UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

FACULDADE DE MEDICINA VETERINÁRIA

PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS VETERINÁRIAS

FATORES ENVOLVIDOS NO DESENVOLVIMENTO CORPORAL E DESEMPENHO REPRODUTIVO DE MATRIZES SUÍNAS

DIOGO MAGNABOSCO

PORTO ALEGRE

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Tese apresentada como requisito parcial para obtenção de grau de Doutor em Ciências Veterinárias na área de Fisiopatologia da Reprodução.

Orientador: Dr. Fernando Pandolfo Bortolozzo

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FATORES ENVOLVIDOS NO DESENVOLVIMENTO CORPORAL E DESEMPENHO REPRODUTIVO DE MATRIZES SUÍNAS

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RESUMO

FATORES ENVOLVIDOS NO DESENVOLVIMENTO CORPORAL E DESEMPENHO REPRODUTIVO DE MATRIZES SUÍNAS

Autor: Diogo Magnabosco
Orientador: Prof. Dr. Fernando Pandolfo Bortolozzo
Co-orientadores: Prof. Dr[a]. Mari Lourdes Bernardi e Prof. Dr. Ivo Wentz

A alta variabilidade no peso ao nascer de leitões e o nascimento de leitões com pesos muito inferiores a média da leitegada evidencia a restrição de crescimento intrauterino, acentuada a partir da seleção genética de matrizes suínas mais prolíferas. Esses animais desenvolvem-se de maneira inferior aos seus contemporâneos e tem aumentado os riscos de morte ou descarte, acarretando menores índices produtivos. O objetivo deste estudo foi avaliar os efeitos do desenvolvimento intrauterino no crescimento, longevidade, produtividade e desempenho reprodutivo de futuras matrizes reprodutoras suínas. Além disso, avaliar a influência do desenvolvimento corporal e sua relação com puberdade e desempenho reprodutivo. No primeiro estudo, o peso ao nascer foi dividido em oito grupos e foram determinadas as curvas de crescimento e o desempenho reprodutivo até o terceiro parto de 1495 leitoas Landrace x Large White (DanBred®). Nas leitoas que pertenciam ao grupo mais leve, ou seja, com menos de 1 kg, o potencial de crescimento foi inferior do que as leitoas do grupo mais pesado, com menor ganho de peso diário (GPD) em todas as fases avaliadas (20, 70 e 170 dias) e com menor peso aos 170 dias, momento onde foi realizada a seleção para entrada no rebanho. A mortalidade e perdas cumulativas até os 170 dias foram maiores em leitoas pesando menos de 1 kg, reduzindo a oportunidade destas de serem selecionadas como futuras matrizes. Além disso, leitoas que nasceram com peso inferior a 1 kg tiveram menor número de dias de permanência no plantel e produziram quase 4,5 leitões a menos ao longo de três partos quando comparado com os outros grupos de peso ao nascer. O segundo estudo utilizou um total de 665 leitoas Landrace x Large White (DanBred®) para avaliar os efeitos da idade e taxa de crescimento no momento de exposição ao macho e suas consequências no desempenho reprodutivo. As leitoas foram retrospectivamente classificadas em grupos de acordo com idade a exposição ao macho (140-155 e 156–170 dias) e taxa de crescimento até a exposição ao macho (Baixa: 500–575 g/d; Intermediária: 580–625 g/d; e Alta: 630–790 g/d). Leitoas expostas ao macho com 140-155 dias tiveram menor manifestação de estro (60,8 vs. 77,0%) até os 30 dias do que àquelas expostas com 156-170 dias de idade. A manifestação de estro até 30 dias após a exposição ao macho foi maior para leitoas com alto ganho de peso (74,3%) do que as de ganho de peso baixo e intermediário (65,5 and 64,3%, respectivamente). A taxa de parto e o número de leitões nascidos no primeiro parto não foram afetados pela idade e pela taxa de crescimento. Os resultados dos nossos estudos apontam para a conclusão que o peso ao nascer e o desempenho de crescimento influenciam no desempenho reprodutivo das leitoas quando adultas.

Palavras-chave: crescimento retardado intrauterino, peso ao nascer, leitões, longevidade, leitoa de reposição

ABSTRACT

FACTORS INVOLVED ON SOW BODY DEVELOPMENT AND REPRODUCTIVE PERFORMANCE.

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The high variability on piglet birth weight and the birth of piglets weighing less than 1 kg show a restriction on intrauterine growth, increased by the large litter size of hyperprolific sows. These animals develop in lower rates than its contemporaries and have increased risk of death or culling, resulting in lower productivity. The aim of this study was to evaluate the effects of intrauterine development in growth, longevity, productivity and reproductive performance of sows destined to breeding herd. In addition, was to evaluate the influence of body development and its relation with puberty and reproductive performance. On the first study, using a retrospective classification into eight classes of birth weight were determined the growth and reproductive performance until the third parity of 1,495 crossbred Landrace x Large White gilts (DanBred®). Piglets from the lower birth weight group, i.e., less than 1 kg, had poorer growth performance when compared with the higher class, with lower body weight and average daily weight gain in all stages of development evaluated. Mortality and cumulative losses until 170 days of life were greater on piglets weighing less than 1 kg at birth, reducing the opportunity for their selection as future breeders. Furthermore, sows born weighing less than 1 kg had lower number of days in the breeding herd and produced almost 4.5 less piglets along three parities than the other gilts. A second study used a total of 665 Landrace x Large White gilts (DanBred®) to evaluate the effects of age and growth rate until the onset of boar exposure on first oestrus manifestation and reproductive performance. Gilts were retrospectively classified in groups according to their age at boar exposure (140-155 and 156–170 days) and into classes according to their growth rate from birth to boar exposure (Low: 500–575 g/d; Intermediate: 580–625 g/d; and High: 630–790 g/d). Gilts exposed to boar at 140-155 days had lower oestrus manifestation (60.8 vs. 77.0%) within 30 days than those exposed at 156-170 days of age. Lower percentages of gilts in oestrus within 30 days after boar exposure were observed in Low and Intermediate growth rate gilts (65.5 and 64.3%) than in High growth rate gilts (74.3%). Farrowing rate and number of total born litter size were affected neither by age or growth rate at onset of boar exposure. The results of our studies point to the conclusion that the birth weight and the developmental performance have influence on the reproductive performance of gilts as sows.

Keywords: *intrauterine growth retardation, birth weight, piglets, longevity, replacement gilt.*

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1. INTRODUÇÃO

A evolução genética, que levou ao aumento no número de leitões nascidos, carrega consigo a consequência de aumentar a variabilidade de peso ao nascer e também o percentual de leitões pequenos dentro da mesma leitegada (QUINIOU et al., 2002; WOLF et al., 2008; FIX et al., 2010). O aumento de lotação uterina gera progênies com a presença de leitões que sofreram restrição de crescimento intrauterino, evidenciado com o nascimento de leitões com pesos muito inferiores a média da leitegada (WU et al., 2006). Esses animais desenvolvem-se de maneira inferior aos seus contemporâneos e tem aumentado os riscos de morte ou descarte, acarretando menores índices produtivos (FIX et al., 2010; ALVARENGA et al., 2012; ALMEIDA et al., 2014). Somado a isso, a taxa de crescimento e desenvolvimento corporal podem afetar a eficiência produtiva da futura matriz (AMARAL FILHA et al., 2009; KUMMER et al., 2009).

A dimensão da importância da leitoa pode ser visualizada no exemplo do plantel de matrizes do Brasil, que apresenta um efetivo de aproximadamente 1,7 milhões de matrizes alojadas em granjas tecnificadas (ABIPECS, 2013) e uma necessidade de introdução de 850 a 950 mil marrãs por ano, devido às altas taxas de reposição anual (35 a 50%). Estima-se que para alcançar esse número de fêmeas na reposição é necessária a disponibilização de uma população anual de 1,6-1,7 milhões de leitoas ao nascer. Além disso, é evidente o aumento dos índices de produtividade do rebanho brasileiro, atingindo médias de aproximadamente 27 leitões desmamados/fêmea/ano. Esses resultados são reflexos de altos índices de leitões nascidos por parto, oriundos de fêmeas hiperprolíferas, que alcançam mais de 13 leitões nascidos em média e superam 15 leitões nas granjas consideradas como as mais produtivas do país (AGRINESS, 2014).

Com isso, existe a necessidade de estabelecer possíveis critérios técnicos que nos permitam identificar precocemente matrizes que tenham maior chance de apresentar um comprometimento no desempenho reprodutivo subsequente. Se de fato futuras reprodutoras que nasceram com baixo peso tiverem comprometimento futuro, elas poderiam ser identificadas ao nascimento e receberem outro destino. Estudos que esclareçam a importância do peso ao nascer e sua relação com o desempenho como futuras matrizes são escassos.

O objetivo deste estudo foi avaliar os efeitos do desenvolvimento intrauterino, evidenciados com o peso ao nascimento, no crescimento, longevidade e desempenho reprodutivo de futuras matrizes reprodutoras suínas. Para tanto, dois estudos foram realizados. O Estudo 1, intitulado “Efeito do peso ao nascer e tamanho de leitegada no desempenho reprodutivo e longevidade de fêmeas suínas Landrace x Large White (DB 25 ® DB DanBred)”, englobou a avaliação de 1495 leitoas que foram pesadas e selecionadas ao nascer e acompanhadas durante toda a vida produtiva até atingir o terceiro parto. Deste projeto, dois artigos foram produzidos e estão contemplados nesta tese como: Capítulo II - Primeiro artigo científico (“Impact of the Birth Weight of Landrace x Large White Dam Line Gilts on Mortality, Culling and Growth Performance until Selection for Breeding Herd”) e Capítulo III - Segundo artigo científico (“Low birth weight affects lifetime productive performance and longevity of swine females”). Um segundo estudo, intitulado “Influência da taxa de crescimento de leitoas Landrace x Large White (DB 25® - DB DanBred®) no desempenho reprodutivo” gerou a publicação do artigo “Effects of age and growth rate at onset of boar exposure on oestrus manifestation and first farrowing performance of Landrace x Large White gilts“, contemplado nesta tese como o Capítulo IV - Terceiro artigo científico.

2. CAPÍTULO I - REVISÃO BIBLIOGRÁFICA

2.1 O ambiente uterino e as consequências na vida adulta – Bases fisiológicas

2.1.1 Desenvolvimento embrionário e fetal

O desenvolvimento embrionário é considerado como uma etapa de rápida multiplicação celular, com diversas alterações na forma do embrião até sua fixação ao útero. O embrião suíno entra no útero no estágio de quatro células, aproximadamente dois dias após a ovulação. Uma rápida multiplicação de células pode ser observada no estágio de clivagem e mórula, até atingir a fase de blastocisto, que ocorre aos 4-5 dias de gestação. No estágio de blastocisto, que vai até 12 dias de gestação, ocorre a migração dos embriões pelo lúmen uterino. Numa última etapa, ocorre o alongamento dos embriões, início da adesão ao útero, fixação, sinalização de gestação (12 até 15 dias de gestação) e adesão placentária. Após fixos, os embriões determinam e delimitam o próprio espaço no útero. A disposição no lúmen uterino é modulada pelo número de embriões presentes, influenciando o maior ou menor desenvolvimento destes, sendo que quando implantados os embriões permanecem equidistantes em toda extensão do útero (DZIUK, 1985).

Entre 19-26 dias o saco alantóico é estabelecido e o processo de formação da placenta se inicia, desenvolvendo-se até o nascimento. A placenta suína é epiteliocorial, difusa, não decidual e possui vilos/vilosidades para a comunicação do córion da placenta com o endométrio (VEJLSTED, 2009). Aproximadamente aos 35 dias de gestação, a formação de órgãos e membros locomotores está completa e então se inicia a fase de deposição cálcica nos ossos, determinando a mudança de fase embrionária para fase fetal (MEREDITH, 1995). Durante esta fase a grande maioria dos tecidos estruturais primários é formada e os órgãos são diferenciados (FORD et al., 2002).

A fase final da formação fetal pode ser considerada como fase hipertrófica, onde os tecidos e órgãos formados primariamente aumentam de tamanho de forma exponencial (MCPHERSON et al., 2004). O crescimento fetal é acelerado durante o terço final da gestação, com taxas de crescimento individual e da leitegada de 4,1 g/d e 45,3 g/d, respectivamente, na fase inicial da gestação (até 69 dias) e de 29,6 g/d e 310,5 g/d na fase final (JI et al., 2005). O ganho de peso pós-natal dos suínos está relacionado à hipertrofia das fibras musculares, cujo número total está definido aos 90 dias de gestação (WIGMORE & STICKLAND, 1983).

2.1.2 Formação de órgãos e músculos

A formação e diferenciação de alguns tecidos já estão estabelecidas pela literatura. Em razão do interesse no desempenho futuro dos leitões, serão descritos mais detalhadamente a organogênese do sistema muscular e do sistema reprodutivo. Os eventos cronológicos do desenvolvimento fetal intrauterino da fêmea suína estão ilustrados na Figura 1.

Miogênese:

A massa muscular total do animal é determinada pelo número e tamanho das fibras musculares (REHFELDT et al., 2000). Os princípios do crescimento do músculo esquelético envolvem eventos de formação propriamente dita e ganho estrutural. No desenvolvimento pré-natal, as fibras musculares se originam de duas populações distintas. As fibras formadas durante os estágios iniciais de fusão dos mioblastos são denominadas de fibras musculares primárias e formam os miotubos primários, entre os dias 35 e 50 de gestação. A formação primária proporciona a base para o desenvolvimento de uma população de fibras menores, presentes em maior quantidade, chamadas de miofibras secundárias. Essa segunda geração de miotubos desenvolve-se entre os dias 50 a 90-95 de gestação, originando a massa muscular total do animal. Considera-se que o número total de fibras musculares está definido aos 90-95 dias, seguindo posteriormente com a hipertrofia e maturação, que ocorrem no terço final da gestação e no desenvolvimento pós-natal (WIGMORE & STICKLAND, 1983).

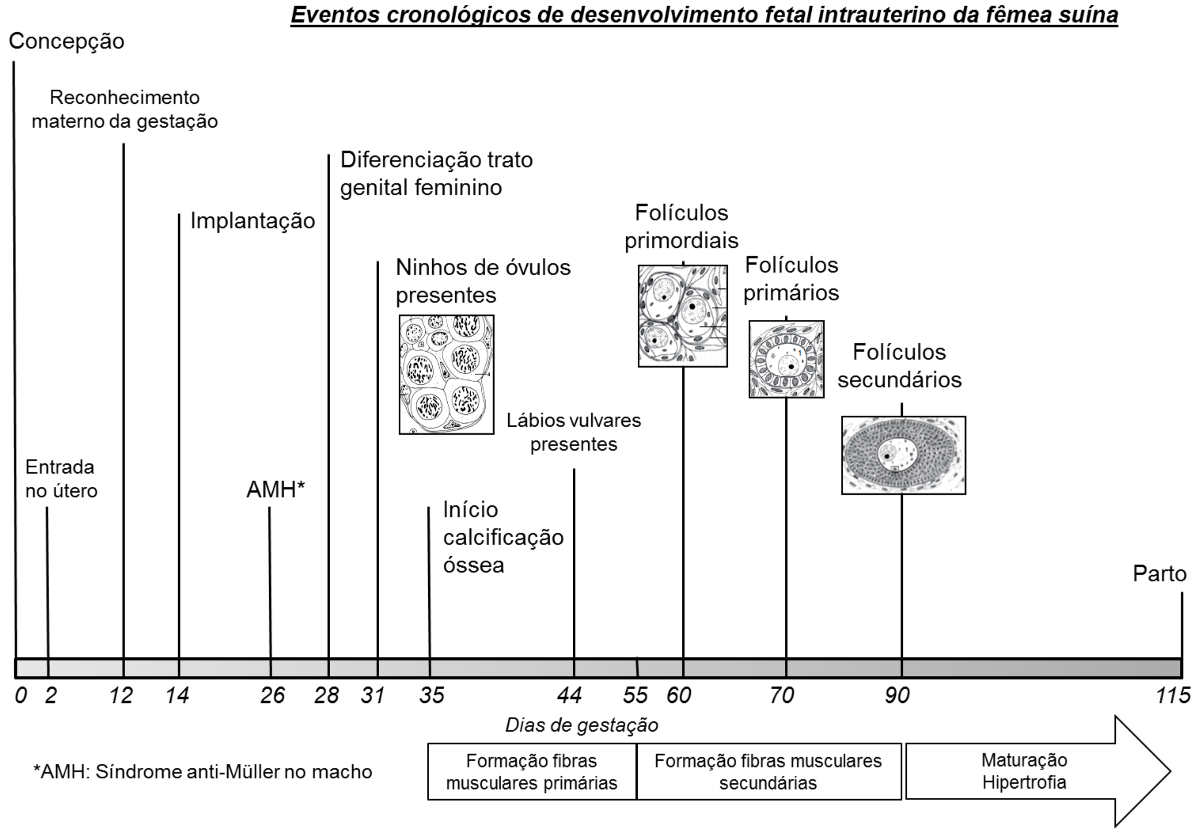

FIGURA 1: Eventos cronológicos de desenvolvimento fetal intrauterino da fêmea suína (adaptado de WIGMORE & STICKLAND, 1983; MEREDITH, 1995; HYTTEL, 2009).

Sistema reprodutivo:

A determinação genética do sexo é influenciada pela presença do gene *SRY* (fator de determinação testicular) do cromossomo Y. O fenótipo sexual no embrião não é aparente até quatro semanas de desenvolvimento, estágio de indiferença do desenvolvimento gonadal, estando presente somente o tubérculo genital e as células germinativas primordiais (SINOWATZ, 2009). Nos machos, aproximadamente aos 26 dias de gestação, as células de Sertoli embrionárias produzem e liberam o hormônio anti-Mülleriano (AMH ou MIS, *Müllerian inhibiting substance*), agindo localmente e induzindo a regressão dos ductos de Müller e inibindo a ação da aromatase, determinando o desenvolvimento das gônadas masculinas. Em fêmeas, a expressão do gene *DAX-1* suprime a formação dos testículos e permite às gônadas indiferentes se desenvolverem como ovários. A ausência do AMH permite que o ducto Mülleriano se desenvolva como as maiores estruturas do trato reprodutivo feminino, formando as tubas uterinas, útero, cérvix e vagina. Ao nascimento, o útero suíno consiste em uma estrutura simples/rudimentar/primária e a maturidade uterina só é atingida a partir do dia 120 pós-natal (SPENCER et al., 2005). As células germinativas primordiais iniciam a diferenciação das estruturas do trato genital feminino a partir dos 28 dias de gestação. A diferenciação da gônada fetal para ovário ocorre próximo ao dia 35 de gestação pelo aparecimento dos ninhos de ovos (oogônias). Folículos primários são observados ao redor de 70 dias e folículos secundários aparecem no final da gestação, próximo dos 90 dias (OXENDER et al., 1979). Células secretoras de FSH são identificadas em fetos com 70 dias de idade e os níveis de FSH, LH e prolactina aumentam próximos ao nascimento (SQUIRES, 2003). O número de oócitos é definitivo ao nascimento, sendo estes recrutados em número de 100-150 a cada ciclo estral (SOEDE et al., 2011).

2.1.3 Programação pré-natal

O adequado desenvolvimento intrauterino do feto suíno é determinante no seu desempenho pós-natal, sendo influenciado principalmente pelo ambiente e pela nutrição ao qual o concepto está submetido (LANGLEY-EVANS, 2006). A programação pré-natal é quem determina características de desenvolvimento de órgãos e tecidos, em decorrência de alterações na expressão do genoma fetal e gerando efeitos permanentes sobre a estrutura, metabolismo e fisiologia do animal. O desenvolvimento do concepto, desde o momento da fecundação, irá determinar características como peso ao nascer dos leitões e as consequências estabelecidas durante a vida pré-natal serão contínuas durante toda a vida do animal (BARKER & CLARK, 1997; FOXCROFT & TOWN, 2004).

A programação fetal é bastante evidente em mamíferos, afetando diversas espécies animais, inclusive humanos. Estudos epidemiológicos de ocorrência de doenças e síndromes metabólicas que se relacionam com a programação e formação fetal foram revelados por Barker, gerando a chamada hipótese de Barker ou a “origem fetal da doença do adulto”. Os resultados demonstraram que o inadequado desenvolvimento intrauterino aumentou os riscos de doenças coronárias, obesidade, disfunções renais e diabetes na vida adulta (BARKER & OSMOND, 1986; BARKER & CLARK, 1997; BARKER et al., 2005). Essa associação de programação fetal e consequências metabólicas e de desenvolvimento também é amplamente estudada em animais, podendo ser vista em trabalhos envolvendo ratos, cabras, ovelhas, vacas, porcas, éguas, entre outros (RHIND et al., 2001). A revisão realizada por Rhind et al. (2001) reporta evidências de que a restrição nutricional pode afetar o desenvolvimento do eixo hipotalâmico-pituitário-gonadal e, consequentemente, a síntese de gonadotrofinas na vida adulta. A programação fetal fica evidente, segundo os mesmos, quando os fatores ambientais, particularmente durante o desenvolvimento gonadal, podem alterar a atividade gênica e influenciar a vida adulta, mas também podem determinar alterações gênicas na geração subsequente, conforme o modelo Lamarckiano. Os estudos são direcionados principalmente às consequências de um baixo desenvolvimento fetal, caracterizado como um retardo no crescimento intrauterino.

2.1.4 Crescimento retardado intrauterino (*IUGR – Intrauterine Growth Retardation*)

O insuficiente desenvolvimento dos fetos durante a gestação pode dar a definição ao *IUGR*. Em revisão realizada por Ashworth et al. (2001), os autores definiram que o conceito de retardo no crescimento inclui:

- Fetos ou neonatos pesando menos do que dois desvios padrões da média de peso corporal na idade gestacional analisada;
- Fetos que representam os 10% mais leves da leitegada;
- O menor de cada leitegada;
- Aqueles que pesam menos do que dois terços da média de peso dos fetos do mesmo corno uterino;
- Fetos com baixo desenvolvimento localizados no meio do corno uterino;
- Aqueles que são considerados *outliers* dentro da população onde eles são gerados.

Trabalhos recentes utilizaram uma escala morfológica baseados no formato da cabeça dos leitões ao nascimento para caracterizar o grau de retardo de crescimento (AMDI et al., 2013; HALES et al., 2013). Os autores utilizaram três critérios para caracterizar crescimento retardado (Figura 2):

1. Cabeça íngreme, tipo testa de golfinho;
2. Olhos esbugalhados;
3. Rugas/dobras perpendiculares com a boca.

A partir disso, foi determinada a classificação em razão do número de características presentes no mesmo animal. Quando todas as características estavam presentes (grau 3), o leitão apresentava *IUGR* severa. Se uma ou duas presentes (grau 2), *IUGR* leve. Se nenhuma das características estivesse presente, o leitão era considerado normal (grau 1).

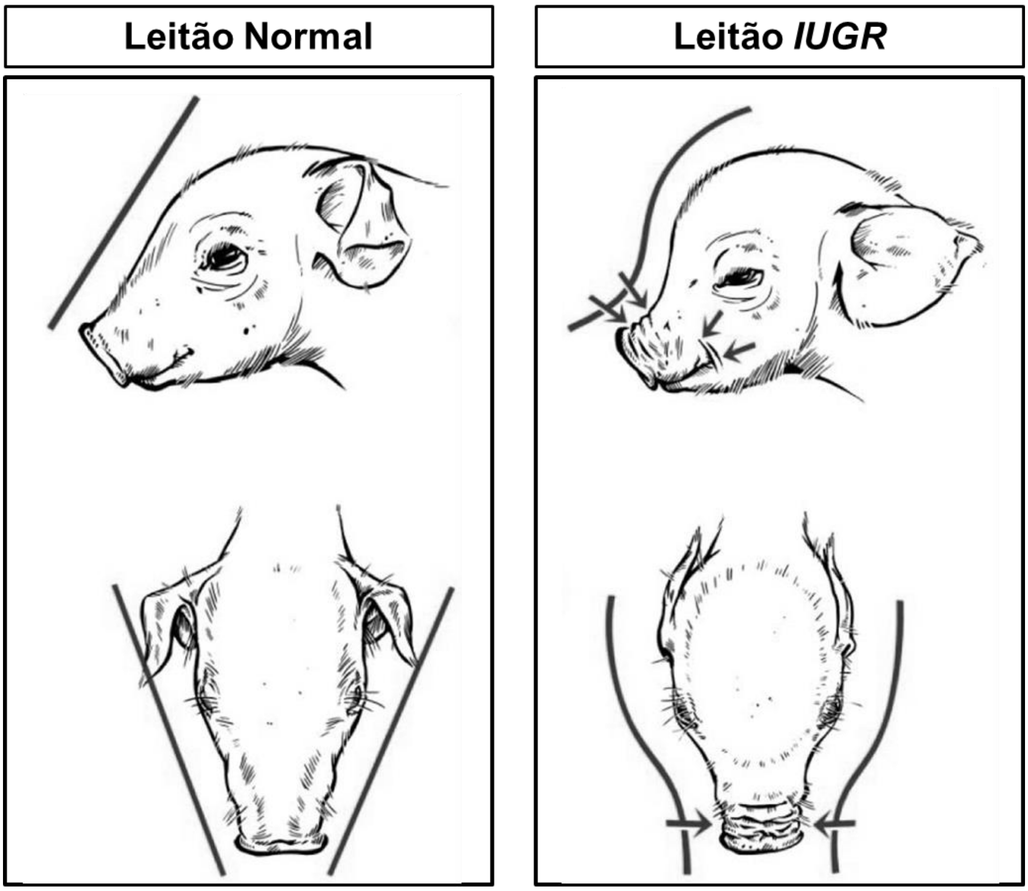

FIGURA 2: Desenhos ilustrativos de leitões normais e com retardo de crescimento intrauterino (*IUGR - Intrauterine Growth Retardation*). Desenho adaptado de Hales et al. (2013), em que os autores definem como critérios do retardo de crescimento a presença de: 1. Cabeça íngreme, tipo testa de golfinho; 2. Olhos esbugalhados; 3. Rugas/dobras perpendiculares com a boca.

A ocorrência de fetos com *IUGR* pode ser considerada natural e endêmica (WU et al., 2006), sendo que os processos que induzem ao retardo são bem documentados em animais de produção (vacas, cabras, éguas, porcas e ovelhas). De acordo com Wu et al. (2006), além da influência genética, o crescimento e desenvolvimento fetal são afetados por fatores ambientais tais como a nutrição materna (baixo ou alto consumo de alimento, desbalanço nutricional), ingestão de substâncias tóxicas, variações de temperatura ambiental ocasionando estresse, distúrbios nos mecanismos homeostáticos e metabólicos maternos e fetais, entre outros. As possíveis causas envolvidas em um processo de retardo no crescimento são detalhadas na Tabela 1.

O crescimento retardado pode ser visualizado em fetos e neonatos em padrões distintos, nos quais um crescimento mais lento que o normal, porém constante, caracteriza um padrão simétrico. Entretanto a forma mais explorada é a ocorrência do desenvolvimento assimétrico dos órgãos, onde o cérebro tem desenvolvimento normal enquanto o crescimento do fígado, baço, coração, pulmões e tecidos somáticos são afetados (ASHWORTH et al., 2001, WU et al., 2006; ALVARENGA et al., 2012). Esse fenômeno em que o crescimento do cérebro é relativamente preservado em relação aos demais órgãos é conhecido como "*brain sparing*" (efeito de poupar o cérebro). Pela praticidade na medição, o peso fetal e o peso ao nascimento são frequentemente utilizados como critério para detectar *IUGR* (WU et al., 2006). Diversos estudos utilizaram a relação entre o peso do cérebro e o peso do fígado como uma medida efetiva de ocorrência de *IUGR* (TOWN et al., 2005; ALVARENGA et al., 2012). Estima-se que aproximadamente 15 a 20% dos leitões nascem com peso inferior a 1,1 kg (WU et al., 2006) e estes leitões são potencialmente mais propensos ao *IUGR*.

TABELA 1: Principais causas envolvidas com a ocorrência de retardo no crescimento intrauterino (*IUGR - Intrauterine Growth Retardation*) de leitões.

Causas	**Detalhamento**	**Referências**
Genótipo	Diferenças na formação, tamanho e vascularização placentária podem influenciar no desenvolvimento do concepto. O efeito do genótipo pode ser visualizado, por exemplo, em linhagens como Meishan, que apresenta maior eficiência placentária.	ASHWORTH et al., 1990 VONNAHME et al., 2002 VALLET et al., 2003
Nutrição materna	Restrições nutricionais quantitativas e qualitativas durante todo o período gestacional podem gerar atrasos no desenvolvimento dos conceptos.	REHFELDT et al., 2004 METGES et al., 2012
Tamanho da leitegada e capacidade uterina	Relação do número de leitões e peso podem levar à superlotação uterina que extrapola a capacidade do útero.	FORD et al., 2002 VALLET et al., 2011 PARDO et al., 2013
Transporte de nutrientes na placenta	A eficiência com que a placenta transporta nutrientes e oxigênio para o feto é determinada pela sua área de contato com a parede uterina e pelo fluxo sanguíneo materno fetal.	REYNOLDS & REDMER, 2001 WU et al., 2006 ØSTRUP et al., 2011

As consequências do retardo intrauterino vão além das diferenças morfológicas encontradas nos leitões ao nascimento. O potencial de crescimento e interferência na reprodução será discutido posteriormente. Muitos são os relatos de diferenciação do sistema imunitário em decorrência de alterações sofridas durante a vida intrauterina. Wang et al. (2008) demonstraram que o *IUGR* diminuiu os níveis de proteínas que regulam a função imunológica, defesas oxidativas, metabolismo intermediário, síntese proteica e crescimento tecidual. Na mesma linha, Zhong et al. (2012) relataram que a proliferação de linfócitos sanguíneos periféricos e a concentração de citocinas que determinam a função imunológica foi menor em leitões *IUGR*. Somados às depleções no desenvolvimento de órgãos, os relatos são claros em relação aos prejuízos que ocorrem na vida adulta de mamíferos com desenvolvimento intrauterino inadequado. E em suínos, a ocorrência de *IUGR* é acentuada em decorrência do aumento do número de fetos no ambiente uterino, o que será discutido na sequência.

2.1.5 Superlotação uterina e peso ao nascer

A causa mais estudada de crescimento retardado dos leitões está relacionada à lotação uterina e ao desenvolvimento dos conceptos. A capacidade uterina foi definida como o número de fetos vivos que poderiam ser mantidos pelo útero durante a gestação (VALLET et al., 2011). Quiniou et al. (2002) relataram a clara relação de associação negativa do tamanho da leitegada com o peso ao nascer, em que o aumento do tamanho da leitegada de menos de 11 nascidos totais para mais de 16 resultou na redução do peso ao nascer de 1.590 g para 1.260 g, ou seja, 35 g por leitão nascido. Além disso, a proporção de leitões pesando menos do que 1 kg aumentou de sete para 23%.

De acordo com Ford et al. (2002), as limitações da capacidade uterina começam no início da gestação, aproximadamente no período de alongamento do embrião, nos dias 11-13. O desenvolvimento do embrião influencia de maneira decisiva a sobrevivência embrionária durante o período de peri-implantação (por volta do dia 18), que é considerado o mais crítico e pode contabilizar 20-30% das perdas gestacionais (POPE, 1994). A capacidade uterina começa a afetar de forma sensível o tamanho da leitegada após os 30 dias de gestação, quando uma real competição por espaços uterinos e nutrientes pelos conceptos começa a ocorrer de forma crítica. As perdas entre 30-40 dias de gestação podem representar 15-20% das perdas totais (FORD et al., 2002).

Antes dos 35 dias de gestação os embriões são distribuídos uniformemente pelos cornos uterinos, entretanto a competição por espaço uterino após essa data pode influenciar o desenvolvimento placentário e dos conceptos. Em estudo realizado por Vallet et al. (2011), os autores acessaram o útero através de laparotomia, aos 35 dias de gestação, e um ou dois fetos foram manualmente esmagados contra a parede uterina para criar espaços vazios dentro do útero. Ao abate, os autores observaram que o peso dos fetos, peso das placentas e crescimento das placentas adjacentes ao espaço vazio que se criou pelos fetos esmagados foram maiores em relação àqueles que ficaram próximos a outros conceptos.

Segundo Foxcroft & Town (2004), dois mecanismos estão ligados ao baixo desenvolvimento, morte dos conceptos e competição uterina. O primeiro tem a ver com a seleção dos embriões (sobrevivência), que pode ser resultado da competição dos mesmos por algum fator bioquímico necessário para seu correto desenvolvimento. O segundo está relacionado com a competição intrauterina por adequada superfície para as trocas de nutrientes da mãe com o concepto. A placenta do suíno, epiteliocorial e difusa, requer um adequado espaço de superfície para realizar as trocas nutricionais concepto-maternais. Entre os dias 20-30 de gestação há um rápido aumento do tamanho da placenta, que diminui assintomaticamente, mantendo um platô até 70 dias e aumentando novamente depois dos 100 dias (FORD et al., 2002). O peso da placenta é positivamente correlacionado ao peso embrionário e fetal (TOWN et al., 2005), entretanto a eficiência placentária é a característica mais desejada, especialmente em leitegadas numerosas. Quanto mais eficiente é a placenta, menor o peso necessário desta para que as trocas sejam bem efetuadas, possibilitando aos conceptos um crescimento mais adequado mesmo em um ambiente superlotado, diminuindo as limitações advindas da capacidade uterina (VONNAHME et al., 2002; VALLET et al., 2011). A eficiência placentária pode ser calculada através da relação do peso do embrião/feto dividido pelo peso da placenta correspondente (TOWN et al., 2005).

2.2 Peso ao nascer e desempenho durante a vida

O peso ao nascimento é determinante para a sobrevivência dos leitões, mas também para o potencial de crescimento durante a vida. Tão importante quanto aumentar o peso médio ao nascimento para a sobrevivência dos leitões é gerar uniformidade no peso ao nascimento dentro da leitegada. O baixo peso e a alta variabilidade entre lotes podem ser considerados como os principais fatores de mortalidade dos leitões, além de variabilidade posterior dos lotes pós-desmame, acarretando em dificuldades de manejos e riscos sanitários (FIX et al., 2010).

2.2.1 Potencial de crescimento e mortalidade

O baixo peso ao nascimento (< 1,0 kg) é particularmente um risco de mortalidade neonatal, sendo que o momento mais crítico são as primeiras 72 horas de vida dos leitões, podendo representar percentualmente índices superiores a todo o restante do ciclo do suíno até o abate (QUINIOU et al., 2002; FURTADO et al., 2012). Isto é fisiologicamente comprovado em termos de reservas de energia e susceptibilidade ao frio, além de ser uma desvantagem na competição por alimento com leitões maiores (PANZARDI et al., 2013).

Além disso, o impacto do peso ao nascimento gera diferenças nos pesos das fases subsequentes de desenvolvimento. As diferenças ao nascer são multiplicadas no decorrer da vida em um fenômeno conhecido como efeito multiplicador dos pesos, no qual diferenças de 1 kg ao nascer podem representar até mais de 10 kg ao abate (ALVARENGA et al., 2012; MAGNABOSCO et al., 2015, dados não publicados).

Os estudos mais atuais a respeito da relação de peso ao nascer e desempenho de crescimento e mortalidades exploram análises de grandes lotes em condições comerciais (QUINIOU et al., 2002; FIX et al., 2010; HALES et al., 2013), experimentos que envolvem o abate e análises complementares de qualidade de carcaça (FIX et al., 2010; ALVARENGA et al., 2012) e monitoramento de índices fisiológicos que possibilitem determinar características que são importantes para a sobrevivência dos leitões (PANZARDI et al., 2013). A Tabela 2 a seguir agrupa diversos trabalhos que demonstraram a influência do desenvolvimento intrauterino e/ou do peso ao nascer sobre o desempenho produtivo e taxas de mortalidade de leitões.

A maior chance de sobrevivência dos leitões pode estar ligada a mais de um fator, relativo a ele mesmo, mas também ao ambiente. A avaliação do conteúdo estomacal dos leitões que morreram por diferentes causas, mostrou que 48% dos leitões que morreram entre o nascimento e o desmame não tinham leite no estômago e que apenas 5% tinham o estômago cheio (HALES et al., 2013). A proporção de leitões que morreram com o estômago completamente vazio foi maior nos dias zero e um do que no restante da lactação (64% vs. 28%). Amdi et al. (2013) relataram que o consumo de colostro foi fortemente influenciado pelo escore de *IUGR*. Leitões normais tiveram um maior consumo de colostro nas primeiras 24 horas de vida do que leitões com severo *IUGR*. Em função disso, os níveis de glicose plasmática foram menores e os de lactato maiores em leitões com severo *IUGR* em comparação aos leitões normais e com moderado *IUGR*, impactando na sobrevivência dos mesmos.

TABELA 2: Estudos avaliando o impacto do peso ao nascer no desempenho produtivo e mortalidade ao longo da produção de suínos.

Autores	**Fatores avaliados**	**Número Animais**	**Linhagem Genética**	**Local do Estudo**	**Tipo de Avaliação**	**Resultados de Crescimento**	**Resultados de Mortalidade**
MILLIGAN et al. (2002)	Peso ao nascer e variação no peso ao nascer	416	Y e YxL	Canadá	Avaliação da taxa de sobrevivência e ganho de peso de leitegadas por oito partos consecutivos	Maior variação de peso ao nascer foi associada com maior variação no peso ao desmame.	A alta variação de peso contribui para reduzir a sobrevivência dos leitões. Leitões de baixo peso tiveram menores taxas de sobrevivência.
QUINIOU et al. (2002)	Peso ao nascer e tamanho leitegada	12 mil	(LxLW) x (LxPietrain)	França	Avaliação de desenvolvimento de animais de terminação	Maior peso ao nascer representou maior GPD na lactação, desmame e creche. Leitões que nasceram mais pesados foram mais pesados ao abate.	Taxa de sobrevivência foi menor nos leitões de baixo peso.
FIX et al. (2010)	Peso ao nascer	5,7 mil	(LxLW) x Duroc	EUA	Avaliação de desenvolvimento de animais de terminação	Maior peso ao nascer representou maior GPD, peso e maior área de músculo.	-
ALVARENGA et al. (2012)	Peso ao nascer	280	DanBred® x PIC®	Brasil	Avaliação de desempenho de animais de terminação, com o abate e medição da qualidade de carcaça.	Leitões de baixo peso ao nascer apresentaram menor desempenho pós-natal, diferenças na composição muscular e menor tamanho de mucosa do intestino delgado.	-
FURTADO et al. (2012)	Peso ao nascer	2 mil	Camborough (PIC®)	Brasil	Avaliação do peso e lesões sobre a sobrevivência e desempenho até o desmame	Leitões com baixo peso tiveram pior desempenho comparado aos de alto peso.	Leitões com peso inferior a 1200 g: maior mortalidade que os pesados. Lesões não comprometeram as taxas de mortalidade.
HALES et al. (2013)	Massa corporal e peso ao nascer	3,4 mil	L x Y	Dinamarca	Avaliação de sobrevivência e desempenho de crescimento até desmame	Peso ao nascer influenciou no GPD até o desmame.	Leitões com maior peso ao nascer tem maior chance de sobrevivência. O índice de massa corporal foi mais eficiente para explicar as diferenças de sobrevivência.
PANZARDI et al. (2013)	Peso nascer	612	Camborough (PIC®)	Brasil	Avaliação de sobrevivência na primeira semana de vida e desenvolvimento até o desmame.	GPD é comprometido em leitões com baixo peso ao nascer.	Maior risco de mortalidade para leitões com peso abaixo de 1275 g.
ALMEIDA et al. (2014)	Peso ao nascer e tamanho da leitegada	1,5 mil	Landrace	Brasil	Avaliação de leitoas de reposição, com a análise do desempenho até o momento da seleção e puberdade.	GPD e peso no desmame, creche e recria foram maiores quanto maior o peso ao nascer.	Risco de morte foi maior para leitoas com baixo peso ao nascer. O risco de não ser selecionada foi maior para leitoas com baixo peso ao nascer.

Y: Yorkshire; L: Landrace; LW: Large White.

2.2.2 Peso, taxa de crescimento e desempenho reprodutivo.

A busca por respostas da influência pré-natal no desempenho futuro de animais destinados à reprodução aumentou o número de estudos na área. Os indícios apontam que o macho suíno é mais influenciado no desempenho reprodutivo quando adulto do que a fêmea (ALMEIDA et al., 2013; SMIT et al., 2013). Entretanto novos estudos tem tentado elucidar a influência da vida pré-natal no desempenho de leitoas destinadas ao plantel reprodutivo de suínos.

É sabido que em fêmeas mamíferas, a população de oócitos já está definida ao nascimento (HYTTEL, 2009) e que, dessa forma, o desenvolvimento dos gametas durante a vida intrauterina tem papel de destaque para o desempenho pós-natal. Em suínos estima-se que aproximadamente 491 mil oogônias e/ou oócitos estejam presentes nos ovários dos fetos em formação aos 110 dias de gestação (HYTTEL, 2009). Ao serem envoltos por células foliculares achatadas, os oócitos formam os folículos primordiais, que constituem o pool de folículos quiescentes do qual as fêmeas irão recrutar folículos para o crescimento e ovulação pelo resto da vida reprodutiva. Essa população é recrutada durante a vida sexual ativa, podendo ser determinante para a longevidade ou desempenho reprodutivo (SOEDE et al., 2011). É importante enfatizar que a grande maioria dos folículos que entram em processo de crescimento falha em atingir o objetivo final, sendo degenerados através de processo de atresia e uma pequena minoria completa o crescimento até atingir a ovulação (HYTTEL, 2009).

Baseando-se nisso, Da Silva-Buttkus et al. (2003) avaliaram os efeitos do ambiente uterino superlotado e da ocorrência de crescimento retardado intrauterino em leitoas oriundas da mesma leitegada na formação ovariana e na população folicular desses ovários. Leitoas com *IUGR* (peso médio 0,73 kg) tiveram maior número de folículos primordiais, menor número de folículos primários e não tiveram folículos secundários, diferindo das leitoas com maior peso ao nascimento (peso médio 1,53 kg). Esses achados indicaram que o *IUGR* diminui o desenvolvimento folicular em ovários de leitoas já ao nascimento.

Almeida et al. (2014) avaliaram o peso ao nascimento e em diversas etapas do desenvolvimento de aproximadamente 1500 leitoas, filhas de matrizes de linhagem pura Landrace. Leitoas com maior peso ao nascimento (acima de 1,6 kg) foram mais pesadas e tiveram maiores taxas de ganho de peso diário do que àquelas que nasceram leves (< 1,2 kg) durante as fases de lactação, de creche e até a chegada à seleção (155 dias). O percentual de leitoas que não atingiram a seleção para entrada no rebanho foi maior nas leitoas nascidas com baixo peso, independente do tamanho da leitegada. Além disso, o risco de não ser aprovada no momento da seleção foi, no mínimo, duas vezes maior para a categoria de baixo peso ao nascer. Considerando que um maior percentual de exclusões ocorreu nos grupos de menor peso ao nascer até a seleção, destaca-se que em relação àquelas leitoas remanescentes, os resultados reprodutivos de idade à puberdade e taxa de anestro não foram diferentes.

A idade de exposição ao macho é um dos fatores que tem importância para a vida reprodutiva futura, assim como a taxa de crescimento. Uma maior taxa de crescimento em leitoas pode resultar em uma primeira cobertura precoce. De acordo com Kummer et al. (2006), leitoas Camborough PIC® com altas taxas de crescimento apresentam puberdade mais precoce e menores taxas de anestro aos 190 dias, quando comparadas com fêmeas com menores taxas de crescimento. Desde que apresentem peso mínimo de 130 kg, essas leitoas podem ser inseminadas entre 185 e 210 dias sem apresentar prejuízo no desempenho reprodutivo até o terceiro parto. A taxa de crescimento e a idade de exposição afetaram a manifestação do primeiro cio em leitoas DanBred® (MAGNABOSCO et al., 2014). Maiores percentuais de manifestação de cio até os 30 dias após o início da exposição ao macho foram encontrados para leitoas expostas em idades mais tardias (156–170 vs. 140–155 dias de idade) ou se elas tiveram maior ganho de peso (630–790 g/d vs. 500–625 g/d). Entretanto a taxa de parto e o número de leitões nascidos do primeiro parto não foram afetados pela taxa de crescimento e idade à exposição (MAGNABOSCO et al., 2014).

O processo fisiológico de formação dos conceptos é de suma importância para a vida adulta e evidencia sua complexidade, passível de influências genéticas e ambientais. A atividade conjunta entre a genética e a nutrição deve ser exigida para auxiliar na obtenção de pesos ao nascer adequados e na maior uniformidade. Cabe ao técnico, entender as características e interpretar a complexidade da ocorrência do retardo de crescimento intrauterino (*IUGR*), sendo capaz de identificar, através de algumas características físicas, leitões com maior risco de baixa viabilidade ao nascimento. Além do mais, ter atenção especial com leitoas destinadas ao plantel reprodutivo, especialmente por se tratar de uma categoria que irá gerar o desenvolvimento genético do sistema de produção. Com isso, considerar o peso ao nascer como um dos principais fatores de desenvolvimento dos leitões, identificando os riscos e permitindo a seleção de animais melhoradores. Dentro das evidências recentes de pesquisa, considerando características de longevidade, produção e fisiológicas, pode-se concluir que o desenvolvimento intrauterino e, por consequência, o peso ao nascer causam impacto na vida reprodutiva futura de leitoas.

3. **CAPÍTULO II – PRIMEIRO ARTIGO CIENTÍFICO**

IMPACT OF THE BIRTH WEIGHT OF LANDRACE X LARGE WHITE DAM LINE GILTS ON MORTALITY, CULLING AND GROWTH PERFORMANCE UNTIL SELECTION FOR BREEDING HERD

ARTIGO SUBMETIDO PARA A REVISTA

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RESEARCH ARTICLE

Impact of the Birth Weight of Landrace x Large White Dam Line Gilts on Mortality, Culling and Growth Performance until Selection for Breeding Herd

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ABSTRACT

Background: Piglets weighing less than 1 kg have become a common occurrence in pig farms due to selection for increasing litter size. Large litters imply a decrease in the mean piglet birth weight and an increase in the within-litter variability of birth weight with a greater risk of mortality and lower growth performance. The aim of this study was to evaluate the effects of birth weight of female piglets on growth performance and on removal rates until selection for entry into the breeding herd (170 days) of Landrace x Large White crossbred gilts.

Material, Methods & Results: A total of 1495 Landrace x Large White (DB 25® - DanBred) crossbred female piglets were individually weighed after birth (BiW) and housed on the same farm from birth onwards. During the following developmental stages, gilts were again individually weighed: at 10 days, at weaning, nursery, rearing

and selection (170 days). A phenotypic evaluation was performed to select the gilts that would be included in the breeding herd. Predicted probabilities for mortality, according to BiW, were estimated using logistic regression models. Female piglets were also retrospectively classified into eight classes of BiW based on percentiles, i.e., approximately 12.5% in each group. Cumulative losses by death or removal until weaning, nursery and selection phase were analysed using logistic regression models. The ability of pigs to compensate for low BiW was estimated using the percentages of gilts that changed at least one body weight (BW) category from birth to 170 days of age. For this purpose, eight classes of BW at 170 days were also created. BW and average daily weight gain (ADWG) were analysed as repeated measures. Overall, the mean BiW of the female piglets was 1387.8 ± 8.8 *g*, with a coefficient of variation of 24.4%. The removal rate until 170 days was 27.0% (403/1495) and locomotion problems were the major cause of culling (16.4%). The best cut-off point estimation for mortality until 24 h after birth was 1020 *g* (Area Under the Curve - AUC = 0.98%; $P < 0.0001$), increasing to 1,090 *g* for mortality until 20 days (AUC = 0.87%; $P < 0.0001$) and to 1,100 *g* for mortality until 70 days (AUC = 0.79%; $P < 0.0001$). Cumulative mortality and cumulative losses until 170 days were greater for piglets born weighing less than 1,000 *g* ($P < 0.0001$). Piglets of the three lightest BiW classes had the greatest percentage of compensatory increase in the weight category (ranging from 52% to 57%). Throughout the developmental stages, the ADWG was different between the two lightest BiW categories (410-1160 *g*) and those belonging to the three heaviest BiW classes (1510-2400 *g*). This resulted in the lower BW of the lightest BiW piglets at the end of rearing and finishing phases compared with other BiW categories.

Discussion: The great occurrence of low BiW piglets in high prolific females and their high susceptibility to mortality and poor growth performance were confirmed in the present study. The most serious consequences for survival and growth occurred in piglets with a BiW of <1.1 kg. It has been reported that smaller piglets have lower colostrum intake and hepatic glycogen reserves, are more susceptible to hypothermia and have a higher risk of crushing. In spite of the partial ability for growth compensation shown by lighter piglets, the differences in BiW seemed to have an amplified detrimental effect on growth, mainly at rearing and finishing periods, since differences between the lightest and the heaviest BiW category increased from 1.1 kg at birth to 21 kg at 170 days of age. The implications of the present study are that piglets with low BiW have low survival and poor growth to finishing, hence reducing the opportunity for their selection as future breeders.

Keywords: piglets, lifetime performance, swine, removal rate, survival.

INTRODUCTION

The increase in litter size over the years has been shown to be connected to a decrease in the mean piglet birth weight and an increase in the within-litter variability of birth weight [20]. There is a great incidence of piglets weighing less than 1 kg, especially in large litters [1, 12, 15]. This occurrence can have a dramatic impact on mortality and culling rates as well as on growth performance of piglets [15, 20]. Although several studies focus on the effect of birth weight on survival and growth performance of commercial market pigs [5, 7, 12, 15, 20], there is a scarcity of studies showing the impact of low birth weight on survival and growth development of female piglets designated for the breeding herd [1]. Studies concerning this aspect may contribute to breeding selection programs, in order to select females with characteristics that increase their longevity and reproductive performance.

The aim of this study was to evaluate the effects of birth weight of female piglets on body development performance and on removal rates until the selection for the entry into the breeding herd (170 days) of Landrace x Large White crossbred gilts[1].

MATERIAL AND METHODS

Animals and location

The study was performed on a multiplier commercial pig farm with an inventory of 5,300 sows, located in Midwest Santa Catarina State (27°16'58"S, 50°35'04"W, altitude 987 m), southern Brazil. The study was conducted during ten months from September through June with data collected only from litters with more than 7 piglets. A total of 1495 female piglets Landrace x Large White (DB 25® - DanBred), a maternal genetic line, were housed on the same farm from birth onwards.

Management of gilts from birth until the selection for the entry into the breeding herd

All of the evaluated gilts were born from sows of parity order (PO) ranging from 1 to 7 (3.2 ± 0.6 parities) and litters with 15.5 ± 0.08 total born piglets. Farrowing induction was performed at Day 114 of gestation using 0.06 mg PGF2-alfa analogue[2] injection by vulvar submucosa route. Farrowings were assisted for 24 h a day, and the numbers of piglets born alive, stillborn piglets, and mummified foetuses were recorded. Piglets born alive and stillborn piglets were individually weighed within a maximum of 12 h after birth with a digital balance (10 *g* of precision), and were identified with both an ear tag and a tattoo.

The female piglets were cross-fostered between 8 and 24 h after birth among foster sows with a minimum of 14 teats and PO ranging from 2 to 7 (3.9 ± 0.03 parities). Litters were equalised with 13-14 (13.5 ± 0.01) piglets of similar size. Tail docking and iron injections were performed three days after birth. Weaning was performed when piglets were 20 days old on average.

After weaning, groups of 25 gilts were housed in nursery facilities, within pens with a full plastic-slatted floor (density of 0.3 gilts/m^2), for seven weeks on average. At approximately 70 days after birth, gilts were transferred to rearing/finishing facilities where they remained until the day of selection for entry into the breeding herd (on average at 170 days of age). They were housed in pens with a partial concrete slatted floor, in batches of 15-20 animals/pen, with a density of 1.0 gilt/m^2. During this time, they received *ad libitum* and standardised corn and soybean diets according to the growing phase and had free access to water.

In addition to the birth weight (BiW), gilts were again individually weighed during the following developmental stages: at 10 days, at weaning (20 days), nursery (70 days), rearing (115 days) and selection (170 days). Average daily weight gain (ADWG) was calculated individually at the same developmental stages considering the weight gain divided by the number of days between the beginning and end of each evaluated phase. The ADWG of each phase was used to adjust the body weight (BW) for a specific age.

At the end of the finishing phase, when gilts were approximately 170 days old, a phenotypic evaluation was performed to select replacement gilts for the breeding herd. Gilts having hoof lesions, lameness, angulations, excessive callus, hernias and infantile vulva were not selected. Only gilts with a minimum of 14 functional teats and with ADWG (from birth until selection time) above 500 *g*/d were considered eligible to remain in the herd. The percentage and causes of death or removal were recorded for each developmental phase.

Statistical Analyses

All data were analysed using the software Statistical Analysis System (SAS) version 9.1 [17]. Differences were considered significant at $P < 0.05$. Throughout the text, numerical data are expressed as LS means ± SEM or as percentages, according to the variable type.

Predicted probabilities for mortality, according to birth weight as a continuous variable, were estimated using logistic regression models (GLIMMIX procedure). The predicted probabilities were used to obtain Receiver Operating Characteristic curves – ROC curves (LOGISTIC procedure) and a critical threshold for predicting mortality. The overall model fit was assessed using the area under the curve (AUC) of the ROC curves. The accuracy of prediction considered that no discrimination exists if the AUC is 0.5, because the true- and false-positive proportions are equal; the accuracy increases as AUC is closer to 1.0, where the discrimination is considered perfect [18].

In another statistical approach, female piglets were retrospectively classified into eight classes of BiW based on percentiles, i.e., approximately 12.5% in each group, from low to high (1 denoting the lightest and 8 the heaviest class) as described: class BiW 1 (410-990 *g*; 828.5 ± 9.59 *g*; n = 193); class BiW 2 (1000-1160 *g*; 1086.3 ± 3.60 *g*; n = 185); class BiW 3 (1170-1280 *g*; 1232.2 ± 2.59 *g*; n = 190); class BiW 4 (1290-1390 *g*; 1344.9 ± 2.22 *g*; n = 186); class BiW 5 (1400-1500 *g*; 1449.6 ± 2.34 *g*; n = 195); class BiW 6 (1510-1610 *g*; 1562.4 ± 2.36 *g*; n = 176); class BiW 7 (1620-1770 *g*; 1685.9 ± 3.34 *g*; n = 184) and class BiW 8 (1780-2400 *g*; 1945.2 ± 10.62 *g*; n = 186). Cumulative losses by death or removal until weaning, nursery and selection phase were analysed using logistic regression models (GLIMMIX procedure). In these models, BiW class was considered a fixed effect and the following factors were included as random effects: foster dams, parity order of foster dams, size of cross-fostered litter, and litter size of origin.

The ability of pigs to compensate for low BiW was estimated using the eight BiW classes and eight new classes of BW at 170 days (BW170) were formed based on percentiles, similar to the approach used by Douglas *et al.* [5]. The eight classes of BW170 were created as described: BW170 A = ≤ 96.5 kg; BW170 B = 96.6-101.5 kg; BW170 C = 101.6-106.0 kg; BW170 D = 106.1-109.7 kg; BW170 E = 109.8-113.3 kg; BW170 F = 113.4-116.7 kg; BW170 G = 116.8-122.0 kg; and BW170 H = >122.1 kg. The percentages of pigs that remained in the same weight category from BiW to BW170, decreased, or increased by at least 1 category were determined.

The variables BW and ADWG were analysed as repeated measures using the MIXED procedure including fixed effects of BiW classes, moment of weighing and their interaction. Litter size of cross-fostered litters and parity order of foster dams were included in the models as random effects.

RESULTS

Overall, the mean BiW of the female piglets was 1,387.8 ± 8.8 *g*, with a coefficient of variation of 24.4%. They were weaned with 5.9 ± 0.04 kg and reached the end of the nursery phase (70 days) weighing 25.5 ± 0.12 kg. At the end of finishing phase, at approximately 170 days of age, the 835 gilts selected for the entry into the breeding herd weighed 108.5 ± 0.38 kg on average.

Overall, the removal rate until 170 days was 27.0% (403/1495) and locomotion problems were the major cause of culling (16.4%; 246), followed by hernias (5.5%; 82), low development (4.1%; 62), illness (0.6%; 9) and an insufficient number of teats (0.3%; 4). Cumulative mortality rates were 2.3%, 9.1%, 16.7% and 17.2% until 24 h, 20 d, 70 d and 170 d, respectively. Starvation (6.3%; 95) accounted for the largest proportion of deaths, followed by diarrhea (3.3%; 49), epidermitis (2.7%; 41), crushing (2.6%; 39) and other diseases (2.2%; 33).

The best cut-off point estimation (Figure 1) for mortality until 24 h after birth was 1020 *g* (AUC = 0.98%; $P < 0.0001$), increasing to 1090 *g* for mortality until 20 days (AUC = 0.87%; $P < 0.0001$) and to 1100 *g* for mortality until 70 days (AUC = 0.79%; $P < 0.0001$).

Cumulative mortality and cumulative losses until 170 days were greater for piglets born with less than 1000 *g* (Table 1; $P < 0.0001$). Relatively high mortality rates were observed in piglets with a BiW ranging from 1000 to 1280 *g* (22.6% of mortality). The lowest cumulative mortality rates (7.9% to 9.8%) until the end of finishing phase were observed in the three heaviest BiW classes, i.e., in piglets weighing 1510-2400 *g*. The percentages of piglets that remained, increased or decreased by at least one BW category from BiW to BW170 days are shown in Figure 2. Piglets belonging to the three lightest BiW classes (410-1280 *g*) had the greatest percentage of increase in the category of weight (ranging from 52% to 57%). In contrast, piglets from the two heaviest BiW classes (1620-2400 *g*) showed the greatest percentage of decrease (ranging from 60% to 67%). The percentage of piglets that remained in the same category throughout their life was greater in lightest (43%) and heaviest (33%) BiW classes, whereas similar percentages were observed among the intermediate BiW classes (ranging from 13% to 25%).

The BW and ADWG were affected by the interaction between BiW classes and the moment of weighing ($P < 0.05$; Table 2). At weaning, the lightest piglets at birth had lower BW than piglets belonging to the heaviest BiW class. At the end of the rearing and finishing phase, gilts of the lightest group at birth remained lighter than piglets of the other BiW classes. Throughout the developmental phases, the ADWG was different between the lightest piglets at birth and those belonging to the three heaviest BiW classes.

DISCUSSION

The great occurrence of low BiW piglets in high prolific females was confirmed in the present study. In a previous study [15] with a litter size of 12.5 piglets, 9% of them weighed less than 1 kg, contrasting with 13% of them belonging to this BiW category in the present study, in which the litter size was 15.5 piglets. BiW has been considered a critical indicator of postnatal survival and performance [5, 11], with a low BiW representing a high risk of mortality until weaning [7, 12, 13, 20]. Therefore, it has been suggested that selection on litter size should be accompanied by selection for an increased minimal birth weight [20].

Considering the great accuracy (AUC ≥0.79%) of the critical threshold, the cut-off point of a BiW >1.1 kg seems realistic for reducing piglet's mortality in addition to providing potential for an adequate growth performance until the breeding selection. However, the mortality rate of piglets with a BiW close to this cut-off point (1.17-1.28 kg) is still relatively high until the end of the nursery period (22%). High mortality rates until weaning have also been reported [15] in piglets belonging to 0.6 and 0.8 kg BiW classes (85% and 52%, respectively). In addition to being lighter at birth, piglets exposed to some degree of intrauterine growth restriction have lower colostrum intake and hepatic glycogen than piglets of normal weight, hence reducing their survival chance [3, 9]. Indeed, a greater amount of colostrum has been shown to be necessary to assure the survival of piglets weighing 1.1-1.2 kg compared with heavier piglets [6].

Furthermore, smaller piglets are more susceptible to hypothermia [10] and have a higher risk of crushing [19].

The greater probability of lighter piglets being removed from the herd corroborates the results of a previous study [1]. The greater mortality until the end of the nursery phase (21.6% to 37.8% vs. 7.5% to 8.1%) had the main contribution for the greater removal rate of piglets belonging to the three lowest BiW categories (410-1280 *g*) compared with piglets belonging to the three highest BiW categories (1510-2400 *g*). Cumulative culling until 170 d (27% on overall) was not affected by BiW categories, probably because the criteria of selection for entry into the breeding herd take into account problems other than low development. Indeed, locomotor disorders accounted for 61% (246/403) of removals until 170 days of age.

It has been suggested that in the majority of low birth weight piglets, a low number of muscle fibres differentiate during prenatal myogenesis and piglets with reduced fibre numbers are unable to exhibit postnatal catch-up growth [16]. However, in the present study, 57% of the lowest BiW gilts increased by at least one category in the final weight, showing that they had, to some extent, growth compensation. In another study [5], the ability of piglets with low birth weight to compensate growth during the postnatal life was also observed, with 70-80% of them increasing at least one weight class. However, the greater incidence of increasing in BiW classes can be explained because only finishing pigs were used in this study. Thus the culling of animals by phenotypic disorders at the selection did not occur, differentiating this from the present study. The fact that a subpopulation of light piglets has the potential to catch up its growth raises the question of how to identify these animals and what physiological mechanisms help them to compensate the weight gain [14].

The importance of birth weight for growth performance [4, 8, 15] was confirmed in the present study since piglets belonging to the lowest BiW category had lower ADWG and BW at 170 days than those belonging to the heaviest BiW category. This result is also in agreement with the differences in weight until 150 days [2] that were observed for two classes of BiW piglets (0.8-1.2 vs. 1.8-2.2 kg). Although under-developed pigs were removed during the developmental phases in the present study, aiming to select the future breeders, differences between the lightest and the heaviest BiW category increased from 1.1 kg at birth to 21 kg at 170 days of age. Likewise, the difference between the lightest and heaviest piglets at birth (<0.61 vs. >2.4 kg) increased to 5.4 kg at weaning and to 11.9 kg at 63 days of age [15]. In spite of the partial ability for growth compensation shown by lighter piglets, the differences in BiW seemed to have an amplified detrimental effect on growth, mainly during the rearing and finishing periods.

The implications of the present study are that piglets with low BiW have low survival and poor growth to finishing, hence reducing the opportunity for their selection as future breeders. It is necessary to evaluate the economic costs of additional assistance that would help the small piglets to increase their survivability and compensate for the growth delay. It is also important to known whether the low birth weight will have long-term effects on the reproductive performance of small piglets that survive and are selected for entry into the breeding herd.

CONCLUSIONS

Birth weight is critical for the survival of Landrace x Large White crossbred female piglets. Piglets weighing less than 1 kg at birth have a little chance of being alive at weaning. Moreover, when they survive, their growth performance is lower than that of heavier piglets. The consequence is less female piglets of low birth weight being selected as future breeders.

SOURCES AND MANUFACTURERS

[1]DB 25®, Danbred, DB Genética Suína, Patos de Minas, MG, Brazil.

[2]Dinoprost Tromethamine, Lutalyses; Pharmacia & Upjohn, México O.F., Mexico.

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Ethical approval. Process n° 23732 approved by CEUA - Ethical Committee of Animal Utilization/UFRGS (Federal University of Rio Grande do Sul).

Declaration of interest. The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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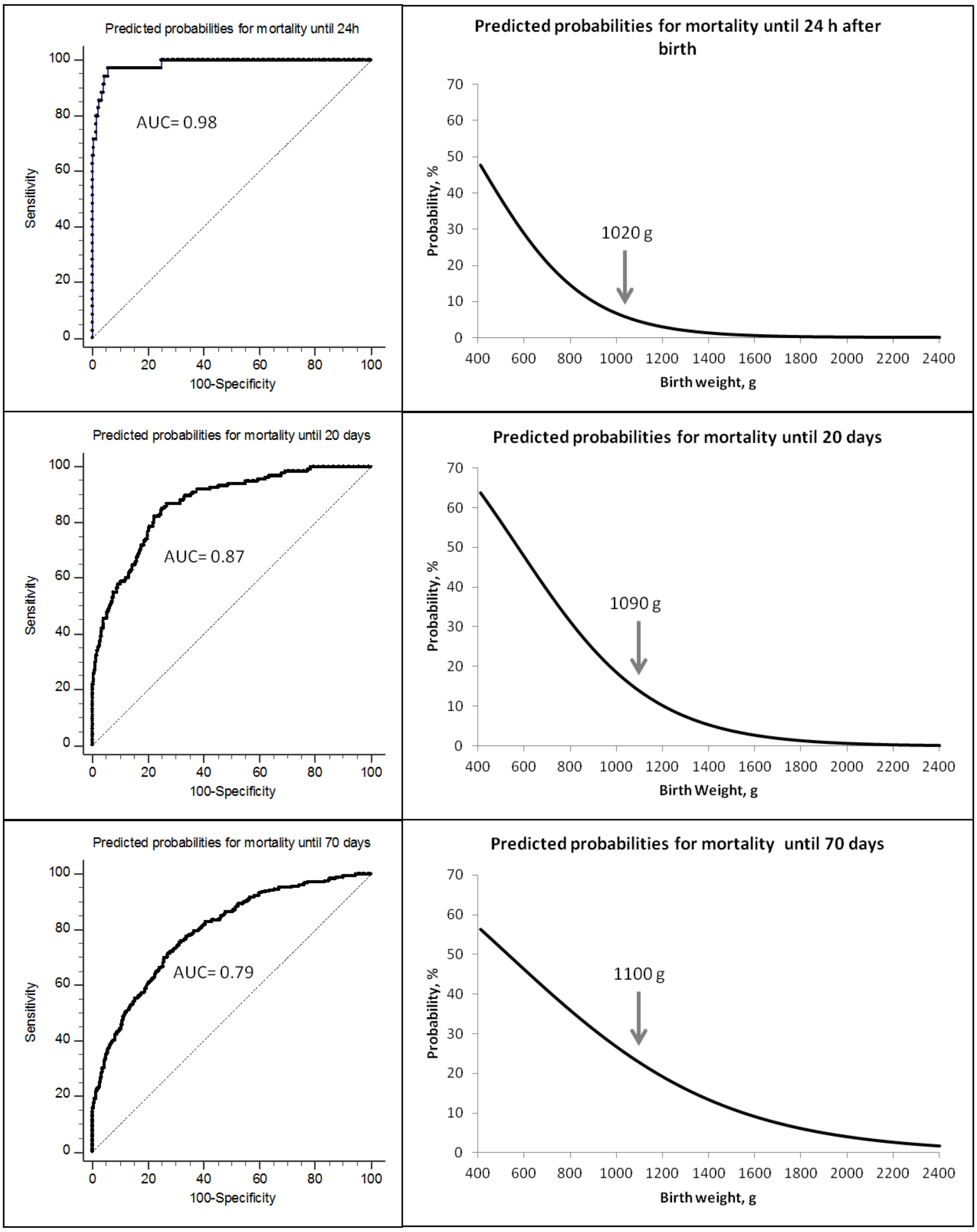

Figure 1. Predicted probabilities for mortality until 24 h, 20 d and 70 d estimated using logistic regression models. Arrows (↓) indicate best cut-off points of birth weight for mortality at each evaluated phase. Left panels display the Receiver Operating Characteristic (ROC) curves, where true-positive (sensitivity) proportion is plotted against the false-positive (100-specificity) proportion. The critical threshold (cut-off

point) was the point on the ROC curve that had the highest combined sensitivity and specificity. The accuracy of the prediction is greater as the AUC (Area Under the Curve) is closer to 1.0.

Table 1. Results of logistic regression analyses for mortality, culling and cumulative losses from birth until 170 days, according to birth weight classes of female piglets.

Variables	Birth Weight Classes, *g*							
	410-990 (n = 193)	1000-1160 (n = 185)	1170-1280 (n = 190)	1290-1390 (n = 186)	1400-1500 (n = 195)	1510-1610 (n = 176)	1620-1770 (n = 184)	1780-2400 (n = 186)
Cumulative mortality								
24 h after birth, % (n)	11.4 (22)a	2.2 (4)bc	1.6 (3)bc	2.7 (5)b	0.0 (0)c	0.0 (0)c	0.5 (1)bc	0.0 (0)c
Pre-weaning, 20 d, % (n)	27.5 (53)a	14.6 (27)b	12.1 (23)bc	7.0 (13)cd	3.6 (7)def	1.7 (3)ef	4.9 (9)de	0.5 (1)f
Nursery, 70 d, % (n)	37.8 (73)a	21.6 (40)b	21.6 (41)b	13.4 (25)bc	14.4 (28)bc	7.9 (14)c	8.1 (15)c	7.5 (14)c
Finishing, 170 d, % (n)	37.8 (73)a	22.2 (41)b	22.6 (43)b	13.4 (25)bc	14.4 (28)bc	7.9 (14)c	9.8 (18)c	8.1 (15)c
Cumulative culling								
Nursery, 70 d, % (n)	8.8 (17)	4.9 (9)	3.7 (7)	7.5 (14)	3.6 (7)	4.0 (7)	2.7 (5)	3.2 (6)
Finishing, 170 d, % (n)	30.6 (59)	27.6 (51)	27.4 (52)	27.4 (51)	27.2 (53)	25.6 (45)	28.3 (52)	21.5 (40)
Cumulative losses[(1)]								
Nursery, 70 d, % (n)	46.6 (90)a	26.5 (49)b	25.3 (48)b	21.0 (39)b	17.9 (35)bc	11.9 (21)cd	10.9 (20)d	10.7 (20)d
Finishing, 170 d, % (n)	68.4 (132)a	49.7 (92)b	50.0 (95)b	40.9 (76)bc	41.5 (81)bc	33.5 (59)cd	38.0 (70)cd	29.6 (55)d

[(1)] Mortality and culling reasons are included in this item.
Lowercase letters in the row indicate significant statistical differences ($P < 0.05$).
The piglets were categorised into eight birth weight classes, resulting in a similar number of pigs, i.e., approximately 12.5% per group.

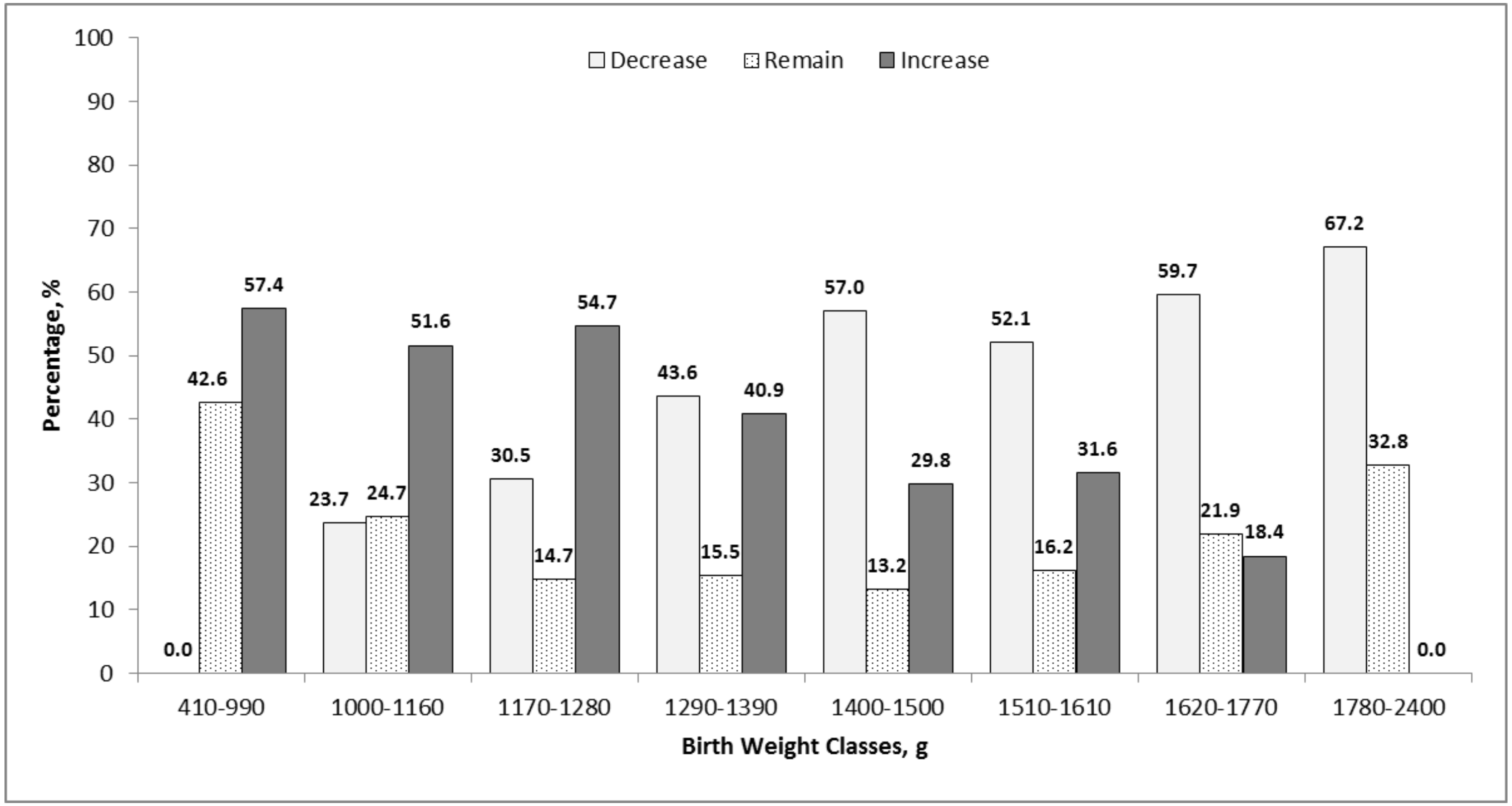

Figure 2. Percentage of gilts that decrease, remain or increase at least 1 weight class from birth (BiW) to 170 days (BW170). The gilts were categorised into 8 classes of approximately 12.5% animals per group in both BiW and BW170. A gilt is categorised as "decrease" when it has decreased at least 1 category from BiW to BW170. A gilt is categorised as "remain" when it has not changed the class from BiW to BW170. A gilt is categorised as an "increase" when it has increased at least 1 category from BiW to BM170.

Table 2. Growth performance of female piglets at 10 days, weaning (20 days), nursery (70 days), rearing (115 days) and finishing (170 days) stages according to birth weight (BiW) classes.

BiW Class,*g*	10 days	Weaning	Nursery	Rearing	Finishing
			Weight, kg		
410-990	2.5 ± 0.6	4.2 ± 0.6a	21.0 ± 0.6a	46.2 ± 0.6a	96.2 ± 0.7a
1000-1160	3.0 ± 0.5	4.9 ± 0.5ab	22.9 ± 0.5ab	51.4 ± 0.6b	101.4 ± 0.6b
1170-1280	3.2 ± 0.5	5.2 ± 0.5ab	24.8 ± 0.5bc	53.5 ± 0.5bc	105.4 ± 0.6c
1290-1390	3.6 ± 0.5	5.7 ± 0.5ab	25.7 ± 0.5bcd	56.3 ± 0.5cde	107.2 ± 0.5c
1400-1500	3.7 ± 0.5	5.8 ± 0.5ab	25.4 ± 0.5bcd	55.6 ± 0.5cd	107.7 ± 0.5c
1510-1610	3.8 ± 0.5	5.9 ± 0.5ab	26.0 ± 0.5cd	57.9 ± 0.5de	111.4 ± 0.5d
1620-1770	4.1 ± 0.5	6.4 ± 0.5ab	27.6 ± 0.5de	58.4 ± 0.5e	112.4 ± 0.5d
1780-2400	4.6 ± 0.5	7.1 ± 0.5b	28.6 ± 0.5e	62.1 ± 0.5f	117.1 ± 0.5e
			Average daily weight gain, g/day		
410-990	172.2 ± 11.1A	201.5 ± 11.6A	332.4 ± 12.9A	566.0 ± 12.4A	906.4 ± 13.0A
1000-1160	203.3 ± 10.1AB	223.5 ± 10.6AB	356.2 ± 11.2AB	640.5 ± 11.2B	915.2 ± 11.5A
1170-1280	215.2 ± 10.0ABC	229.2 ± 10.3AB	386.5 ± 10.9ABC	639.2 ± 10.8B	945.4 ± 11.1ABC
1290-1390	232.7 ± 9.8BC	243.5 ± 10.1ABC	396.9 ± 10.5BC	683.8 ± 10.6BC	930.7 ± 10.7AB
1400-1500	232.0 ± 9.5BC	243.3 ± 9.7ABC	385.9 ± 10.3ABC	671.4 ± 10.4BC	950.2 ± 10.7ABCD
1510-1610	232.5 ± 9.8BC	242.3 ± 9.9ABC	402.9 ± 10.5BC	716.3 ± 10.5CD	976.4 ± 10.8BCD
1620-1770	257.9 ± 9.8CD	264.0 ± 9.9BC	418.4 ± 10.4C	684.7 ± 10.5BC	980.8 ± 10.9CD
1780-2400	274.9 ± 9.7D	284.4 ± 9.8C	421.9 ± 10.2C	740.7 ± 10.2D	997.6 ± 10.4D

Differences ($P < 0.05$) in the columns are indicated by lowercase letters for weight and capital letters for ADWG.
The female piglets were categorised into eight birth weight classes using percentiles, resulting in a similar number of pigs per category, i.e., approximately 12.5% in each group.

4. CAPÍTULO III – SEGUNDO ARTIGO CIENTÍFICO

LOW BIRTH WEIGHT AFFECTS LIFETIME PRODUCTIVE PERFORMANCE AND LONGEVITY OF SWINE FEMALES

ARTIGO A SER SUBMETIDO PARA PUBLICAÇÃO

Low birth weight affects lifetime productive performance and longevity of swine females[1]

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ABSTRACT:

There is a scarcity of studies showing the impact of low birth weight on survival and growth development of female piglets selected for the breeding herd. It is known that large litters leads to a lower average birth weight, increasing the rate of piglets born weighing less than 1 kg, resulting in a negative impact on piglets growth performance. The aim of this study was to evaluate the effects of birth weight on reproductive performance and longevity up to the third farrowing of Landrace x Large White crossbred gilts. A total of 1,495 female piglets were selected at birth. Birth weight was included as a categorical variable, which consisted of a retrospective classification into eight classes of birth weight (BiW) based on percentiles, i.e., approximately 12.5% in each group. Lifetime reproductive performance was measured considering total born piglets in three productive cycles and the number of days into the herd. Logistic regression models were used for analyses of puberty and first mating indexes, age at third farrowing, number of total born piglets during three productive cycles and the number of herd days. Farrowing rates and percentages of females reaching the third farrowing were also analyzed using logistic regression models. Females born weighing less than 1 kg produced about 4.5 less piglets along three parities than the other BiW classes ($P \leq 0.05$). When data for gilts that died or were removed before selection were also taken into account, female piglets weighing between 1.0 and 1.28 kg were negatively affected in terms of lifetime herd days, although in less extent than those weighing < 1 kg. However, the number of herd days, from selection for entry into the breeding herd to third farrowing or removal, was not different ($P > 0.05$) among BiW classes. The two lightest BiW classes (410-990 and 1000-1160 g) had lower weight at puberty than gilts of heavier classes ($P < 0.0001$). The age at first mating was not different ($P > 0.05$) among BiW classes, but gilts of the three lightest BiW classes were lighter ($P < 0.05$) at first mating. The first farrowing rate and the percentage of gilts that reached the third farrowing were not affected by birth weight classes ($P > 0.05$). The results of this study show that a birth weight lower than 1 kg influenced negatively piglets production and longevity of swine females.

Key words: birth weight, lifetime performance, longevity, piglets, reproduction, swine.

INTRODUCTION

The high variability on piglets' birth weight has become a common event in the course of genetic selection for high prolific sows (Wolf et al., 2008). The production of large litters leads to a lower average birth weight, increasing the rate of piglets born weighing less than 1 kg (Quiniou et al., 2002; Milligan et al., 2002; Almeida et al., 2014).

Low birth weight has a negative impact on growth performance of piglets (Beaulieu et al., 2010; Alvarenga et al., 2012), resulting in increased risk of mortality and culling (Wolf et al., 2008; Almeida et al., 2014), which affects their longevity. There is a scarcity of studies showing the impact of low birth weight on survival and growth development of female piglets designated for the breeding herd (Almeida et al., 2014; Magnabosco et al., 2015). The impact of weight gain, from birth to selection for the breeding herd or to the first mating, on reproductive performance and longevity is reported in some studies (Kummer et al., 2006; Amaral Filha et al., 2010; Roongsitthichai et al., 2013). However, there is a lack of information about the relationship between birth weight and reproductive performance or longevity of swine females.

The aim of this study was to evaluate the effects of birth weight on reproductive performance, productivity and longevity up to the third farrowing of Landrace x Large White crossbred gilts.

MATERIAL AND METHODS

All management and trial procedures for this study were approved by the CEUA - Ethical Committee of Animal Utilization/UFRGS (Federal University of Rio Grande do Sul), process nº 23732.

Animals and location

The study was conducted during two years, from September 2011 to September 2013 on a multiplier farm, with an inventory of 5,300 sows, located in the Santa Catarina State (27°16'58"S, 50°35'04"W, altitude 987 m), at southern Brazil.

A total of 1,495 female piglets (Landrace x Large White crossbred gilts - DB 25® - DanBred) were selected at birth and followed until their third farrowing. They were housed at the same farm from birth onwards. All gilts were born from sows of parity order (PO) ranging from 1 to 7 and were individually weighed within 12 h of birth with a digital balance (10 g of precision). All management procedures, performed from birth until selection of gilts for the breeding herd, were described elsewhere (Magnabosco et al., 2015).

Management of gilts from puberty stimulation until the first mating

Immediately after selection for the breeding herd, the gilts were housed in groups of 12 to 15 in 3.80 x 4.00 m pens with partially slatted floor. Stimulus for puberty onset started with 170 days on average and was provided through boar contact into the pens, once a day, for 10 min, every morning. The gilts were considered in estrus when they exhibited a standing reflex through back pressure in the presence of the boar. Cycling gilts were weighed and transferred to individual crates. The gilts were tested until 30 days after the onset of boar exposure (BE). Gilts that did not show estrus within

30 days of initial exposure to boars were defined as being anestrous. These gilts received 400 IU eCG + 200 IU hCG (PG600®; MSD-Animal Health) and were followed for 30 more days for estrus detection.

Gilts were inseminated at their second to fourth post-pubertal estrus and with minimum of 130 kg. The artificial insemination was performed at the onset of estrus (0 h) and then every 24 h until gilts were no longer in standing estrus. Gilts were inseminated with intracervical deposition of pooled semen doses containing 3 x 10^9 sperm cells diluted in BTS® extender (Beltsville Thawing Solution - MINITUB®, Minitub GmbH, Tiefenbach, Germany), stored at 15-18ºC and with no more than 72 h of storage.

Management of gilts from the first mating until the third farrowing

During pregnancy, gilts remained in individual crates (0.6 x 2.5m) with a partially slatted concrete floor, and were automatically fed twice a day (7:00 and 13:00h) with a corn soybean diet (3,220 kcal ME/kg, 14.0% CP and 0.65% lysine). From mating until 90 days of gestation, they received 1.8 to 2.8 kg feed/day, according to their body condition score and gestational phase (Young et al., 2004); from day 91 of gestation until the transfer to farrowing room (110 days), they received 3.3 kg feed/day. During lactation, the sows were housed in individual crates with full plastic slatted floor. Automatic feeders allowed the sows to have *ad libitum* access to a lactation diet (3,400 kcal ME/kg, 19.2% CP and 1.00% lysine). Water supply was provided *ad libitum* throughout the experimental period.

Farrowing was induced at Day 114 of gestation using 0.06 mg PGF2-alfa analogue injection (Dinoprost Tromethamine, Lutalyse; Pharmacia & Upjohn, México O.F., Mexico) by vulvar submucosa route. The first farrowing was assisted for 24 h a day. In all farrowings, the numbers of piglets born alive, stillborn piglets, and mummified fetuses were recorded. Data about the reproductive performance up to third farrowing were obtained from a farm´s database (AGRINESS S2 System®, Florianopolis, Santa Catarina, Brazil).

Measurements and Statistical Analysis

All data were analyzed using the software Statistical Analysis System version 9.1 (SAS Inst. Inc., Cary, NC). Differences were considered significant at $P \leq 0.05$ and P-values between 0.06 and 0.10 were designated as a tendency. Throughout the text, numerical data are expressed as LS means ± SEM or in percentages, according to the variable type.

Initially, the effect of birth weight on the percentage of gilts showing estrus and farrowing was investigated as a continuous variable using logistic regression models (GLIMMIX procedure), but it was not significant ($P > 0.05$). Then, birth weight was included as a categorical variable as reported by Magnabosco et al. (2015), which consisted of a retrospective classification into eight classes of birth weight (BiW) based on percentiles, i.e., approximately 12.5% in each group, from low to high (1 denoting the lightest and 8 the heaviest class). After discounting dead and culled animals, the number of female piglets belonging to each class of BiW were the following: BiW 1 (410-990 g; 828.5 ± 9.59 g; n= 61); BiW 2 (1000-1160 g; 1086.3 ± 3.60 g; n= 93); BiW 3 (1170-1280 g; 1232.2 ± 2.59 g; n= 95); BiW 4 (1290-1390 g; 1344.9 ± 2.22 g; n= 110); BiW 5 (1400-1500 g; 1449.6 ± 2.34 g; n= 114); BiW 6 (1510-1610 g; 1562.4 ± 2.36 g; n= 117); BiW 7 (1620-1770 g; 1685.9 ± 3.34 g; n= 114) and BiW 8 (1780-2400 g; 1945.2 ± 10.62 g; n= 131).

Lifetime reproductivity performance was measured considering the total piglets born in three productive cycles and the number of days in the herd, calculated from birth or from selection for entry into the breeding herd until the third farrowing or removal from the herd. Data concerning age and weight at first estrus and first mating, age at third farrowing, number of total born piglets during three productive cycles and the number of herd days were analyzed using the MIXED procedure. In all the models, comparisons among birth weight classes were performed using the Tukey-Kramer's test. Only gilts that showed spontaneous estrus within 30 days of BE were included in the analyses concerning age and weight at first estrus. In all models, BiW class was considered as a fixed effect and the following factors were included as random effects: foster dams, parity order of foster dams and size of cross-fostered litter.

Percentages of gilts in estrus within 10, 20 and 30 d after BE, farrowing rates and percentages of females reaching the third farrowing were analyzed using logistic regression models (GLIMMIX procedure) with fixed effect of BiW classes and random effects of foster dams, parity order of foster dams and size of cross-fostered litter.

The number of estrus cycles and PG600 application were also investigated as possible factors affecting farrowing rate (GLIMMIX models) and the number of piglets born in first farrowing (MIXED models) but were removed from the models because they were not significant ($P > 0.05$).

RESULTS

From the initial 1,495 female piglets, 835 were selected for the breeding herd, at approximately 170 days (see Magnabosco et al., 2015). The percentage of estrus at 10, 20 and 30 days after boar exposure was not different for the eight classes of BiW (**Fig. 1**). Overall, estrus manifestation occurred in 23.8%, 44.4% and 64.6% of gilts within

10, 20 and 30 days of boar exposure. Estrus manifestation after PG600 treatment (74%; 216/292) was not affected by birth weight class ($P > 0.05$).

Although gilts weighing 410-990 g were older at boar exposure ($P < 0.05$) than heavier gilts, there were no differences ($P > 0.05$) in age at puberty among BiW classes (**Table 1**). Overall, gilts were 188.8 ± 0.41 days old at first estrus manifestation. The two lightest BiW classes (410-990 and 1000-1160 g) had lower weight at puberty than gilts of heavier classes ($P < 0.0001$; **Table 1**). The age at first mating was not different ($P > 0.05$; overall 221.1 ± 0.64 days) among BiW classes, but gilts of the three lightest BiW classes were lighter ($P < 0.05$) at first mating (**Table 1**). Gilts were mated with 2.1 ± 0.02 estrus cycles with no difference ($P > 0.05$) among BiW classes.

The first farrowing rate (90.9%; 657/723) and the percentage of gilts that reached the third farrowing (68.7%; 497/723) were not affected by BiW ($P > 0.05$). The age at third farrowing was reached with 627.4 ± 1.17 days of age on average, with no differences among BiW classes ($P > 0.05$). Total born piglets in the first farrowing tended to be different ($P = 0.08$) among BiW classes with the lighter BiW class (410-990 g) producing 1.6 less piglets than the mean of the other classes (12.8 vs. 14.4 piglets). The lightest BiW class produced fewer piglets ($P \leq 0.05$) over three parities than the other BiW classes (**Fig. 2**).

The number of herd days, from selection for the breeding herd to third farrowing or removal, was not different ($P > 0.05$) among BiW classes (**Fig. 3A**), being of 398.2 ± 4.96 days on average. When data of gilts that died or were removed before selection (Magnabosco et al., 2015) were also taken into account, the number of days in herd life was lower in the lightest BiW compared with the other classes; gilts of BiW classes 2 and 3 also remained less time in the herd than gilts heavier at birth (**Fig. 3B**).

DISCUSSION

Females born weighing less than 1 kg produced about 4.5 less piglets along three parities than the other gilts. The lower number of piglets born in the first farrowing had the greatest contribution for productivity over three parities. Hoge and Bates (2011) indicated that the performance of a female during her first litter does provide insight into the rest of her productive life. The lower production of piglets over three parities of the lightest BiW group can be the result of its lower body weight at first mating when compared with their contemporaries. It has been shown that greater growth rates until mating result in more piglets born at first farrowing (Kummer et al., 2006; Amaral Filha et al., 2010). In another study (Roongsitthichai et al., 2013), more piglets were born in the second parity of gilts with greater body weight (>150 kg) and growth rate at entering the breeding unit (Roongsitthichai et al., 2013). DanBred gilts weighing <139kg at the 1st mating had greater risk ($P \leq 0.05$) of farrowing lower litter size in the second parity (OR= 2.00) and over three parities (OR= 3.28) compared to those weighing ≥139kg (Lesskiu et al., 2015). Concentrations of circulating IGF-1 and insulin are greater in females with rapid growth rate (Cox, 1997), which could increase the ovulation rate by reducing the chance of follicular atresia (Britt et al., 1988). However, different growth rates at approximately 144 days of age (626 compared with 737 g/d) had not effect on ovulation rate (Kummer et al., 2009), indicating that greater litter size is not necessarily related to more oocytes being ovulated. Indeed, some studies (Pope et al., 1990, Hunter, 2000) provided convincing evidence that the preovulatory development of pig follicles and oocytes has consequences for embryo development and survival, which could result in more piglets born.

Pinilla and Williams (2010) suggest that once gilts are selected it is reasonable that more than 95% reach the first mating, with > 87% remaining until parity one and >

72% until parity three. Although our results of gilts reaching the first (87%) and third farrowing (59%) are a little below of targets suggested by Pinilla and Williams (2010), they are similar to percentages reported in other studies (Lucia et al., 2000; Moeller et al., 2004; Kummer et al., 2006; Knauer et al., 2011). Several studies use the lifetime production as a definition of productivity and longevity of sows (Lucia et al, 2000; Serenius and Stalder, 2006; Tarrés et al., 2006). In the present study, female piglets weighing between 1.0 and 1.28 kg were negatively affected in terms of lifetime herd days, although in less extent than those weighing < 1 kg. The reduction in the number of herd days in gilts belonging to these BiW classes is explained by their greater pre-weaning mortality (Magnabosco et al., 2015) rather than by their lower retention rate after selection for entry into the breeding herd. As age at puberty and first mating were similar for BiW classes, it is reasonable to expect that the number of herd days, when counted from selection for entry into the breeding herd onwards, would not be affected by birth weight, as observed in the present study. Even with different puberty ages, the retention rate until the third farrowing has not been affected (Patterson et al., 2010). In contrast, it has been reported that selecting for fewer days to reach 113 kg can have an unfavorable effect on longevity and lifetime reproductive traits (Nikkilä et al., 2013).

The lower growth rate and weight at the end of finishing phase (Magnabosco et al., 2015) explains the older age at boar exposure of low BiW female piglets, confirming the results of Almeida et al. (2014). Several studies have demonstrated the negative impact of low birth weight on growth performance in pigs designated to be slaughtered. Piglets born with low birth weight take more days to achieve the recommended market weight (Beaulieu et al., 2010) or reach slaughter with a lower weight than their contemporaries (Fix et al., 2010; Alvarenga et al., 2012). It is expected that a later exposure to boar stimulus would reduce the boar exposure-puberty interval (van Wettere et al., 2006; Amaral Filha et al., 2009; Magnabosco et al., 2014), but this was not observed in the present study. The fact that age at puberty was not affected by birth weight is probably due to the small difference in age at boar exposure (4 days) between the lightest and heaviest BiW category, which on a weekly management determines that the gilts remain in the same group during the growth phase. Kummer et al. (2009) reported that puberty is reached earlier in gilts with a greater growth rate, when exposed to boars at 144 days. In the present study, gilts of the lightest BiW group were lighter (less 18.6 kg) at puberty than gilts of heaviest BiW group, although they had a similar age. It is important to note that the growth rate of the lightest BiW group was approximately 610 g/day at puberty, which has resulted in reasonable reproductive results in other studies (Amaral Filha et al., 2009; Tummaruk et al., 2009).

Estrus manifestation within 30 days of boar exposure (65%) is below of >80% observed in another genetic line (Amaral Filha et al., 2009). Results concerning puberty age of DanBred lines when stimulated at younger ages are scarce and not yet consistent. Ribeiro et al. (2012) reported greater percentages of gilts in estrus with stimulation at 200 days than at 170 days of age (77% vs 34%). On the other hand, 77% of estrus manifestation was recently reported for gilts exposed to boars at 156-170 days of age (Magnabosco et al., 2014).

Little information about age and weight requirements for mating of DanBred dam line gilts is available in literature. Reports of successful Danish producers suggest that the first mating should occur when gilts are at least 260 days old (Rathje and Himmelberg, 2004), whereas more recent recommendations are of an age older than 230 days (DanBred, 2013). It has been reported that high-performing herds had earlier age at first mating (Kaneko and Koketsu, 2012), and that there is a risk of lower longevity and piglet production in gilts that are older at first mating (Saito et al., 2011). In DanBred line females, Serenius et al. (2006) reported that older age at first farrowing increased the risk of culling. Indeed, the productive performance of gilts in the present study seems to have not been negatively affected in spite of having been mated younger (221 days on average) than the recommended age. Similar results were reported by Lesskiu et al. (2015) showing that DanBred gilts can be bred at an earlier age (≤ 210 days of age) than previously recommended, without compromising their reproductive performance, provided that they reach at least approximately 140kg on the first mating. The recommended weight for the first mating has varied from ≥ 160 kg (Jensen and Peet, 2010) to ≥ 138 kg (DanBred, 2013). The average weight of 153 kg, reached by gilts of the present study at 221 days of age, shows that the recommended weight for the first breeding was reached before 230-260 days of age, which is considered an adequate age for good productivity (Rathje and Himmelberg, 2004; DanBred, 2013). Furthermore, the weight reached at first mating by most BiW classes seems to not have unfavorable long term effects, since 69% (497/723) of the first-mated gilts reached the third farrowing.

The results of this study show that a birth weight lower than 1 kg influenced negatively piglet production and longevity of swine females. Although gilts born with a low birth weight have greater mortality or culling rates, those selected for entry into the breeding herd showed satisfactory results in terms of estrus manifestation and farrowing rates. Nevertheless, the number of piglets produced over three parities and the number of days remaining in the reproductive herd were lower for sows that were born with less than 1 kg.

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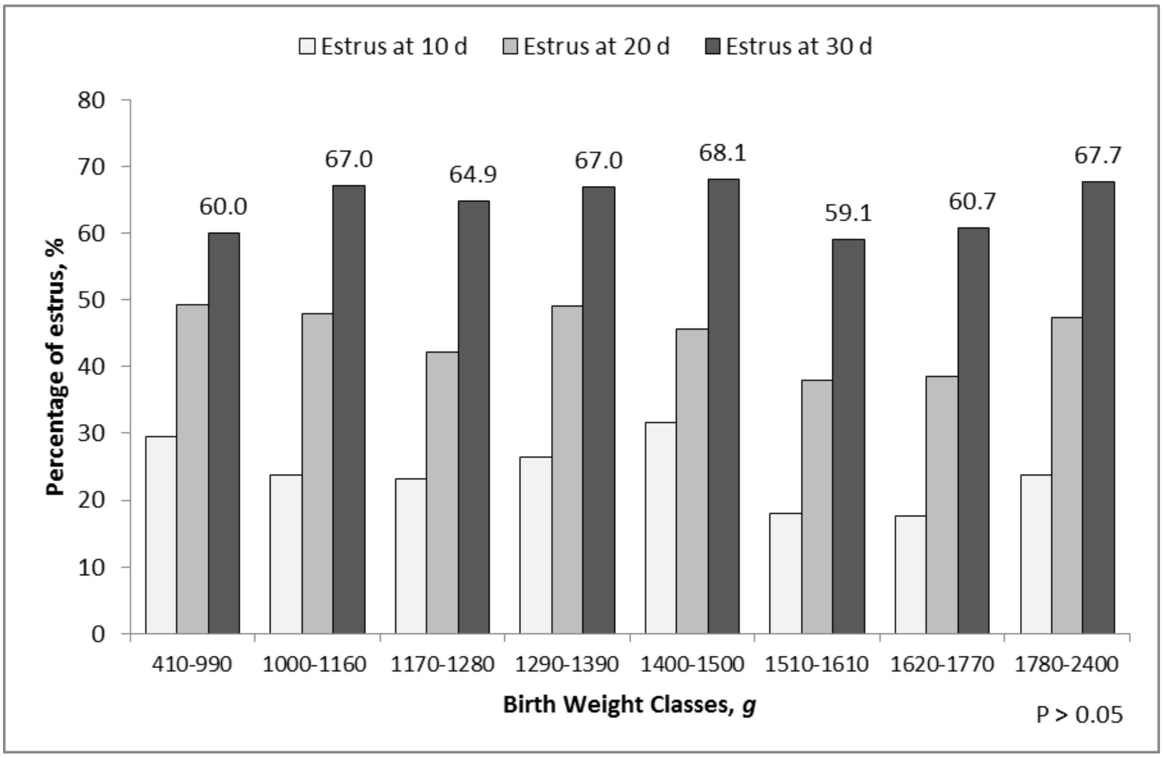

Figure 1. Frequency of spontaneous estrus for gilts, 10, 20 and 30 days after boar exposure according to their birth weight (n= 835).

Table 1. Age at onset of boar exposure, puberty and first mating, weight at puberty and first mating of gilts according to their birth weight (LSMeans ± SEM).

Birth Weight	Age, days			Weight, kg	
Class, g	Boar Exposure	Puberty	Mating	Puberty	Mating
410-990	177.0±1.0a	189.0±1.5	224.7 ± 2.6	115.6±2.0a	145.6 ± 2.2a
1000-1160	174.4±0.9b	188.8±1.2	223.1 ± 2.0	119.4±1.6a	148.8 ± 1.7a
1170-1280	173.0±0.9c	189.4±1.2	221.0 ± 2.0	123.9±1.6b	149.0 ± 1.7a
1290-1390	173.2±0.9bc	188.1±1.1	222.8 ± 1.8	124.6±1.5bc	153.8 ± 1.6b
1400-1500	173.1±0.9bc	188.9±1.1	221.1 ± 1.8	125.7±1.4bc	153.6 ± 1.5b
1510-1610	172.1±0.9c	188.2±1.2	219.9 ± 1.9	127.6±1.5bc	154.1 ± 1.6b
1620-1770	172.0±0.9c	188.9±1.2	220.9 ± 1.8	128.3±1.5c	156.1 ± 1.6bc
1780-2400	172.9±0.9c	188.7±1.1	219.0 ± 1.8	134.2±1.4d	158.7 ± 1.5c

Different lowercase letters in the column indicate differences between classes of birth weight (P<0.05).

For the analysis until puberty only gilts that reached spontaneous estrus until 30 days after boar exposure were considered (n= 532).

For the analysis until first mating all the mated gilts (n= 723) were considered.

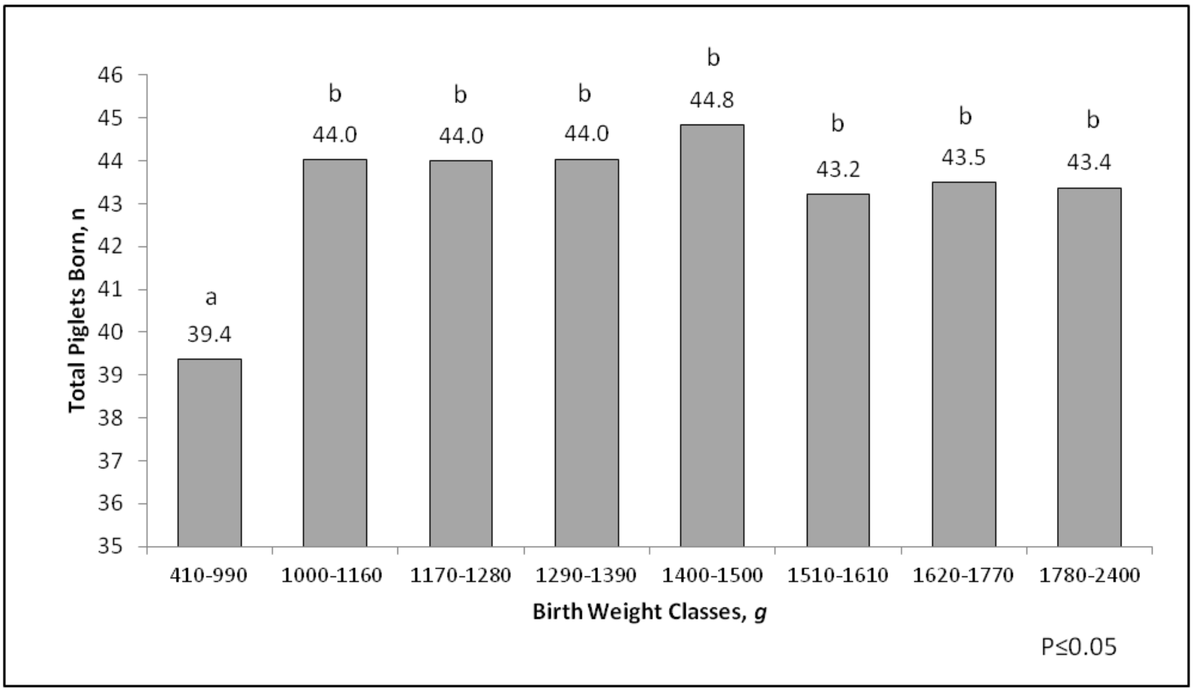

Figure 2. Number of total piglets born in three parities (n= 497) according to the birth weight.

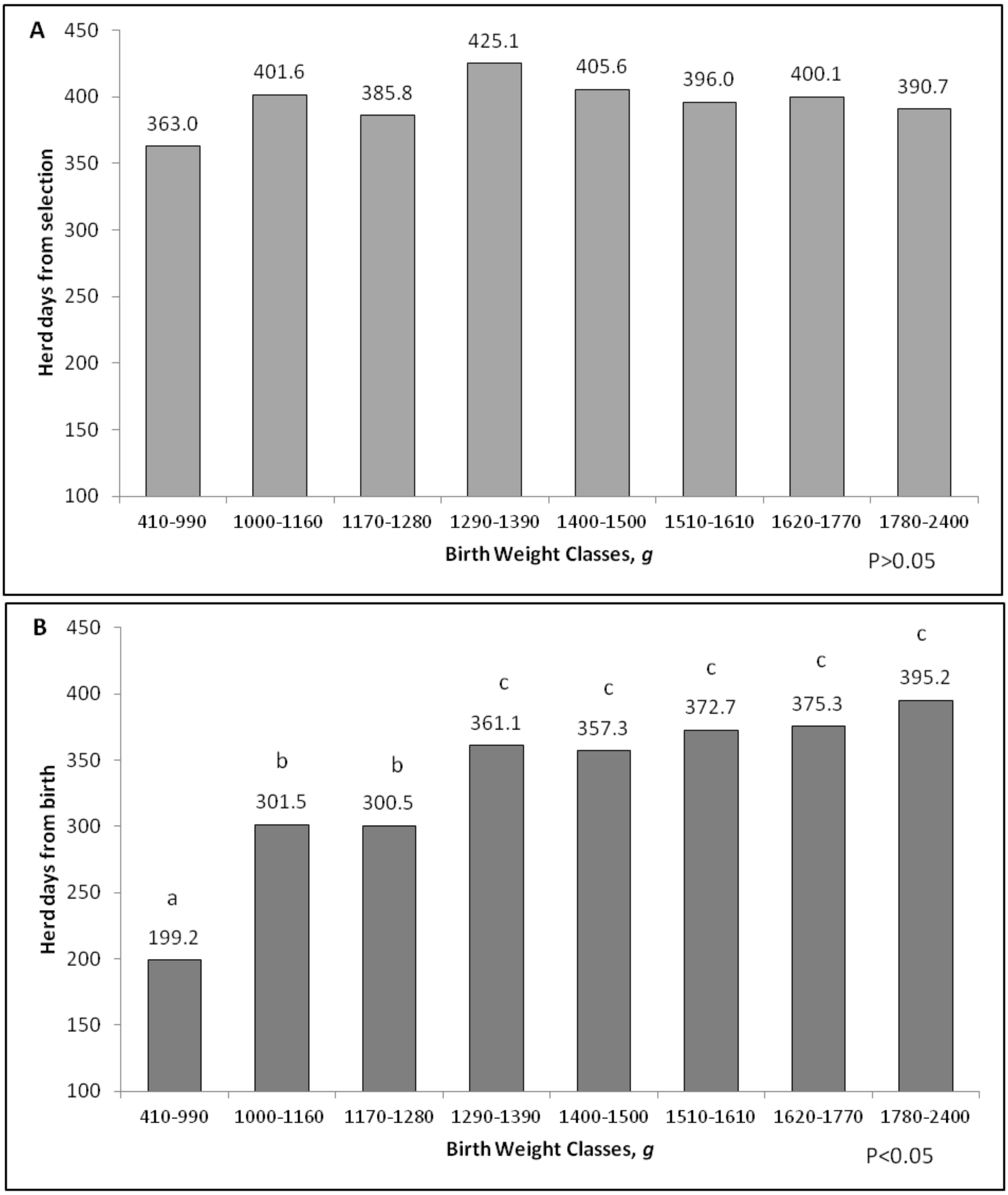

Figure 3. Number of herd days according to the birth weight. In Figure 3A, the number of days are being considered from selection for entry into the breeding herd until the third farrowing or removal date (n= 835) whereas in Figure 3B days are being counted from birth onwards, including all female piglets weighed at birth (n= 1495). At birth, female piglets were categorized into eight birth weight classes using percentiles, resulting in approximately 12.5% in each group.

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Short communication

Effects of age and growth rate at onset of boar exposure on oestrus manifestation and first farrowing performance of Landrace × large white gilts

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Effects of age and growth rate at onset of boar exposure on oestrus manifestation and first farrowing performance of Landrace x Large White gilts

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ABSTRACT

The objective of this study was to evaluate the effects of age and growth rate until the onset of boar exposure on oestrus manifestation and reproductive performance in Landrace x Large White crossbred gilts (DanBred). Gilts were retrospectively classified into groups according to age at boar exposure – BE (140-155 and 156–170 days) and in three classes of growth rate (GR) at BE (Low GR: 500–575 g/d; Intermediate GR: 580–625 g/d; and High GR: 630–790 g/d). Overall, gilts had an average weight of 105.4 ± 0.53 kg and age of 170.6 ± 0.41 days at their first oestrus. There was no significant effect of age x GR interaction (P > 0.05) on weight and age at first oestrus, interval between boar exposure and oestrus (BEOI), and percentages of gilts showing oestrus. Gilts exposed at 140-155 days of age showed oestrus at a lower age (167.6 ± 0.76 vs. 173.7 ± 0.73 days) but with similar BEOI (15.1 ± 0.75 vs. 14.2 ±

0.73 days) and weight (104.7 ± 1.04 vs. 105.5 ± 1.00 kg) compared with gilts exposed at 156-170 days ($P < 0.05$). Gilts exposed to boar at 140-155 days had lower oestrus manifestation (60.8 vs. 77.0%) within 30 days than those exposed at 156-170 days of age. High GR gilts showed the first oestrus at a lower age (169.3 ± 0.78 vs. 172.1 ± 0.82 days of age) and had a shorter BEOI (13.5 ± 0.77 vs. 16.0 ± 0.81 days) than Low GR gilts ($P < 0.05$). Lower percentages of gilts in oestrus within 30 days after BE ($P < 0.05$) were observed in Low GR and Intermediate GR gilts (65.5 and 64.3%) than in High GR gilts (74.3%). Farrowing rate and number of total born piglets were neither affected by age and GR at onset of boar exposure nor by their interaction ($P > 0.05$). In conclusion, first oestrus manifestation is greater when gilts are exposed to boars after 155 days of age or with a GR >625 g/d. Provided that gilts are bred with a minimum of 130 kg, the reproductive performance is not affected by age or GR at boar exposure.

Keywords: boar effect, anoestrous, first oestrus, replacement gilts, modern genotypes

1. Introduction

Induction to puberty in gilts through a boar contact stimulus is already well established, and it is known that age and growth rate at boar exposure can influence the age at puberty (Foxcroft et al., 2005, Amaral Filha et al., 2009, Kummer et al., 2009), and consequently the age of mating. As the age at exposure increases, the interval between boar exposure and puberty is shortened, even in genotypes with later physiological maturity (Patterson et al., 2002; Van Wettere et al., 2006).

Potential breeding herd reproductive efficiency increases as the number of non-productive days (NPD) associated with gilt development are decreased (Rozeboom et al., 1995). Since low growth rate and unnecessary delays in stimulating oestrus are important contributors to NPD in the herd (Lucia et al., 2000; Patterson et al., 2003), achieving puberty and first service earlier can be an efficient strategy to reduce NPD.

As age at puberty can be genetically influenced (Evans and O'Doherty, 2001), different targets for breeding of gilts are recommended by dam-lines companies. Onset of puberty stimulation in Danbred gilts is usually recommended at 190-200 days of age (Ketchem and Rix, 2009; DB Genética Suína, 2013). Nevertheless, the fact that some Danbred gilts have high growth rates and can reach the recommended breeding weight faster, offers the opportunity to start stimulation with boars when gilts are 160-170 days old (DB Genética Suína, 2013). Within this context, it would be important to know the effects of body development and age at boar exposure on oestrus manifestation with the purpose of establishing criteria for the onset of puberty stimulation. The aim of this study was to evaluate the effects of age and growth rate until the onset of boar exposure on first oestrus manifestation and reproductive performance in Landrace x Large White crossbred gilts.

2. Material and Methods

2.1 Animals and location

The study was performed on a commercial multiplier pig farm with 5300 sows, located in Midwest region of Santa Catarina State (27°16'58"S, 50°35'04"W, altitude 987 m), southern Brazil, during spring and summer seasons. A total of 665 Landrace x Large White gilts (DanBred), housed on the same farm from birth onwards, were selected during 13 consecutive weeks to be exposed to mature boars (more than 12 months of age) for puberty induction. Gilts with apparent health problems, defective hooves and angulations, excessive callus and those with infantile vulva were excluded. Only gilts with a minimum of 14 functional teats, and with a growth rate (GR) above

500 g/d were analysed. The GR was considered the daily gain from birth until boar exposure.

2.2 Management

The gilts were housed in 3.80 x 4.00 m pens with partially slatted floor, semiautomatic feeders and two water nipple drinkers. Each pen contained 12 to 15 gilts. They were fed *ad libitum* with a standard corn-soybean diet, formulated to contain 18.1% protein, 0.98% lysine and 3097 Mcal ME kg^{-1}.

Boar contact started immediately after selection of gilts to entry in the herd and was provided once a day, every morning, by 10 min of direct contact, in the pen where gilts were housed. In total, 12 boars of the same genetic line (Landrace x Large White) were used in a rotation system performed by replacing the boar used in the morning by another one in the next morning. While the boar was present, gilts were back pressure tested and oestrus manifestation was recorded. The gilts were tested until 30 days after the onset of boar exposure. Gilts that did not show oestrus within 30 days after initial exposure to boars were defined as being anoestrous. These gilts received 400 IU eCG + 200 IU hCG (PG600®; MSD-Animal Health) and were followed for more 30 days for oestrus detection. After oestrus being detected, the cycling gilts were weighed and transferred to individual crates where they received 3 kg of the standard diet described above, twice a day. They had free access to water throughout the experimental period. Gilts were mated with a minimum of 130 kg of weight and with at least two manifested oestrus.

2.3 Groups

Gilts were retrospectively classified in two groups according to their age at boar exposure (BE): 140-155 days (mean = 151.6 d; n= 365) and 156–170 days (mean = 159.7 d; n= 300). Gilts from each group were distributed into three classes according to their GR from birth to BE: Low GR (500–575 g/d; mean= 544.8 g/d; n= 223), Intermediate GR (580–625 g/d; mean = 601.0 g/d; n= 216) and High GR (630–790 g/d; mean = 670.8 g/d; n= 226). The groups were formed in order to have approximately 50% of gilts in each age group and approximately 33% in each GR group.

2.4 Statistical Analysis

All data were analysed using the software Statistical Analysis System (SAS) version 9.1 (SAS, 2005). Differences were considered significant at $P < 0.05$. Throughout the text, numerical data are expressed as LS means ± SEM or in percentages, according to the variable type. Data concerning age at first oestrus, boar exposure-oestrus interval (BEOI), and number of total born piglets in the first farrowing were analysed using the MIXED procedure. Comparisons were performed using the Tukey-Kramer’s test. Percentages of gilts in oestrus within 10, 20 and 30 d after BE and farrowing rate were analysed using logistic regression models (GLIMMIX procedure). All the models included fixed effects of age, GR, age x GR interaction as well as random effects of the week of boar exposure onset and littermate. For the analysis of farrowing rate and total born piglets, models also contained fixed effect of oestrus number at mating. Only gilts that showed oestrus within 30 days were included in analyses concerning age and weight at first oestrus, BEOI, farrowing rate and litter size.

3. Results

On average, gilts were 155.3 ± 0.2 days old, weighed 94.0 ± 0.3 kg, and had a GR of 605.9 ± 2.2 g/d by the time of boar exposure. Overall, oestrus manifestation occurred in 25.7, 50.8 and 68.1% of gilts within 10, 20 and 30 days after boar exposure, respectively.

There was no significant effect of age x GR interaction on weight and age at first oestrus, as well as on BEOI and percentages of gilts showing oestrus after boar exposure ($P > 0.05$). Gilts exposed at 140-155 days of age showed oestrus at a similar weight, but at a lower age than gilts exposed at 156-170 days (Table 1). Gilts exposed at 156-170 days had greater oestrus manifestation within 10, 20 and 30 days ($P < 0.05$) after boar exposure than gilts exposed at 140-155 days of age (Table 2). Weight at first oestrus differed ($P < 0.001$) among all GR classes (Table 1). First oestrus manifestation occurred at a lower age in High GR gilts compared with Low GR gilts, but they did not differ from Intermediate GR gilts. High GR gilts had ($P < 0.05$) shorter BEOI than Low GR gilts. High GR gilts had greater oestrus manifestation within 20 and 30 days ($P < 0.05$) than Low and Intermediate GR gilts (Table 2). There was no effect ($P > 0.05$) of age, GR and age x GR interaction on farrowing rate and number of total piglets born at first farrowing (Table 2).

4. Discussion

Gilt management concerning puberty induction aims at high oestrus manifestation after boar exposure. In a well-managed farm, approximately 85% of gilts should manifest oestrus within 3 or 4 weeks after initial contact with boars (Foxcroft et al., 2005). In a previous study, a high growth rate was important for oestrus manifestation in gilts exposed to boar contact before 150 days of age (Amaral Filha et al., 2009). However, in the present study, both age and growth rate at boar exposure affected first oestrus occurrence in Landrace x Large White gilts. Satisfactory results were obtained when gilts were stimulated at 156-170 days of age, with 77% of them showing oestrus within 30 days after boar exposure. On the other hand, oestrus manifestation in gilts exposed to boars at 140-155 days of age (61%) was below the range of 75% to 84% observed in gilts of other genotypes, when stimulated at approximately 140 days of age (Patterson et al., 2003; Amaral Filha et al., 2009; Kummer et al., 2009).

The overall mean age at first oestrus (171 days) was lower than that reported for Danbred gilts (222 days) exposed to boars at approximately 180 days of age (Moeller et al., 2004). In a previous study performed with gilts of the same genotype (Ribeiro et al., 2012), a lower oestrus rate in gilts exposed at 150 and 170 days of age was observed when compared to gilts exposed to a mature boar after 200 days of age (47% and 49% vs. 80%, respectively). The shorter interval to show oestrus when gilts were exposed to boars at 155-170 days of age corroborates results of previous studies (Van Wettere et al., 2006; Amaral Filha et al., 2009). As puberty onset is dependent on maturation of the hypothalamic-pituitary-gonadal axis, especially concerning LH action (Evans and O'Doherty, 2001), it is likely that gilts exposed to boars later have greater maturity of the reproductive axis, hence showing a faster response to boar stimulation and greater synchrony in manifestation of the first oestrus (Van Wettere et al., 2006; Amaral Filha et al., 2009).

Differences in age at puberty or reproductive performance of swine females may be attributed to genetic line differences (Evans and Doherty, 2001; Moeller et al., 2004; Miller et al., 2011), indicating that traditional management practices concerning puberty induction should be adapted according to genotypes. In the present study, successful first oestrus induction in Landrace x Large White gilts was possible at a lower age (~160 days of age) than the usual recommendation of approximately 200 days of age (Ketchem and Rix, 2009). This implies that advancing the start of puberty stimulation may advance the first mating, without incurring in excessive NPD.

For the genotype evaluated in the present study, the threshold to obtain high percentages of oestrus manifestation was shown to be a growth rate above 625 g/d, quite close to 600 g/d, which was suggested for other genotypes (Foxcroft et al., 2005). The greater percentage of oestrus manifestation in gilts with a GR >625 g/d is in agreement with the assumption that if the growth rate is greater than 620 g/d (Kirkwood and Thacker, 1992), or with maximal rates of protein accretion, sexual precocity seems to be limited more by innate variability in LH secretion than by growth performance (Beltranena et al., 1993). High GR gilts were likely to be physiologically more mature in terms of a possible minimum threshold of weight, lean:fat ratio, fatness or rate of body reserve accumulation (Hughes, 1982; Kirkwood and Aherne, 1985) which are necessary for responsiveness to boar contact. Considering the recommendation of age and weight at mating (DB Genética Suína, 2013), the expected growth rate (600-650 g/d) for the genetic line studied seems to be lower than that reported for other genetic lines (Amaral Filha et al., 2009). In the present study, only 34% of gilts reached the threshold of >625 g/d at boar exposure contrasting with 75% of gilts with a growth rate >649 g/d reported by Amaral Filha et al. (2009).

Similarly to results of Kummer et al. (2009), farrowing rate and litter size were not affected by age or growth rate at boar exposure, probably because the minimum weight of 130 kg was taken into account for breeding the gilts of the present study. In order to ensure a high percentage of gilts with an adequate breeding weight at their second or third oestrous, it is important to emphasise that both the age and growth rate criteria should be taken into account to start puberty stimulation. For gilts exposed to boars at the age that provided the best results in terms of oestrus manifestation (156-170 days of age), the target breeding weight was easily reached by gilts with a GR >625 g/day at their second (69.6%) or third (29.0%) oestrus. On the other hand, based on the mean weight at first oestrus, reached by gilts with a GR between 580-625 g/day (104 kg), they would need to be bred at their third or even fourth oestrus in order to have an adequate breeding weight. Indeed, within the group exposed to boars at 156-170 days, more gilts with a GR >625 g/day were bred at their second oestrus (69.6%; 48/69) than gilts with a GR of 500-625 g/day (31.6%; 48/152).

5. Conclusions

Growth rate and age at boar exposure affect the first oestrus manifestation in Landrace x Large White gilts. Greater percentages of oestrus manifestation within 30 days after boar exposure are observed in gilts exposed to boars at an older age (156-170 vs. 140-155 days of age), or if they have a greater growth rate (630-790 g/d vs. 500-625 g/d). Farrowing rate and number of piglets born in the first farrowing are not affected by growth rate or age at boar exposure.

Conflict of interest statement

None of the authors have any conflicts of interest to declare.

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Table 1

Effects of age and growth rate at boar exposure on weight and age at first oestrus, and on the boar exposure-oestrus interval (BEOI) of gilts (Least squares means ± standard error of mean).

Variable	Age, days	Growth rate, g/day			Mean
		500-575	580-625	630-790	
Weight at 1st oestrus, kg	140-155	97.0±1.47	104.7±1.37	112.4±1.25	104.7±1.04
	156-170	99.0±1.25	104.0±1.37	113.4±1.35	105.5±1.00
	Mean	98.0±1.09a	104.4±1.09b	112.9±1.05c	
Age at 1st oestrus, days	140-155	168.5±1.18	167.8±1.08	166.5±0.97	167.6±0.76a
	156-170	175.6±0.98	173.4±1.09	172.2±1.07	173.7±0.73b
	Mean	172.1±0.82a	170.6±0.82ab	169.3±0.78b	
BEOI, days	140-155	16.4±1.16	15.1±1.07	13.8±0.96	15.1±0.75
	156-170	15.7±0.96	13.6±1.07	13.2±1.05	14.2±0.73
	Mean	16.0±0.81a	14.4±0.82ab	13.5±0.77b	

abc Values followed by different lowercase letters within row or column are significantly different ($P < 0.05$).

Analyses included gilts that showed oestrus within 30 days after boar exposure.

Table 2

Effects of age and growth rate on oestrus manifestation, at 10, 20 and 30 days after boar exposure, and reproductive performance of gilts.

Variable	Age, days	Growth rate, g/day			Mean
		500-575	580-625	630-790	
Oestrus at	140-155	16.8 (17/101)	17.5 (22/126)	28.2 (39/138)	21.4a
10 days, %	156-170	25.4 (31/122)	34.4 (31/90)	35.2(31/88)	31.0b
	Mean	21.5a	24.5ab	31.0b	
Oestrus at	140-155	37.6 (38/101)	39.7 (50/126)	53.6 (74/138)	44.4a
20 days, %	156-170	51.6 (63/122)	60.0 (54/90)	67.0 (59/88)	58.7b
	Mean	45.3a	48.1a	58.8b	
Oestrus at	140-155	56.4 (57/101)	55.6 (70/126)	68.8 (95/138)	60.8a
30 days, %	156-170	72.9 (89/122)	76.7 (69/90)	82.9 (73/88)	77.0b
	Mean	65.5a	64.3a	74.3b	
Farrowing	140-155	92.2 (47/51)	89.4 (59/66)	94.2 (82/87)	92.2
Rate, %	156-170	95.3 (81/85)	95.5 (64/67)	89.9 (62/69)	93.7
	Mean	94.1	92.5	92.3	
Number of total	140-155	16.0±0.50	15.8±0.43	15.5±0.41	15.8±0.30
piglets born at	156-170	15.6±0.37	15.0±0.44	15.3±0.46	15.3±0.28
1^{st} Farrowing	Mean	15.8±0.33	15.4±0.34	15.4±0.35	

ab Values followed by different letters within row or column are significantly different ($P < 0.05$) for each variable analysed through logistic regression.

Interaction between age and growth rate had no effect ($P > 0.05$) on oestrus manifestation or on reproductive performance.

Analyses of farrowing rate and number of piglets born (Least squares means ± standard error of mean) included gilts showing oestrus within 30 days after boar exposure.

6. CONSIDERAÇÕES FINAIS

A importância do peso ao nascimento cresce à medida que a seleção de fêmeas para a produção de um número maior de leitões é parte intensa de programas de melhoramento genético das empresas responsáveis por esse setor na cadeia produtiva. Entretanto, há a necessidade de adequações, ou intensificação, dos programas de seleção para que atendam também a sobrevivência dos leitões nos primeiros dias de vida, carregando consigo características de viabilidade e por consequência do peso ao nascimento.

Em nível prático, identificar que possíveis interferências ambientais intensificam as respostas no desenvolvimento dos conceptos é importante para auxiliar em práticas diárias, passíveis de manipulação, que efetivam uma melhora no desempenho. Intensificar manejos, especialmente voltados à nutrição da matriz durante a gestação é uma das principais ações necessárias no ambiente de granja. Além disso, ter atenção especial com leitoas destinadas ao plantel reprodutivo, especialmente por se tratar de uma categoria que irá gerar o desenvolvimento genético do sistema de produção. Isso traz a oportunidade de estabelecer possíveis critérios técnicos que nos permitam identificar precocemente matrizes que tenham maior risco de comprometer o desempenho reprodutivo subsequente.

Baseando-se nos resultados obtidos em nossos estudos, é possível afirmar que o desenvolvimento intrauterino causa impacto no desenvolvimento e na mortalidade quando jovens e no desempenho reprodutivo de matrizes quando adultas. Entretanto, todo esse processo implica em continuar a realizar estudos e avaliações mais detalhadas dos processos fisiológicos que levam a alterações na morfologia e desempenho dos animais.

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