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PHYSIOLOGY: *Short Communication*

Evaluating the efficacy of visual assessment of gilt vulva size prior to puberty on subsequent reproductive performance*

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ABSTRACT

Objective: This study's objective was to assess the relationship between visually assigned prepubertal vulva score and subsequent sow productivity in a commercial production system.

Materials and Methods: The study was conducted at a genetic nucleus herd, where farm personnel visually classified prepubertal gilts into categories: vulva score 1 (VS1; below average size), VS2 (average vulva size), and VS3 (above average vulva size), at approximately 15 wk of age. Reproductive performance from gilts incorporated into the breeding herd were tracked through 2 parities of production.

Results and Discussion: Age at parity 1 (P1) was greatest ($P \leq 0.01$) in gilts assigned a VS1 score compared with those receiving a VS2 or VS3 score. The P1 total pigs born for gilts categorized as VS2, VS3, and VS2/3 (VS2 and VS3 combined into one group) was greater ($P \leq 0.05$) compared with gilts receiving a score of VS1. The number of pigs born alive was also lower ($P \leq 0.05$) for gilts assigned a VS1 compared with those assigned VS2 or VS3 and the combined group (VS2/3). Second parity litter performance was not affected ($P > 0.18$) by prepubertal vulva score assignment, although total pigs born and pigs born alive through 2 parities combined tended to be greater ($P \leq 0.08$) for gilts in the combined VS2/VS3 group compared with those assigned a score of VS1.

Implications and Applications: These results suggest that visually assessing prepubertal vulva development may identify females more likely to farrow at a younger age with improved P1 litter performance.

Key words: sow lifetime productivity, vulva size, litter size, gilt

INTRODUCTION

The sow's reproductive success and longevity largely determine her profitability (Stalder et al., 2003). Currently, one of the best predictors of sow lifetime productivity is age at which a gilt achieves first estrus (i.e., puberty). Gilts reaching puberty earlier tend to produce more pigs over their lifetime (Nelson et al., 1990), have decreased number of days from weaning to estrus (Sterning et al., 1998), and are more likely to produce at least 3 parities (Patterson et al., 2010). Likewise, younger gilts at first service have increased parity 1 farrowing rates, are older when eventually removed from the herd, and produce more lifetime piglets (Koketsu et al., 1999). However, selecting for longevity and reproductive performance in commercial swine production systems is challenging because they are influenced by environmental factors, along with numerous traits associated with reproduction (Rydhmer, 2000; Serenius and Stalder, 2006).

Previously, we have discovered gilts having a smaller vulva width at 95 to 115 d of age are less likely to reach puberty by 200 d of age (Graves et al., 2020). Furthermore, expansion of this work identified that gilts having a below average vulva size at 15 wk of age can be used to effectively identify gilts that will have poorer longevity and be less productive when compared with gilts having an average or above average vulva size (Romoser et al., 2020). The objective of this study was to validate these findings and determine the efficacy of subjective visual assessment of prepubertal vulva size and the associated effect on subsequent reproductive performance. This experiment tested

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the hypothesis that gilts with a small vulva size by visual assessment at approximately 15 wk of age would produce fewer piglets through 2 parities compared with contemporaries subjectively scored as average or above average for vulva size.

MATERIALS AND METHODS

Animals

Existing data and animal records used in this study were provided by an industry collaborator (TriOak Foods, Inc.) from a commercial swine herd production system. Purebred (Fast Yorkshire) gilts (Fast Genetics, Saskatoon, SK, Canada) approximately 15 wk of age (n = 1,520) were visually assessed for prepubertal vulva development. The evaluation was conducted at a cooperating nucleus sow herd by trained farm staff visually classifying gilts according to vulva size. Evaluation involved subjectively classified gilts based on perceived total surface area and vulva development. Evaluators of gilts were trained based on our previous work, which has more intensively characterized vulva size differences during prepubertal development (Graves et al., 2020; Romoser et al., 2020). Based on that prior work and the distribution of vulva size during the specific age of development, evaluators were trained in scoring in a manner that would result in assigning scores to yield a distribution expected to result in approximately 15% of the gilt pool considered below average for vulva development, approximately 15% considered above average for vulva size, and the remaining being considered average. Gilts were subjectively assigned vulva score 1 (**VS1**) if the scorer thought the gilt had a below average vulva size for the given cohort. Gilts receiving a vulva score 2 (**VS2**) were considered to have an average vulva size, and gilts receiving vulva score 3 (**VS3**) were considered to have an above average vulva size.

Gilt Development

At the nucleus gilt development unit gilts were housed in groups of approximately 25 on fully slatted floors with approximately 0.74 m^2 provided per individual. Gilts were subjected to routine boar exposure (approximately 10 min of contact per pen) beginning around 190 d of age, for puberty stimulation and estrus detection. Of those gilts receiving a vulva score (**VS**), 867 were eventually bred and entered the breeding herd. This reduction of gilts was the result of gilt demand at receiving multiplication farms and selection criteria independent of VS (i.e., conformation and underline), although specific details on individual gilts that did not enter the breeding herd were not provided.

Reproductive Performance

Reproductive performance from gilts incorporated into the breeding herd were tracked through production. For gilts who successfully farrowed, farrowing date and litter data were recorded. Data including total pigs born (**TB**), pigs born alive (**BA**), stillborn (**SB**), and mummified fetuses (**MM**) were recorded at parturition. Records were documented and stored in an online swine database (PigKnows LLC, Greeley, CO).

Statistical Analysis

Statistical Analysis Systems (SAS) University Edition, version 9.4 (Cary, NC) was used for all statistical analysis. Mixed model methods (PROC MIXED, SAS V9.4) was used to analyze litter and farrowing age data. The model included the fixed effect of VS on reproductive performance. Each gilt was considered an experimental unit. If a fixed effect was a significant source of variation ($P < 0.05$), individual LSM were separated using P-diff where a P-value of 0.05 or less was considered statistically significant and a P-value >0.05 but <0.1 was considered a tendency toward significance. Additionally, comparisons were made comparing gilts with a VS1 score with the combined group of VS2 and VS3 (**VS2/3**) to detect production differences between gilts with a perceived small vulva compared with the rest of the gilts in her cohort.

RESULTS AND DISCUSSION

Utility of Prepubertal Vulva Assessment as an Indicator of Sow Productivity

While age at first estrus (i.e., puberty) is a valuable phenotype for identifying gilts with increased sow lifetime productivity potential (Patterson et al., 2010), events influencing puberty onset begin well before initially observed. Initiation of the processes that precede puberty occur as early as 70 d of age, when initial luteinizing hormone pulses from the anterior pituitary instigate early follicular development and subsequent estrogen production (Dyck and Swierstra, 1983). This initial estrogen production in turn causes increased reproductive tract size (Dyck and Swierstra, 1983; Evans and O'Doherty, 2001), which, as described in this study, may be a useful index to identify gilts with differing levels of reproductive ability. This is consistent with variation between breeds as well. For example, Meishan pigs, a breed known for reproductive prolificacy and fecundity, initiate follicular development and reach puberty very early in life (Miyano et al., 1990). Considering the association between early reproductive tract development and greater fecundity in Meishan pigs, we proposed this same concept, that earlier reproductive-tract development is associated with improved fecundity, may exist in commercially used European breeds as well.

Graves et al. (2020) confirmed that prepubertal follicular development begins between 75 and 115 d of age and is associated with variation in vulva size between gilts of this age. Presumably, the variation in vulva size at this time point can serve as an indication for the variation in the timing of prepubertal follicular development and resultant

estrogen synthesis. Further, the variation in vulva width around 95 to 115 d of age was associated with a gilt's ability to reach puberty by 200 d of age (Graves et al., 2020). In agreement with those observations, when prepubertal gilts were classified based on vulva width at approximately 15 wk of age, inclusion rate into the breeding herd improved, and enhanced litter size through 2 parities was observed (Romoser et al., 2020).

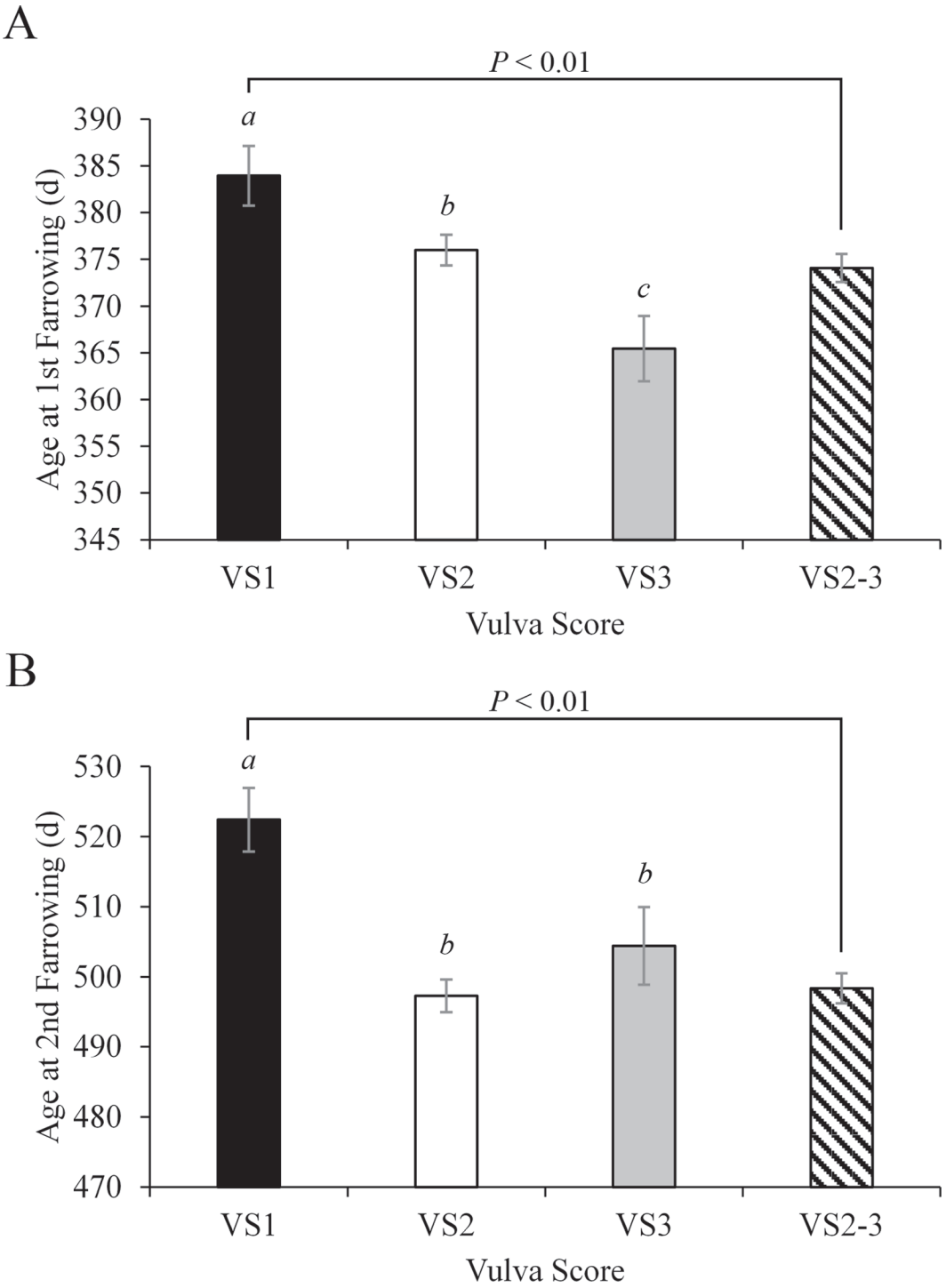

Figure 1. The effects of prepubertal vulva size classification on age at parity 1 (P1) and 2 (P2). Gilts were classified by visual assessment at approximately 15 wk of age. Gilts received a vulva score 1 (VS1) if subjectively estimated to be below average for vulva size. Gilts receiving a vulva score 2 (VS2) were considered average. Likewise, gilts receiving vulva score 3 (VS3) were estimated to be above average for vulva size. For P1 (A) and P2 (B), the number of days from birth to farrowing was affected ($P < 0.01$) by vulva score. Bars depict LSM ± SEM; scores with different superscripts (a–c) differ significantly ($P \leq 0.05$). Gilts scored VS1 had greater ($P < 0.01$) days to P1 (A) and P2 (B) when compared with all gilts scoring average or above (VS2–3).

Prepubertal VS Was Associated with Reduced Age at First and Second Farrowing

In this study, of the 867 gilts scored that entered the breeding herd, 18.1, 69.0, and 12.9% were assigned to VS1, VS2, and VS3, respectively, which was consistent with the intended scoring approach defined in the Materials and Methods. Gilts with a VS1 had an increased age at P1 (383.9 d) compared with VS2 (376.0 d; $P = 0.03$) or VS3 (365.5 d; $P \leq 0.01$). When gilts having a VS2 were compared with gilts with a VS3, age at P1 was also shorter ($P < 0.01$) in VS3-scored gilts. When gilts from the VS2 and VS3 groups were combined (VS2/3), their average age at first farrowing was lower ($P < 0.01$) when compared with gilts with a VS1 (Figure 1A).

Gilts from the VS1 group were older ($P \leq 0.01$) at P2 when compared with gilts from the VS2 and VS3 groups (522.4 vs. 497.3 and 504.4 d, respectively). When comparing gilts from the combined VS2/3 group (498.3 d) with gilts from the VS1 (522.4) group, a similar reduction ($P < 0.01$) in age at P2 was observed (Figure 1B).

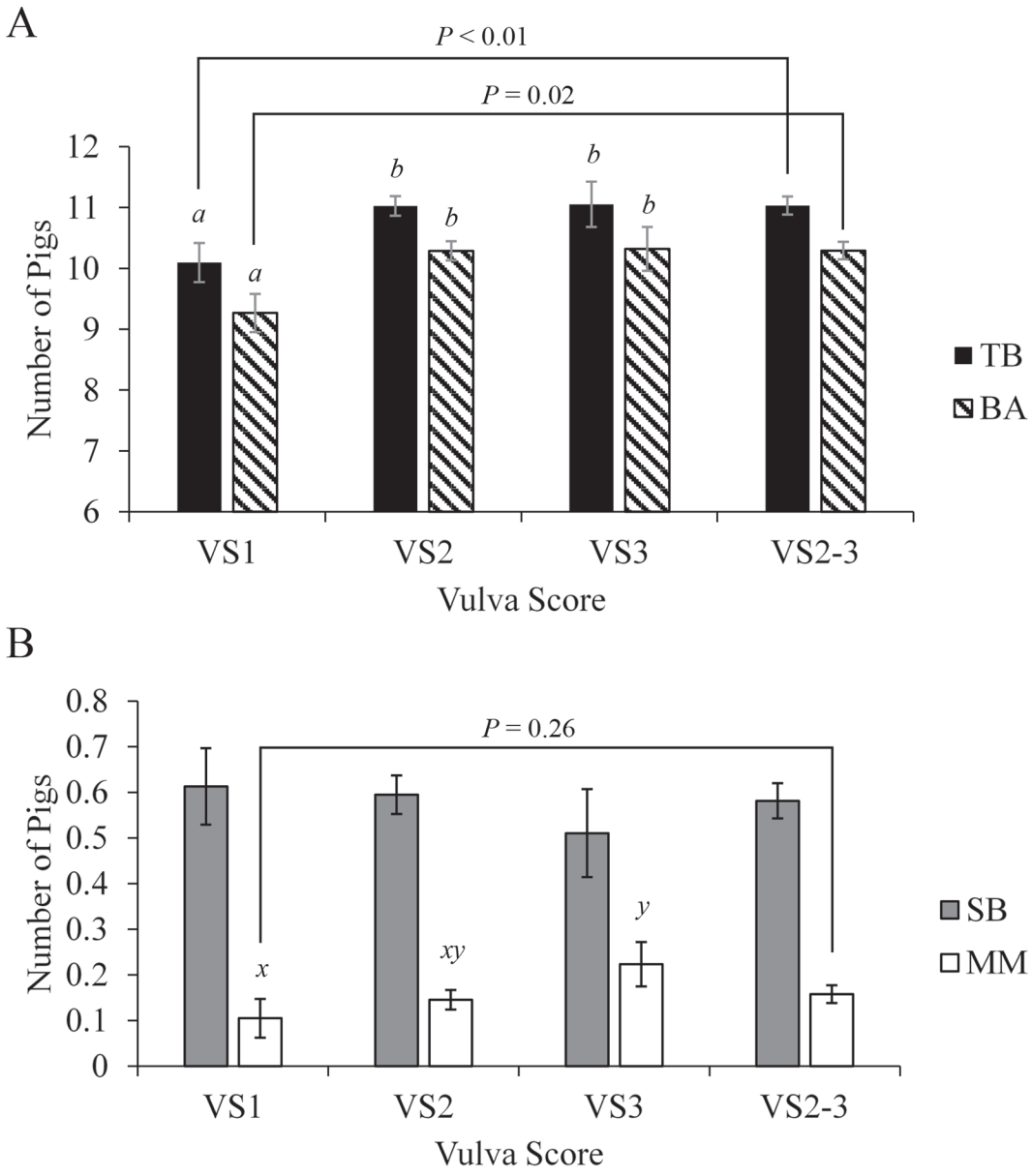

Figure 2. The effects of prepubertal vulva size classification on parity 1 (P1) litter size. Gilts were classified by visual assessment at approximately 15 wk of age. Gilts received a vulva score 1 (VS1) if subjectively estimated to be below average for vulva size. Gilts receiving a vulva score 2 (VS2) were considered average. Likewise, gilts receiving vulva score 3 (VS3) were estimated to be above average for vulva size. (A) Parity 1 total pigs born (TB) and pigs born alive (BA) were affected by vulva score ($P < 0.03$). (B) Parity 1 stillborn (SB) pigs and mummified fetuses (MM) were not affected by vulva score ($P > 0.18$). Bars, depicting LSM ± SEM, of the same color with different superscripts denote significant differences ($^{ab}P \leq 0.05$; $^{xy}P \leq 0.1$). Gilts scored VS1 had fewer TB ($P < 0.01$) and BA ($P = 0.02$) when compared with all gilts scoring average or above (VS2–3).

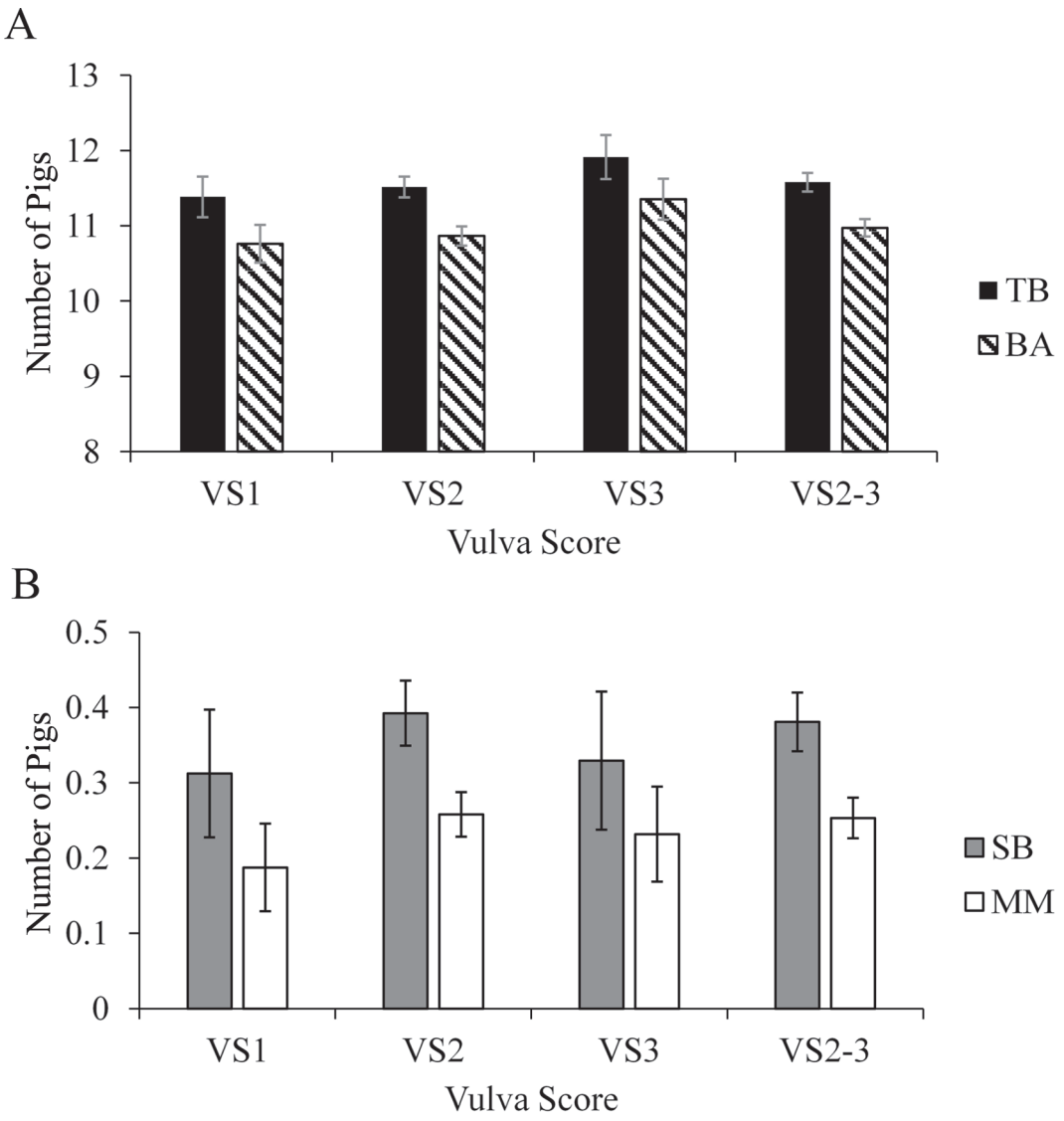

Figure 3. The effects of prepubertal vulva size classification on parity 2 (P2) litter size. Gilts were classified by visual assessment at approximately 15 wk of age. Gilts received a vulva score 1 (VS1) if subjectively estimated to be below average for vulva size. Gilts receiving a vulva score 2 (VS2) were considered average. Likewise, gilts receiving vulva score 3 (VS3) were estimated to be above average for vulva size. VS2–3 is all gilts scoring average or above. Bars depict LSM ± SEM. (A) Parity 2 total pigs born (TB) and pigs born alive (BA) were not affected by vulva score ($P > 0.21$). (B) Parity 2 stillborn (SB) pigs and mummified fetuses (MM) were not affected by vulva score ($P > 0.55$).

Prepubertal VS Affects Parity 1 Litter Size

First parity TB was affected by VS classification ($P = 0.03$), specifically TB was 0.9 pigs greater ($P \leq 0.01$) when comparing gilts from VS2 group (11.03) or the combined VS2/3 group (11.03) to gilts with a VS1 classification (10.1). When P1 TB from gilts receiving the VS1 score was compared with gilts receiving the VS3 score (11.05), a difference ($P = 0.05$) was also observed. Similarly, the P1 BA was affected by vulva score classification ($P = 0.01$), with BA from gilts assigned VS2 (10.3) and VS2/3 (10.3) being greater ($P \leq 0.01$) when compared with gilts receiving a VS1 (9.3). Gilts receiving a VS3 (10.3) had greater ($P = 0.03$) BA when compared with gilts receiving a VS1 (Figure 2A). There were no differences observed when evaluating P1 SB piglets across VS classifications ($P = 0.68$). Vulva score classification was also not a significant source of variation when evaluating P1 MM ($P = 0.18$; Figure 2B). When P2 data were evaluated, VS did not affect TB, BA, SB, or MM traits ($P > 0.21$; Figures 3A and 3B).

Effect of Prepubertal VS Classification on Total Production Through 2 Parities

Sow lifetime productivity refers to the number of quality piglets produced during a sow's productive life and is largely affected by the number of parities a sow remains in the breeding herd (Serenius and Stalder, 2006). When total production over 2 parities was assessed for gilts that

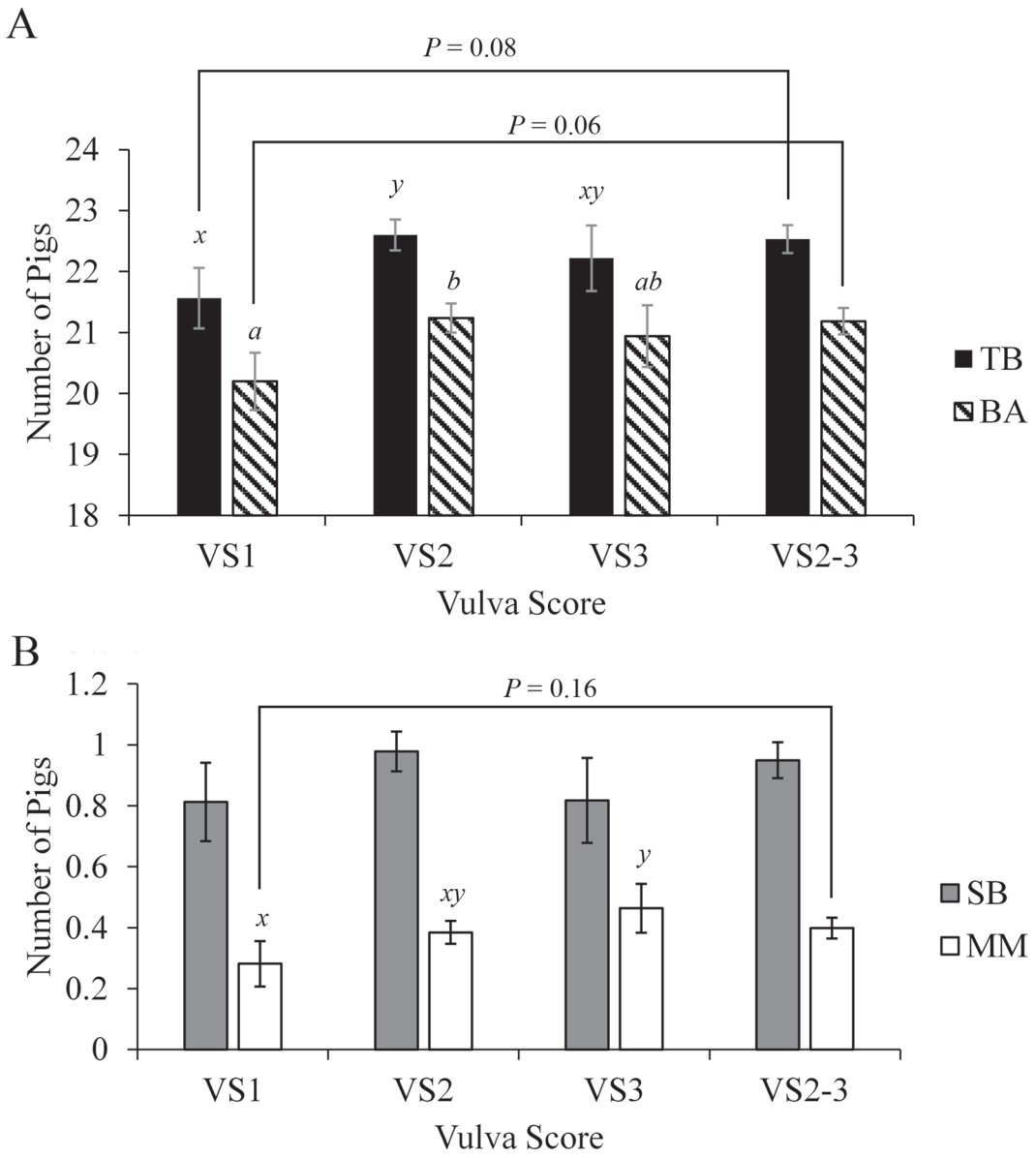

Figure 4. The effects of prepubertal vulva size classification on combined parity 1 (P1) and 2 (P2) litter performance. Gilts were classified by visual assessment at approximately 15 wk of age. Gilts received a vulva score 1 (VS1) if subjectively estimated to be below average for vulva size. Gilts receiving a vulva score 2 (VS2) were considered average. Likewise, gilts receiving vulva score 3 (VS3) were estimated to be above average for vulva size. (A) Total pigs born (TB) and pigs born alive (BA) for combined parity 1 and 2 pigs. (B) Parities 1 and 2 stillborn (SB) pigs and mummified fetuses (MM) were not significant across vulva score ($P > 0.24$). Bars depict LSM for litter parameter ± SEM. Bars with different letters are significantly different ($^{ab}P \leq 0.05$; $^{xy}P \leq 0.1$). Gilts scored VS1 tended to have fewer TB ($P = 0.08$) and BA ($P = 0.06$) when compared with all gilts scoring average or above (VS2–3).

farrowed a second litter, VS did not affect TB or BA ($P > 0.14$). However, when directly comparing VS groups, TB tended to be less ($P \leq 0.08$) in gilts assigned VS1 (21.6) compared with those in the VS2 (22.6) and VS2/3 (22.5) groups. Similarly, BA was greater ($P = 0.05$) for VS2 assigned gilts (21.2) compared with VS1 assigned gilts (20.2) through 2 parities. Additionally, BA for VS2/3 (21.2) tended to be greater ($P = 0.06$) compared with VS1 (Figure 4A). The VS classification did not affect SB ($P = 0.36$) or MM ($P = 0.24$) through 2 parities (Figure 4B).

A gilt's ability to remain productive over multiple parities is associated with the age at which she reaches reproductive maturity and is included into the breeding herd (Patterson et al., 2010; Hoge and Bates, 2011). Additionally, gilts that reach puberty at a younger age are more likely to demonstrate estrus and ovulate within 10 d after weaning their first litter (Sterning et al., 1998). In the current literature, however, the association between early reproductive-tract development and subsequent fecundity as sows is scant. Selection for increased uterine capacity has been reported to be associated with decreased embryonic loss (Bolet et al., 1986) and improved litter size over the sow's lifetime (Freking et al., 2016). This provides a potential explanation as to why litter size was associated

with difference in prepubertal vulva size in the current study. It is possible that distinguishing gilts with average or above average vulva size relative to cohort contemporaries before puberty may result in indirect selection for gilts with greater potential for larger reproductive tract development.

APPLICATIONS

The complexity and low heritability of reproductive traits associated with sow lifetime productivity make selection for this phenotypic trait difficult. The findings in this study suggest scoring or classifying gilts based on vulva size before puberty can serve as a potential strategy for selecting breeding herd replacements or identifying gilts to exclude as breeding herd replacement gilt candidates. Gilts below average for reproductive-tract development at approximately 15 wk of age, as assessed by vulva size, achieve their first 2 parities later in life and produce fewer piglets compared with their contemporaries with greater vulva size. Continued research using a subjective assessment of VS is needed to confirm the efficacy as a primary selection criterion across different genetic lines. Furthermore, the effectiveness of this approach requires reliable evaluation and scoring of gilts, which can only be accomplished by having single individuals assign scores. Otherwise, strategies to develop consistent scoring between or among evaluators is necessary if more than one person is responsible for assessing vulva size. Additionally, the fundamental biology causing the improvement in litter size and age at farrowing presents additional opportunities for research.

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LITERATURE CITED

Bolet, G., F. M. Botte, A. Locatelli, J. Gruand, M. Terqui, and F. Berthelot. 1986. Components of prolificacy in hyperprolific Large White sows compared with the Meishan and Large White breeds. Genet. Sel. Evol. 18:333–342. https://doi.org/10.1186/1297-9686-18-3-333.

Dyck, G. W., and E. E. Swierstra. 1983. Growth of the reproductive tract of the gilt from birth to puberty. Can. J. Anim. Sci. 63:81–87. https://doi.org/10.4141/cjas83-010.

Evans, A. C. O., and J. V. O'Doherty. 2001. Endocrine changes and management factors affecting puberty in gilts. Livest. Prod. Sci. 68:1–12. https://doi.org/10.1016/S0301-6226(00)00202-5.

Freking, B. A., C. A. Lents, and J. L. Vallet. 2016. Selection for uterine capacity improves lifetime productivity of sows. Anim. Reprod. Sci. 167:16–21. https://doi.org/10.1016/j.anireprosci.2016.01.018.

Graves, K. L., B. R. Mordhorst, E. C. Wright, B. J. Hale, K. J. Stalder, A. F. Keating, and J. W. Ross. 2020. Identification of measures predictive of age of puberty onset in gilts. Transl. Anim. Sci. 4:285–292. https://doi.org/10.1093/tas/txz173.

Hoge, M. D., and R. O. Bates. 2011. Developmental factors that influence sow longevity. J. Anim. Sci. 89:1238–1245. https://doi.org/10.2527/jas.2010-3175.

Koketsu, Y., H. Takahashi, and K. Akachi. 1999. Longevity, lifetime pig production and productivity, and age at first conception in a cohort of gilts observed over six years on commercial farms. J. Vet. Med. Sci. 61:1001–1005. https://doi.org/10.1292/jvms.61.1001.

Miyano, T., J. Akamatsu, S. Kato, I. Nanjo, and S. Kanda. 1990. Ovarian development in Meishan pigs. Theriogenology 33:769–775. https://doi.org/10.1016/0093-691X(90)90812-8.

Nelson, A. H., J. W. Mabry, L. L. Benyshek, and M. A. Marks. 1990. Correlated response in reproduction, growth and composition to selection in gilts for extremes in age at puberty and backfat. Livest. Prod. Sci. 24:237–247. https://doi.org/10.1016/0301-6226(90)90004-P.

Patterson, J. L., E. Beltranena, and G. R. Foxcroft. 2010. The effect of gilt age at first estrus and breeding on third estrus on sow body weight changes and long-term reproductive performance. J. Anim. Sci. 88:2500–2513. https://doi.org/10.2527/jas.2008-1756.

Romoser, M. R., B. J. Hale, J. T. Seibert, T. Gall, C. J. Rademacher, C. J. Stalder, L. H. Baumgard, A. F. Keating, and J. W. Ross. 2020. Methods for reproductive tract scoring as a tool for improving sow productivity. Transl. Anim. Sci. 4:275–284. https://doi.org/10.1093/tas/txz160.

Rydhmer, L. 2000. Genetics of sow reproduction, including puberty, oestrus, pregnancy, farrowing and lactation. Livest. Prod. Sci. 66:1–12. https://doi.org/10.1016/S0301-6226(99)00170-0.

Serenius, T., and K. J. Stalder. 2006. Selection for sow longevity. J. Anim. Sci. 84(Suppl. 13):E166–E171. https://doi.org/10.2527/2006.8413_supplE166x.

Stalder, K. J., R. C. Lacy, T. L. Cross, and G. E. Conatser. 2003. Financial impact of average parity of culled females in a breed-to-wean swine operation using replacement gilt net present value analysis. J. Swine Health Prod. 11:69–74.

Sterning, M., L. Rydhmer, and L. Eliasson-Selling. 1998. Relationships between age at puberty and interval from weaning to estrus and between estrus signs at puberty and after the first weaning in pigs. J. Anim. Sci. 76:353–359. https://doi.org/10.2527/1998.762353x.

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