annualisés supplémentaires pour la durée de leur vie que celles réformées pour des troubles de reproduction (*P* < .01).

Implications: Il est primordial de diminuer les jours de non-productivité dans chaque parité de femelles avec des troubles de reproduction afin d’augmenter l’efficience des truies pour la durée de leur vie.

Improving lifetime efficiency of female pigs (females) increases herd productivity[1] and sustainability in commercial breeding herds. Lifetime efficiency of females can be measured as annualized lifetime pigs born alive (PBA), which combines lifetime PBA with lifetime nonproductive days (NPD).[2] Lifetime PBA is a litter-size trait[3] derived by summing by-parity PBA values, whereas lifetime NPD is a fertility trait[4] that includes weaning-to-first-mating intervals and re-service intervals.[5] Both intervals are related to farrowing percentage.

The lifetime performance in culled females varies with culling reason.[3] For example, females culled for reproductive failure are reported to have the most lifetime NPD of all culled females,[3,4] whereas sows culled for old age have the fewest NPD per parity and greatest lifetime PBA of all culled females.[3] Additionally, females with poor leg conformation tend to be culled in low parity,[6] and therefore those females have poor lifetime performance. Lifetime performance and lifetime efficiency of females are also affected by culling management, which varies among commercial herds. In high-performing herds, defined by the number of pigs weaned per mated female per year, culling management is better than in average commercial herds,[7,8] and the culling rates across parity are different from those in average commercial herds.[9] Culling management in high-performing herds tends to reduce last-weaning-to-culling intervals and increase efficiency of females more than in low-performing herds.[10] However, the culling risks for individual females associated with different culling reasons in high-performing herds, especially by-parity culling risks, have not been fully elucidated. In addition, to the authors’ knowledge, no study has reported reproductive profiles across parity and lifetime efficiency for culled females by culling reason and by herd groups that are defined by herd productivity. Performance and management measurements in high-performing herds can provide feasible targets for swine producers and veterinarians as an application of best-practice benchmarking.[11]

Therefore, the objectives of the present study were to compare lifetime efficiency and culling risk for each culling reason by herd groups defined by herd productivity, and to investigate by-parity reproductive performance by culling reason and herd group in commercial herds.

Materials and methods

Data selection

All Japanese pig producers (approximately 130 herds) using PigCHAMP (PigCHAMP, Ames, Iowa) were requested to mail their data files to Meiji University each time they renewed their yearly maintenance contract. This database comprised 1.9% of the 6780 breeding herds in Japan and approximately 4.6% of the 907,100 females in these herds.[12] By August 31, 2008, data files were received from 113 breeding herds. All records received by August 31, 2008, were eligible for inclusion in this study. Of the 113 herds responding, data from eight herds were excluded because birth dates of females were not recorded, and four more herds were excluded because birth dates of females were inaccurate. Thus, the final dataset contained 101 commercial farrow-to-finish herds.

Two datasets were constructed: a mean dataset of annual herd performance and a sow-parity dataset for individual females. Mean herd measurements for the 5-year period from 2002 to 2006 were collected for the 101 breeding herds. The sow-parity data, from birth to the last parity of females born from 2001 to 2004, were extracted from the data files of each herd. Of 63,990 females in the 101 herds, 1215 females were excluded because they had either inaccurate lifetime records or incomplete parity records in their lifetime. Thus, 62,775 females were included in analysis of culling risks. Of these females, 2784 were still active when the data were collected, and they were omitted when lifetime performance and by-parity reproductive performance were analyzed. Similarly, 5995 dead females were omitted from the analyses of lifetime performance and by-parity reproductive performance because their removals due to death were an involuntary event, whereas culling was a voluntary decision. Therefore, the final number of animals used for analyses of lifetime performance and by-parity reproductive performance was 53,996, comprising 46,795 sows and 7201 gilts. The proportions of euthanized females, type-unrecorded females, and females that transferred to other herds were 0.3%, 0.6%, and 1.1%, respectively.

Herd description

In the 101 studied herds, mean (± SEM) herd size was 378 ± 50.4 females, with a range of 25 to 3304 females. Natural or mechanical ventilation was used in gestation and lactation barns of the studied herds. Gestating females and weaned sows were housed in stalls on a partially slatted floor, and late gestating females and lactating sows were housed in a farrowing unit, with each female provided with a farrowing pen and a crate that had creep areas on each side. Gestation and lactation diets were formulated with imported corn and soybean meal. Replacement gilts were either home-grown crossbreds (mainly Landrace × Large White) or purchased from outside breeding companies. Sows were commonly mated at first estrus after weaning, and both natural mating and artificial insemination were practiced. Real-time ultrasound devices were commonly used to detect pregnancy status in mated females.

Categories of culling reasons

Reasons for culling were recorded by producers when females were removed from the herds. Culling reasons were grouped into four categories: “reproductive failure,” “locomotor problems,” “high parity,” and “other.” Reproductive failure included no estrus, failure to farrow, found not pregnant, and abortion. Locomotor problems consisted of sow unable to rise, joint infection, and lameness. Culling for high parity conventionally implies planned culling. Culling for high parity was restricted to sows of parity ≥ 5 at culling, because culling in low parity due to "high parity" does not make sense for planned culling.[4] Therefore low-parity sows culled for high parity were categorized into "other" reasons, which also included euthanasia, transfer, unknown, and nonspecific reasons.

Definitions and categories of measurements

Herd productivity was measured as the number of pigs weaned per mated female per year over 5 years, from 2002 to 2006.[5] Three herd categories were defined on the basis of the upper and lower 25th percentiles of the number of pigs weaned per mated female per year: high-performing herds (≥ 23.6 pigs; 26 herds), intermediate-performing herds (20.2 to 23.5 pigs; 49 herds), and low-performing herds (≤ 20.1 pigs; 26 herds). The number of pigs weaned per mated female per year was a herd-basis measurement for females bred in a herd from first mating as gilts to removal.

Females included gilts and sows: a gilt was defined as a female entered into a herd but not farrowed, and a sow was a female that had farrowed at least once. Lifetime efficiency was measured by annualized lifetime PBA that was calculated as lifetime PBA ÷ female life-days from birth to culling × 365 days.[2] This calculation was performed only for sows. Annualized lifetime PBA includes both lifetime fertility (NPD) and prolificacy (PBA) measurements. The calculation of annualized lifetime PBA includes number of days from birth to first mating, which is ignored in the calculation of the number of pigs weaned per mated female per year. Lifetime PBA was defined as the sum of PBA in a sow's lifetime, and female life-days was defined as total days from birth to culling. Lifetime NPD was defined as number of days when females were neither gestating nor lactating during their reproductive herd life.[13] Reproductive herd life was defined as number of days from the date that the gilts were first mated to culling. Culling risk in each parity for each of the four reasons was calculated as number of culled females ÷ number of surviving females at farrowing × 100.

Lifetime performance included annualized lifetime PBA, lifetime NPD, and lifetime PBA. Annualized lifetime PBA is a sow-basis measurement from birth to removal. By-parity reproductive performance included PBA, weaning-to-first-mating interval, and farrowing percentage. Performance records for the parity when females were culled were not included in the analysis of by-parity reproductive performance, because reproductive performance in the parity at culling might be unsuitable for analysis of reproductive profiles of females. For example, in a sow culled at parity 3 due to reproductive failure, performance in parity 3 (eg, weaning-to-first-mating interval or farrowing percentage) is significantly poorer than in the previous parity and may bias overall reproductive performance of the sows at parity 3.

Statistical analysis

All statistical analyses were performed using SAS software, version 9.1 (SAS Institute Inc, Cary, North Carolina). A multilevel model was used to take into account the hierarchical structure of the individual females within a herd.[14] Two-level analysis was applied by using a herd at level two and an individual record at level one.[14] A linear mixed-effects model using the MIXED procedure with a Tukey-Kramer multiple comparisons test was applied to compare lifetime measurements among herd groups and culling reasons. The dependent variables were lifetime measurements (annualized lifetime PBA, lifetime PBA, lifetime NPD, and parity at culling) and by-parity measurements (PBA and weaning-to-first-mating interval). The independent variables were herd group, culling reason, and the interaction between herd group and culling reason. We also included herd size as a fixed effect. The herd, birth year, and an interaction between herd and birth year were included as a random intercept in order to adjust for the variance component representing the effect of herd, and the denominator degree of freedom = Between-Within option was used.[14]

A mixed-effects logistic regression model using the GLIMMIX procedure with contrasts was used to compare farrowing percentage and culling risk in individual females by herd group in each parity. In Model One, the dependent variable was whether or not a female farrowed at first service (farrowing percentage), and the independent variables were herd group, culling reason, and the interaction between herd group and culling reason. In Model Two, the dependent variable was whether a female was culled or not for each culling reason (culling risk), and the independent variable was herd group. In these models, herd size was also included as a fixed effect. The herd, birth year, and an interaction between herd and birth year were included as a random intercept, and the denominator degree of freedom = Between-Within option was used.[14] For all methods of analysis, $P < .05$ was considered statistically significant.

Results

Mean values (± SEM) of annualized lifetime PBA, lifetime PBA, lifetime NPD, and parity at culling were 17.2 ± 0.03 pigs, 52.5 ± 0.13 pigs, 88.3 ± 0.29 days, and 4.4 ± 0.01, respectively. Mean herd sizes in high-, intermediate-, and low-performing herds were 471 ± 133.4 females, 366 ± 63.4 females, and 305.1 ± 80.7 females, respectively. Herd size did not differ among the herd-productivity groups. High-performing herds had the greatest annualized lifetime PBA and the lowest lifetime NPD ($P < .01$; Table 1), but parity at culling and lifetime PBA were similar to those in intermediate-performing herds. Lifetime PBA decreased as herd size increased ($P = .03$). Range of parities at culling across 101 herds in females culled for reproductive failure, locomotor problems, and high parity were 1.0 to 4.6, 1.0 to 4.4, and 6.1 to 8.9, respectively.

Females culled for reproductive failure had the lowest annualized lifetime PBA, the greatest lifetime NPD, and the lowest parity at culling ($P < .01$; Table 1). In those females, annualized lifetime PBA was lower by 7.5 pigs and parity at culling was lower by 4.6 than in females culled for high parity, but lifetime NPD was 43.0 days more than in females culled for high parity ($P < .01$). In females culled for locomotor problems, annualized lifetime PBA was lower by 7.2 pigs and lifetime NPD was 15.0 days lower than in females culled for high parity ($P < .01$).

There was a significant interaction between culling reason and herd group for annualized lifetime PBA, lifetime PBA, lifetime NPD, and parity at culling ($P < .01$; Table 2). Herd groups did not differ in lifetime PBA of females culled for reproductive failure. In contrast, in females culled for high parity in high-performing herds, lifetime PBA was 10.4 pigs greater than that in low-performing herds ($P < .01$). Additionally, parity at culling was higher for females culled for reproductive failure in high-performing herds than in low-performing herds ($P < .01$), but herd groups did not differ for any other culling reason. Lifetime NPD was lower by approximately 30 days and annualized lifetime PBA was approximately four pigs greater in females culled for reproductive failure and high parity in high-performing herds than in low-performing herds ($P < .01$).

Table 1: Comparisons of culling reasons and lifetime measurements by herd groups defined by numbers of pigs weaned per mated female over 5 years*

	Annualized lifetime PBA†		Lifetime PBA		Lifetime NPD (days)		Parity at culling	
	n	Mean	n	Mean	n	Mean	n	Mean
Herd groups‡								
High	15,059	19.5[a]	15,059	58.9[a]	16,033	70.3[a]	17,073	4.7[a]
Intermediate	21,235	17.3[b]	21,235	53.1[a]	22,898	93.6[b]	24,141	4.4[a]
Low	10,501	13.9[c]	10,501	42.2[b]	11,739	102.6[c]	12,782	3.8[b]
Pooled SEM§	NA	0.19	NA	0.98	NA	3.43	NA	0.05
Culling reasons¶								
Reproductive failure	11,982	14.0[a]	11,982	36.0[a]	14,738	119.5[a]	16,415	2.5[a]
Locomotor problems	2641	14.3[b]	2641	32.4[b]	2832	61.5[b]	3122	2.7[b]
High parity	19,289	21.5[c]	19,289	76.1[c]	19,289	76.5[c]	19,289	7.1[c]
Other	12,883	14.5[d]	12,883	36.7[d]	13,811	77.1[d]	15,170	3.2[d]
Pooled SEM§	NA	0.12	NA	0.90	NA	2.08	NA	0.04

* Lifetime records of sows born from 2001 to 2004 were obtained from 101 Japanese commercial farrow-to-finish herds using PigCHAMP software (PigCHAMP, Ames, Iowa). The numbers of records used for the analysis of annualized lifetime PBA, lifetime PBA, lifetime NPD, and parity at culling were 46,795, 46,795, 50,670, and 53,996, respectively.

† Annualized lifetime PBA = (sum of pigs born alive in lifetime ÷ female life-days) × 365 days.

‡ Three herd groups (high, intermediate, and low) were formed on the basis of the upper and lower 25th percentiles of number of pigs weaned per mated female per year over 5 years (≥ 23.6 pigs, 26 herds; 20.2 to 23.5 pigs, 49 herds; ≤ 20.1 pigs, 26 herds, respectively).

§ Estimated from standard error of least squares means in the mixed model.

¶ Reproductive failure included no estrus, failure to farrow, found not pregnant, and abortion. Locomotor problems consisted of sow unable to rise, joint infection, and lameness. Culling for high parity conventionally implies planned culling. "Other" culling reasons included euthanasia, transfer, unknown, and nonspecific reasons.

[abcd] Values with no common superscript in a herd-group or a culling-reasons column differ ($P < .01$; linear mixed-effects models).

PBA = pigs born alive; NPD = nonproductive days; NA = not applicable

Comparisons of reproductive performance in each parity are shown in Table 3. No differences were found in PBA from parity 1 to parity ≥ 6 among females culled for reproductive failure, locomotor problems, or high parity. However, females culled for reproductive failure had the lowest farrowing percentage among the reason groups from parity 1 to parity ≥ 6 ($P < .01$). In addition, weaning-to-first-mating interval was longer in females up to parity 4 culled for reproductive failure than in females culled for high parity ($P < .01$). No significant two-way interaction between culling reason and herd group was found in any parity groups for PBA, weaning-to-first-mating interval, or farrowing percentage.

Overall culling risks for females due to reproductive failure, locomotor problems, and high parity were 26.1% ± 0.18%, 5.0% ± 0.09%, and 30.7% ± 0.18%, respectively. There was no difference among herd productivity groups in either overall culling risk or by-parity culling risk due to reproductive failure in any parity groups (Table 4). By-parity culling risks for high parity in parity ≥ 6 was higher in high-performing herds than in intermediate- or low-performing herds ($P < .01$). In addition, overall culling risk and by-parity culling risks for locomotor problems in parities 1, 2, 3, 4, and ≥ 6 were lower in high-performing herds than in low-performing herds ($P < .01$).

Discussion

The overall culling risk of 26.1% for reproductive failure in the present study is consistent with the values of 29.8%,[15] 33.6%,[3] and 26.9%[5] found in other studies. The lack of any difference in culling risks for reproductive failure among the herd groups in our study indicates that the risk of reproductive failure is the same regardless of herd productivity. Nevertheless, shorter weaning-to-culling intervals in high-performing herds indicate that decisions on culling of nonpregnant females in these herds are made more quickly than in other herds.[10] In addition, our study suggests that females having suboptimal reproductive performance, such as prolonged weaning-to-first-mating interval or returning to estrus, are more likely to be culled for reproductive failure in later parities. However, guidelines for culling a sow should not include sows with prolonged weaning-to-first-mating interval, because the repeatability for weaning-to-first-mating interval is low.[16]

Lifetime NPD was lower in females culled for reproductive failure in high-performing herds than in the other herd categories, although lifetime PBA did not differ among the herd categories. Additionally, there were no differences in PBA from first parity to last parity among the reproductive-failure, locomotor-problems, and high-parity groups. These results indicate that reducing NPD is more critical than increasing lifetime PBA for producers wanting to improve herd productivity and lifetime efficiency in sows. An effective way to decrease lifetime NPD and improve lifetime efficiency is to reduce the culling interval for females having reproductive failure, because females

Table 2: Interactions between herd productivity groups and culling reasons for annualized lifetime PBA, lifetime PBA, lifetime NPD, and parity at culling*

Culling reasons	Herd groups: High		Intermediate		Low	
	n	Mean	n	Mean	n	Mean
Annualized lifetime PBA† (pooled SEM‡ = 0.21)						
Reproductive failure	3777	15.5[ax]	5735	14.1[ay]	2470	11.7[az]
Locomotor problems	600	16.5[bx]	1279	14.3[ay]	762	12.7[bz]
High parity	7480	23.0[cx]	8435	21.4[by]	3374	18.2[cz]
Other	3202	16.5[bx]	5786	15.1[cy]	3895	11.9[bz]
Lifetime PBA (pooled SEM‡ = 1.06)						
Reproductive failure	3777	39.1[a]	5735	36.4[a]	2470	30.4[a]
Locomotor problems	600	37.0[ax]	1279	32.4[bxy]	762	28.9[by]
High parity	7480	78.2[bx]	8435	77.6[cx]	3374	67.8[cy]
Other	3202	41.3[a]	5786	38.6[d]	3895	30.3[a]
Lifetime NPD (pooled SEM‡ = 3.59)						
Reproductive failure	4575	100.7[ax]	6917	124.6[ay]	3246	135.0[az]
Locomotor problems	637	49.6[bx]	1381	63.5[bxy]	814	67.3[by]
High parity	7480	58.8[cx]	8435	82.9[cy]	3374	100.0[cz]
Other	3341	58.8[cx]	6165	80.2[cy]	4305	86.9[dz]
Parity at culling (pooled SEM‡ = 0.06)						
Reproductive failure	4861	2.8[ax]	7602	2.6[ax]	3952	2.0[ay]
Locomotor problems	758	2.7[a]	1501	2.7[a]	863	2.7[b]
High parity	7480	7.0[b]	8435	7.2[b]	3374	7.2[c]
Other	3974	3.2[c]	6603	3.3[c]	4593	3.0[d]

* Lifetime records of sows were obtained from 101 Japanese commercial farrow-to-finish herds using PigCHAMP software (PigCHAMP, Ames, Iowa).

† Annualized lifetime PBA = (sum of pigs born alive in lifetime ÷ female life-days) × 365 days.

‡ Estimated from standard error of least squares means in the mixed model.

abcd Values within a column with no common superscript differ ($P < .01$; linear mixed-effects models).

xyz Values within a row with no common superscript differ ($P < .01$; linear mixed-effects models).

PBA = pigs born alive; NPD = nonproductive days.

culled for reproductive failure have a longer weaning-to-culling interval than those culled for other reasons.[4,17] It is possible that low-performing herds have higher reservice rates, higher rates of found not pregnant, and greater failure to detect open females than high-performing herds, and thus do not make quick decisions for culling. Further, it is necessary to decrease the impact of other factors contributing to NPD, such as weaning-to-first-mating interval and mating-to-conception interval. For example, increasing lactation feed intake[18] and performing multiple matings[19,20] can improve the weaning-to-first-mating interval and farrowing percentage that decrease lifetime NPD.

Our results showed a lower risk of culling for locomotor problems in high-performing herds than in low-performing herds. Gilts with undesirable limb conformation were removed earlier than those with desirable conformation, and lameness was a major reason for their removals,[21] thus the undesirable limb conformation could be related to high risk of culling due to locomotor problems. More effort can be made on selection of gilts having desirable limb conformation in order to reduce the risk of culling for locomotor problems, especially in low-performing herds. Increased numbers of females culled due to locomotor problems would raise a concern for animal well-being, because females having locomotor problems must endure pain until they are culled.[22] In addition, higher risk of culling due to locomotor problems in parity 1 than in parity 0 is in agreement with a previous study.[23] Parity 1 sows appeared to have a higher occurrence of locomotor problems than gilts. However, our culling risk for locomotor problems (5.0%) is much lower than the 9.9% found in a study performed in US commercial herds.[23] This discrepancy suggests that there may be large country-to-country variations in identifying sows to cull for locomotion due to genotype, gilt development, and selection.

Our result indicates that high-performing herds cull high-parity sows due to high

Table 3: Comparisons of reproductive performance of sows by culling reason in each parity*

Culling reasons	Parity					
	1	2	3	4	5	≥ 6
No. of females at farrowing						
Reproductive failure	9168	7347	5654	3917	2284	1345
Locomotor problems	1923	1469	1092	738	379	234
High parity	19,289	19,289	19,289	19,289	18,347	22,900
Other	10,435	8757	6944	4841	2872	1943
No. of pigs born alive						
Reproductive failure	9.8[a]	10.4[a]	11.0[a]	11.0[a]	10.9[a]	10.7[a]
Locomotor problems	9.7[a]	10.3[a]	10.9[a]	10.9[a]	10.9[a]	10.3[ab]
High parity	10.0[a]	10.5[a]	11.1[a]	11.2[a]	11.1[a]	10.7[a]
Other	9.4[b]	9.9[b]	10.4[b]	10.5[b]	10.4[b]	10.3[b]
Pooled SEM†	0.06	0.07	0.07	0.07	0.07	0.06
Weaning-to-first-mating interval (days)						
Reproductive failure	9.8[a]	7.3[a]	6.5[a]	6.4[a]	6.1	5.5
Locomotor problems	9.9[ab]	7.0[ab]	6.4[ab]	6.3[ab]	6.4	5.8
High parity	8.2[c]	6.4[b]	6.0[b]	5.9[b]	5.8	5.7
Other	9.5[b]	7.1[a]	6.6[a]	6.2[ab]	6.0	5.8
Pooled SEM†	0.19	0.16	0.15	0.13	0.13	0.12
Farrowing at first service (%)						
Reproductive failure	88.7[a]	90.9[a]	91.1[a]	91.4[a]	92.3[a]	92.9[a]
Locomotor problems	90.0[bc]	89.8[a]	92.7[ab]	92.7[ab]	91.6[ab]	94.0[ab]
High parity	91.3[b]	93.0[b]	93.8[b]	93.7[b]	94.4[b]	95.2[b]
Other	89.2[ac]	91.1[a]	91.5[a]	92.1[a]	92.9[ab]	93.4[ab]
Pooled SEM†	1.79	1.44	1.31	1.29	1.18	1.11

* Lifetime records of sows were obtained from 101 Japanese commercial farrow-to-finish herds using PigCHAMP software (PigCHAMP, Ames, Iowa). Culling for high parity was restricted to sows of parity ≥ 5 at culling.

† Estimated from standard error of least squares means in the mixed model.

abc Values within a column with no common superscript differ (*P* < .01; linear mixed-effects models).

parity more than low-performing herds. Previous studies reported that most sows culled for high parity have been defined as preplanned culling,[4] and weaning-to-culling intervals were shorter than in other females.[17] Further, higher lifetime PBA in high-performing herds than in low-performing herds can be explained by greater sow longevity in the high-performing herds. Greater longevity in sows results in a greater opportunity to achieve higher PBA at mid-parity.[3]

Finally, lifetime measurements of the high-performing herds in the present study provide feasible targets for reproductive efficiency in swine breeding herds. It is important for producers to increase lifetime efficiency by decreasing lifetime NPD of individual females in order to improve overall herd productivity.

In high-performing herds in the present study, parity at culling was higher than in low-performing herds, especially in females culled for reproductive failure. Increased sow longevity improves herd productivity and stable health status by decreasing the low-parity female subpopulation, increasing the opportunity to achieve greater PBA at mid-parity, and lowering expenses for gilt replacements.[2-4] In addition, it is crucial for swine producers to monitor lifetime measurements and culling patterns in their herds in order to improve sow longevity and herd productivity.

Results of this observational study using records from commercial herds might be biased by differences in housing, genotype, nutrition, and environment, which we did not measure. Thus, our findings should not be interpreted as biological causation, but as association. Furthermore, culling reasons recorded by producers were not validated.[24] Even with these limitations, this study provides practicing veterinarians and producers with valuable information about lifetime efficiency and reproductive profiles of females revealed by their reasons for being culled in order to improve lifetime efficiency of sows and herd productivity.

Table 4: By-parity comparisons of culling risks (%) by herd productivity groups for each culling reason in 292,009 parity records of 62,775 females*

Herd productivity groups†	All females	Parity						
		0	1	2	3	4	5	≥ 6
No. of surviving females								
High	19,213	19,213	16,416	14,702	13,580	12,364	10,916	9178
Intermediate	28,210	28,210	23,587	20,441	18,287	16,161	13,898	11,284
Low	15,352	15,352	11,966	9937	8569	7254	6017	4677
Risk of culling for reproductive failure (%)								
High	25.3	5.6	5.0	3.6	3.8	4.6	5.1	8.6
Intermediate	26.9	6.6	5.7	4.3	4.3	5.1	5.8	9.8
Low	25.7	9.7	5.4	4.2	4.7	4.7	4.6	8.4
Pooled SEM‡	3.48	1.72	1.69	1.66	1.66	1.69	1.69	1.37
Risk of culling for locomotor problems (%)								
High	3.9[a]	0.8	1.0[a]	0.5[a]	0.6[a]	0.8[a]	1.0	0.9[a]
Intermediate	5.3[a]	0.8	1.5[a]	1.1[b]	1.0[b]	0.9[a]	1.3	1.6[a]
Low	5.6[b]	0.7	1.8[b]	1.5[c]	1.2[c]	1.4[b]	1.3	2.4[b]
Pooled SEM‡	1.67	0.71	0.71	0.67	0.66	0.67	0.69	0.70
Risk of culling for high parity (%)								
High	38.9[a]	NA	NA	NA	NA	NA	2.2[a]	78.9[a]
Intermediate	29.9[b]	NA	NA	NA	NA	NA	3.1[a]	71.0[b]
Low	22.0[c]	NA	NA	NA	NA	NA	4.6[b]	66.2[b]
Pooled SEM‡	4.19	NA	NA	NA	NA	NA	1.01	1.97
Risk of culling for other reasons¶								
High	31.8[a]	8.1[a]	4.5[a]	3.5[a]	4.6[a]	6.3[a]	7.6	11.7
Intermediate	37.8[ab]	9.0[ab]	6.2[a]	5.1[a]	6.3[a]	8.0[a]	8.7	17.6
Low	46.7[b]	11.7[b]	9.7[b]	9.7[b]	9.4[b]	11.0[b]	11.8	23.0
Pooled SEM‡	4.54	1.44	1.75	1.75	1.76	1.81	2.55	3.15

* Lifetime records of sows were obtained from 101 Japanese commercial farrow-to-finish herds using PigCHAMP software (PigCHAMP, Ames, Iowa). When data were collected, 2784 females were still alive and 5995 had died. Culling risk in each parity for each of the four culling reasons was calculated as no. of culled females ÷ number of surviving females at farrowing × 100.

† High, intermediate, and low categories based on upper and lower 25th percentiles of the no. of pigs weaned per mated female per year: high-performing herds, ≥ 23.6 pigs, 26 herds; intermediate-performing herds, 20.2 to 23.5 pigs, 49 herds; and low-performing herds, ≤ 20.1 pigs, 26 herds.

‡ Estimated from standard error of least squares means in the mixed model.

¶ "Other" included euthanasia, transfer, unknown, and nonspecific reasons, including planned culling for high parity in low-parity sows.

abc Values within a column with no common superscript differ ($P < .01$; mixed-effects logistic regression models).

NA = not applicable

Implications

- It is critical to reduce lifetime NPD in females having reproductive problems, such as no estrus, failure to farrow, found not pregnant, and abortion, in order to increase lifetime efficiency.
- Fertility traits are more important than litter-size traits to define sows with low lifetime efficiency.
- Improving farrowing percentage and reducing weaning-to-first-mating interval and culling interval are critical to improve sow lifetime efficiency and herd productivity.
- Reducing the risk of culling due to locomotor problems in low-performing herds alleviates concerns about sow well-being, which would otherwise require such females to be euthanized.

Acknowledgements

The authors gratefully thank cooperative producers for providing their data to be used in the present study, and the PigCHAMP staff in Global Pig Farms, Inc (Shibukawa, Gunma, Japan) for their technical assistance. We also thank Dr I. McTaggart for his critical review of this manuscript. This work was supported by Research Project Grants from Meiji University, the Ministry of Education, Culture, Sports, Science and Technology of Japan, and Grant-in-Aid from the Japan Society for the Promotion of Science (No. 22–7255).

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