UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
FACULDADE DE MEDICINA VETERINÁRIA

EFEITO DE UM SISTEMA DE RESFRIAMENTO ADIABATICO EVAPORATIVO CONDUZIDO POR DUCTOS NA PERFORMANCE DE FÊMEAS SUINAS EM LACTAÇÃO E SUAS LEITEGADAS.

Autor: Jonas Perin

PORTO ALEGRE
2013/1

UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

FACULDADE DE MEDICINA VETERINÁRIA

EFEITO DE UM SISTEMA DE RESFRIAMENTO ADIABATICO EVAPORATIVO CONDUZIDO POR DUCTOS NA PERFORMANCE DE FÊMEAS SUINAS EM LACTAÇÃO E SUAS LEITEGADAS.

Autor: Jonas Perin

Matrícula:00172745

Orientador: Fernando Pandolfo Bortolozzo

Co-orientadora: Thais Schwarz Gaggini

Trabalho de conclusão de curso apresentado
à Universidade Federal do Rio Grande do Sul
como requisito parcial para a obtenção do título
de Graduação em Medicina Veterinária.

PORTO ALEGRE

2013/1

AGRADECIMENTOS

.

Agradeço a Deus por me iluminar.

A minha mãe Gilmara, meu pai Jandir, minha irmã Julia pelo apoio, carinho, educação, amor e por sempre estarem ao meu lado.

A minha namorada Renata, pelo apoio incondicional e por ter estado ao meu lado dia após dia nestes dois últimos anos.

Ao meu orientador e amigo Fernando Pandolfo Bortolozzo pelos conselhos e ensinamentos passados durante todos esses anos.

A professora Mari Lourdes Bernardi pela amizade, disponibilidade e ajuda, pois sem ela este trabalho não teria uma análise estatística.

Ao grande amigo e companheiro Diogo Magnabosco, por todo o apoio, ajuda e conselhos transmitidos nestes mais de quatro anos.

A minha co-orientadora Thais Schwarz Gaggini pela ajuda.

A todos amigos do Setor de Suínos da UFRGS, por todo conhecimento obtido e pelos belos momentos convividos.

A empresa Master® e Agroceres PIC® por permitir e apoiar que este trabalho fosse realizado.

A UFRGS por me proporcionar um ensino de altíssima qualidade.

RESUMO

A manutenção de matrizes suínas fora da sua zona de conforto térmico durante a fase lactacional implica em prejuízos para as fêmeas e suas leitegadas. As fêmeas apresentam uma redução no consumo de ração e tem seu catabolismo lactacional acentuado, podendo ter reflexos negativos no seu desempenho reprodutivo subsequente. Além disso, há uma redução na produção de leite e desempenho dos leitões. O estresse térmico é um desafio para a espécie suína (devido sua dificuldade em dissipar calor) que tem como principal alternativa para perder calor em altas temperaturas o uso da respiração. Alternativas estruturais como sistemas de gotejamento, ventilação, pisos refrigerados e sistemas de refrigeração evaporativos adiabáticos tem sido utilizados na tentativa de amenizar o estresse térmico e reduzir as perdas ocasionadas pelo calor. O objetivo deste estudo foi comparar e avaliar a influência de um sistema tradicional de controle de temperatura (manejo de cortinas - sistema utilizado em granjas no Brasil), frente a um sistema de climatização com ar refrigerado conduzido sobre as fêmeas suínas na maternidade, avaliando os aspectos produtivos das fêmeas e de suas leitegadas. Foram pesadas, no pós-parto e ao desmame, 241 fêmeas para avaliar a porcentagem de perda de peso durante a lactação. Para avaliar o consumo voluntário de ração e o desempenho das leitegadas foram utilizadas 71 fêmeas (32 primiparas e 39 multiparas), sendo o controle de arraçoamento realizado a cada quatro dias e os leitões pesados após a uniformização e aos 18 dias de idade. Foi realizado diariamente o controle de temperatura retal de 24 fêmeas e o registro da temperatura externa. As fêmeas alojadas em salas convencionais perderam mais peso (5.3±0.9% e 2.2±0.9%, respectivamente; $P<0.05$), e consumiram menos ração (4.8±0.2 e 5.8±0.2 kg/dia, respectivamente; $P<0.05$) frente as alojadas em salas climatizadas, além de desmamarem leitegadas mais leves (60.7±1.4 e 65.3±1.4 kg, respectivamente; $P<0.05$). As primiparas alojadas em salas sem climatização apresentaram um intervalo desmame estro maior que as alojadas em salas com climatização (10.9±1.3 e 7.0±1.2 dias, respectivamente; $P<0.05$). Em conclusão, as fêmeas alojadas em sala climatizada apresentam um maior consumo de ração, menor catabolismo lactacional e desmamam leitões com maior peso que as fêmeas alojadas em sala sem climatização, e ainda há uma redução no intervalo desmame estro das primiparas.

Palavras chave: Estresse térmico, consumo voluntário de ração, catabolismo lactacional das fêmeas, peso dos leitões.

ABSTRACT

Maintaining sows outside your comfort zone heat during the lactation implies losses for the sows and their litters. The sows show a reduction in feed intake and lactational catabolism has its sharp and may have negative effects on their subsequent reproductive performance. Furthermore, have a reduction in milk production and performance of piglets. Heat stress is a challenge for swine (due to their difficulty in dissipating heat) whose main alternative to lose heat at high temperatures using the breath. Structural alternatives such as drip systems, ventilation, chilled floors and adiabatic evaporative cooling systems have been used in attempts to reduce thermal stress and reduce losses caused by heat. The aim of this study was to compare and evaluate the influence of a traditional system of temperature control (management of curtains - system used on farms in Brazil), compared to an air conditioning system with air-cooled conducted on the sows in maternity, evaluating the productive aspects of females and their litters. Were weighed, postpartum and at weaning, 241 sows to assess the percentage of weight loss during lactation. To assess the voluntary feed intake and the performance of piglets were used 71 females (32 primiparous and 39 multiparous), and the control feeding performed every four days and the heavy piglets after standardization and 18 days of age. Was performed daily control of rectal temperature of 24 sows and external temperature record. Sows housed in conventional rooms lost more weight (5.3 ± 0.9% and 2.2 ± 0.9%, respectively, P <0.05), and higher feed intake (4.8 ± 0.2 and 5.8 ± 0.2 kg/day, respectively, P <0.05), forward housed in the air-conditioned rooms, plus lighter weaned piglets (60.7 ± 1.4 and 65.3 ± 1.4 kg, respectively, P <0:05). The primiparous housed in rooms without air conditioning had a range greater than the weaning-to-oestrus interval housed in rooms with climate control (10.9 ± 1.3 and 7.0 ± 1.2 days, respectively, P <0:05). In conclusion, sows housed under controlled temperature conditions have a higher feed intake, reduced catabolism lactation and weaned piglets with higher weight than sows housed in a room without air conditioning, and there is still a reduction in the interval weaning estrus of primiparous.

Keywords: Heat stress, voluntary feed intake, catabolism of lactating sows, weight of piglets.

SUMÁRIO

1 INTRODUÇÃO

O Brasil encontra-se em uma posição de destaque no mercado mundial de carne suína. O país é o quarto maior produtor, estando atrás somente da China (maior produtor), União Europeia e Estados Unidos. Também é o quarto maior exportador desta carne, perdendo apenas para os Estados Unidos, União Europeia e Canadá (ABIPECS, 2013). As exportações de carne suína brasileira, no entanto, vêm perdendo espaço no mercado mundial (passando de 625 mil toneladas exportadas em 2005 para 550 mil toneladas em 2012), mas, ao mesmo tempo, busca adequar-se as normas sanitárias para atingir novos mercados, como China e Japão. O mercado interno é o principal destino da carne suína e alem disso tem sido fortalecido nos últimos anos através de campanhas promocionais do consumo de carne in natura, possibilitando absorver o excedente da produção retida no país, gerando um aumento do consumo per capita de 11,6 kg/habitante/ano em 2005 para 15,2 em 2012 (ABIPECS, 2013).

O plantel total de matrizes se manteve estável nos últimos anos, fechando 2012 com 2.379 milhões de cabeças. Cerca de 70% deste plantel encontra-se em sistemas industriais (produção tecnificada) e 30% são matrizes alocadas em criações de subsistência (ABIPECS, 2013). O plantel brasileiro de matrizes suínas se concentra na região sul (Rio Grande do Sul, Santa Catarina e Paraná), sudeste e centro oeste (60, 20 e 15%, respectivamente). Nos últimos anos houve uma expansão do plantel de suínos na região centro oeste, devido a maior facilidade logística na oferta de grãos (milho e soja) e a menor concentração de granjas.

A posição de destaque do Brasil no cenário mundial da carne suína se deve a uma suinocultura de alta tecnificação e com vários avanços genéticos, aperfeiçoamento de manejos, qualificação da mão de obra e a melhoria das instalações. Estes itens são de extrema importância para a eficiência produtiva e lucratividade.

O Brasil é um país continental, o quinto maior país em extensão territorial (8.5 milhões de km^2) e possui clima distinto nas diversas regiões e estações do ano, sendo influenciado por massas de ar equatoriais, tropicais e polares (Almeida; Tersio, 2004). A região sul (maior produtora de suínos) possui clima subtropical, com estações bem definidas. A temperatura média anual e a amplitude térmica são próximas a 18 e 10°C, respectivamente, com invernos frios (temperaturas inferiores que podem chegar a 0°C) e verões muito quentes (ultrapassando 30°C). Já a região centro oeste (região em franca expansão na suinocultura), apresenta um clima tropical, com temperaturas elevadas (de 18-28°C) durante todo o ano e com menor amplitude térmica (5-7°C) com regimes de chuva bem definidos em dois períodos anuais. A região sudeste, por sua vez, também apresenta clima tropical, porém, com temperaturas mais baixas no inverno (Almeida; Tersio, 2004).

A manutenção de temperaturas adequadas aos animais é um desafio na produção de suínos, sendo agravada na maternidade. As fêmeas em lactação apresentam uma Zona de Conforto Térmico (ZCT) entre 12 e 22°C (BLOEMHOF *et al.*, 2008). Quando expostas a temperaturas acima da ZCT, tem seu consumo de ração reduzido, comprometendo a produção de leite e desempenho dos leitões, além de aumentar seu catabolismo lactacional e desempenho reprodutivo subsequente (RENAUDEAU; NOBLET, 2001; THAKER; BILKEI, 2005; FARMER *et al*., 2006). Já os leitões neonatos têm a ZCT entre 32 a 34°C (BERTHON *et al.* 1993), apresentando assim um grande desafio de manutenção de temperatura dentro da maternidade, a fim de atender duas zonas tão distintas de temperatura.

No sistema brasileiro não existe uma padronização no modelo das instalações para criação de suínos por diversos fatores, entre eles podemos citar a diferença de temperatura e clima entre as regiões, falta de subsidio e alto custo para construção das instalações. Esta falta de padronização, além de afetar o desempenho dos animais, dificulta a avaliação do efeito da temperatura sobre os mesmo, dificultando estudos que auxiliam estimar as perdas causadas pelo stress térmico. Especula-se que os prejuízos na suinocultura brasileira são substanciais, já que se tem baixo controle de temperatura nas instalações. Já nos EUA, estima-se que o prejuízo anual relacionado ao stress térmico é da ordem de U$ 299 milhões (ST-PIERRE *et al*., 2003).

A suinocultura brasileira, deste modo, tem entre seus desafios, propiciar aos animais uma temperatura adequada (dentro da zona de conforto térmico) que possibilite a maximização da performance reprodutiva das fêmeas e que não comprometa o desempenho dos leitões.

O objetivo deste estudo foi comparar e avaliar a influência de um sistema tradicional de controle de temperatura (manejo de cortinas), sistema mais utilizado nas granjas brasileiras, frente a um sistema de climatização com ar refrigerado conduzido sobre as fêmeas suínas na maternidade. Este sistema de climatização possui receptores de temperatura ambiente localizados no centro da sala, sendo responsáveis pela ativação e desativação do sistema.

2 REVISÃO DA LITERATURA

2.1 Mecanismos de termo regulação em suínos

Os suínos são animais homeotérmicos e produzem calor através de sua alta taxa metabólica (DUKES, 2006) necessitando, desta forma, trocar calor continuamente com o ambiente. A taxa metabólica pode ser influenciada pelo plano nutricional e pelo ambiente em que o animal está inserido (QUINIOU; NOBLET, 1999). Contudo, os suínos adultos possuem mecanismos de perda de calor relativamente fracos, sendo o principal deles a chafuração (mergulhar em lama para que haja perda evaporativa de calor) (DUKES, 2006). Atualmente, com os sistemas intensivos de criação (animais confinados) torna-se impraticável esta forma de termo regulação, encontrando-se, os suínos, inseridos em um micro ambiente onde a temperatura, umidade relativa do ar e a velocidade do vento são os principais componentes que afetam a sua termorregulação. Além disso, outros fatores como o peso, idade e a genética dos animais podem gerar variação na zona de conforto térmico dentro das diferentes classes de suínos (HANNAS *et al*., 1999).

A temperatura ideal para os suínos varia ao longo de sua vida e os animais apresentam uma diminuição das exigências térmicas com o passar do tempo. Para os leitões recém-nascidos a temperatura ideal fica em torno dos 30°C e para animais adultos a temperatura deve ser inferior a 24°C (HARTMANN *et al*., 1997). A umidade relativa do ar, por sua vez, assume importante papel como facilitador ou complicador da liberação de calor pela via evaporativa (respiração), uma vez que os suínos não possuem glândulas sudoríparas ativas (apenas algumas no focinho e escassamente em outros pontos do corpo) e dependem deste mecanismo para termo regulação (principalmente quando as temperaturas excedem os 30°C) (SORENSEN, 1964). A umidade relativa do ar não deve, desta forma, ultrapassar 70% (SAMPAIO *et al.,* 2004), pois a umidade acima quando excede este valor aumenta sensação térmica de calor. A velocidade do vento age na termorregulação dos suínos dissipando o calor proveniente da radiação, condução e convecção. Segundo Sainbury (1972), 35% das perdas de calor nos suínos ocorrem por convecção, 40% por radiação e 15% por condução, demonstrando desta forma a importância em dissipar todo o calor produzido. A velocidade do ar ideal para os leitões lactentes é entre 0,1 e 0,2 m/s e para as fêmeas entre 0,1 e 0,3 m/s (MOURA, 1999).

Na maternidade existe uma incompatibilidade na ZCT entre as matrizes e os leitões. Segundo Bloemhof *et al*. (2008), a ZCT para fêmeas suínas é entre 12 e 22°C e, de acordo com Berthon *et al*. (1993), a zona de termoneutralidade para leitões neonatos é de 32 a 34°C. Segundo Ferreira (2001), a habilidade de leitões recém nascidos de regular sua temperatura corporal é limitada, devido o seu desenvolvimento hipotalâmico ainda incompleto, a pequena quantidade de gordura subcutânea e pelas poucas reservas de glicogênio corporal. Desta forma a maternidade é o setor que apresenta maior desafio em relação a manutenção do conforto térmico para os suínos.

2.2 Efeitos do estresse pelo calor

As fêmeas apresentam mudanças comportamentais e fisiológicas quando expostas a temperaturas acima da sua zona de conforto térmico. No trabalho realizado por Oliveira Junior *et al*. (2011), foi observado um aumento na frequencia respiratória e no tempo que as fêmeas ficam no bebedouro quando expostas a diferentes salas de maternidade em altas temperaturas.

Além das mudanças comportamentais, as fêmeas apresentam mudanças em seus níveis hormonais ao serem submetidas a estresse térmico. Há uma redução na concentração de insulina e glucagon circulantes em fêmeas submetidas a altas temperaturas (MESSIAS DE BRAGANÇA; PRUNIER, 1999) e uma redução nos níveis circulantes de triiodotironina (T3) e tiroxina (T4) (PRUNIER; MESSIAS DE BRAGANÇA; LE DIVIDICH, 1997), podendo resultar em efeitos negativos sobre a mobilização de reservas corporais para a produção de leite (FERREIRA *et al*., 2007).

As altas temperaturas no período lactacional causam uma redução no consumo voluntário de ração e aumento na perda de peso das fêmeas (FARMER *et al.*, 2006; PRUNIER *et al.*, 1997). Estudo realizado por Quiniou; Noblet, (1999), constatou que fêmeas suínas, quando alojadas a 18 e 29°C, apresentam um decréscimo no consumo diário de ração (5,6 vs. 3,1 kg/dia), e maior perda de peso durante a lactação (23 vs. 35 kg), respectivamente. Já no estudo realizado por Silva *et al*. (2006), foi observado um maior consumo de ração (6.47 vs. 5.61 kg/dia) e maior perda de peso (5.8 vs.−2.8 kg) durante a lactação, nas fêmeas alojadas em piso refrigerado frente as alojadas em piso não refrigerado, respectivamente. Contudo, as fêmeas alojadas em piso refrigerado também apresentaram maior produção de leite (8.05 vs. 10.20 kg/fêmea/dia), explicando seu maior catabolismo lactacional. Já no estudo realizado por Morales, (2010), utilizando três sistemas de climatização (ambiente climatizado (AC), ar sobre as fêmeas (ASF) e manejo de cortinas (MC)), e três repetições durante a fase de lactação, não foi observado diferença no percentual de perda de peso das fêmeas em nenhuma das repetições. Contudo, o consumo voluntário de ração na primeira repetição foi maior no grupo AC que nas demais repetições e na terceira repetição o consumo de ração no grupo AC foi maior que no ASF que, por sua vez, foi maior que no MC, não sendo observado diferença estatística apenas na segunda repetição. Messias de Bragança *et al.* (1999), constataram uma diminuição de 43% no consumo voluntário de ração quando as fêmeas são alojadas a temperaturas que passam de 20 para 30°C e Black *et al.* (1993) sugeriram que fêmeas de aproximadamente 200 kg apresentam uma redução no consumo de 0,17 kg/dia para cada 1°C em que a temperatura aumente entre 16 e 32°C. Deve-se ainda ressaltar que o consumo de ração durante a lactação não é suficiente para suprir a mantença e manter a produção de leite (REVELL *et al.*, 1998), e assim o estresse pelo calor, por comprometer o consumo de ração, acaba exacerbando o catabolismo lactacional (RENAUDEAU; ANAÍS; NOBLET, 2003)

Fraser; Phillips (1989) relataram uma relação positiva entre o consumo de água pelas fêmeas e o ganho de peso de suas leitegadas. Jeon *et al.* (2006), observaram que fêmeas expostas a temperaturas acima de 29°C e que receberam água refrigerada, tiveram uma redução na frequencia respiratória, quando comparadas as fêmeas que receberam água em temperatura ambiente. Além disso, as fêmeas que recebiam água refrigerada apresentaram menor temperatura retal, um aumento de 40% no consumo voluntário de ração, de 22% no consumo de água e de 20% na produção de leite. Todos estes fatores auxiliam na redução do catabolismo lactacional e melhor desempenho da leitegada durante a lactação.

A maior perda de peso durante a lactação pode causar efeitos negativos na taxa de parto, intervalo desmame estro (IDE) e número de leitões nascidos no parto subsequente (THAKER; BILKEI, 2005), porém os dados na literatura são contraditórios. Segundo Thaker; Bilkei (2005), a perda de peso na lactação exerce um efeito quadrático no IDE, apresentando um aumento significativo quando o percentual de perda de peso é superior a 5% em primíparas e 10% em multíparas. Além do IDE, houve um efeito negativo na taxa de parto subsequente e número de leitões nascidos totais (em primíparas), quando a perda de peso foi superior a 10%. Resultado semelhante foi encontrado por Prunier *et al*. (1997), onde as fêmeas multíparas expostas a 27°C perderam mais peso e tiveram um maior IDE que as fêmeas expostas a 18°C. Já no estudo realizado por Silva *et al*. 2006, ao utilizar um sistema de piso refrigerado sob as fêmeas, não foi observado diferença no IDE (talvez pelo catabolismo lactacional ser inferior a 3%). Em contrapartida, Silva *et al.* 2009 em um trabalho subsequente utilizando o mesmo sistema porém com outra linhagem genética, observou diferença no IDE.

Além destes efeitos diretos sobre a fêmea, o estresse térmico compromete o desempenho dos leitões durante a fase lactacional, principalmente devido a redução na produção de leite (RENAUDEAU; NOBLET, 2001). Segundo os mesmos autores, há uma diminuição na produção de leite (10.43 para 7.35 kg/dia) e no ganho de peso dos leitões (272 para 203 g/dia), ao aumentar a temperatura ambiente de 20°C para 29°C, respectivamente. Da mesma forma, ao tentar reduzir o estresse térmico das fêmeas suínas com a utilização de piso refrigerado, Silva *et al.* (2006) observaram uma menor produção de leite (8.05 vs. 10.20 kg/dia) e menor ganho de peso dos leitões (202 vs. 257 g/dia) quando as fêmeas são alojadas em piso sem refrigeração frente ao refrigerado, respectivamente. Um maior peso ao desmame de leitões provenientes de fêmeas alojadas em salas climatizadas (AC e ASF) também foi observado no trabalho de Morales, (2010). O efeito da temperatura sobre a composição do leite apresenta dados contraditórios na literatura. No trabalho realizado por Renaudeau; Noblet (2001) houve uma tendência de diminuição na matéria seca e energia quando as fêmeas foram expostas a 29°C, porém, em um trabalho semelhante realizado por Renaudeau *et al.* (2003) a alta temperatura não afetou a composição do leite. Além da produção de leite ser reduzida em situações de estresse térmico, efeitos comportamentais puderam ser visualizados sendo que os leitões de fêmeas mantidas em altas temperaturas apresentaram uma redução no intervalo entre as mamadas (42,4 minutos VS. 37 minutos) quando a temperatura passa de 20 para 29°C (QUINIOU; NOBLET, 1999).

2.3 Sistemas de climatização utilizados na suinocultura brasileira

Desta forma, inúmeros manejos têm sido utilizados na tentativa de minimizar os efeitos prejudiciais das altas temperaturas. Entre eles podemos citar os manejos nutricionais (QUINIOU; NOBLET, 1999), o uso de sistemas adiabáticos evaporativos (TOLON; NAAS, 2005), sistemas de gotejamento e de piso refrigerado (BARBARI; CONTI, 2009; OLIVEIRA JUNIOR *et al.*, 2011).

Os principais sistemas utilizados com a finalidade de manter as fêmeas em sua ZCT são a ventilação forçada e o resfriamento adiabático (NAAS, 1989). A ventilação forçada pode ser feita através de exaustores ou ventiladores. Já o sistema adiabático consiste na passagem de ar por placas com alvéolos úmidos. Este ar evapora adiabaticamente uma parcela da água presente nos alvéolos, retirando o calor necessário para a evaporação do próprio ar, tornando este refrigerado (ABREU; ABREU; MAZZUCO, 1999) e conduzido para climatização das salas ou sobre as fêmeas.

Todos esses manejos podem ser eficientes, mas dependem da manipulação correta e adequada manutenção para funcionamento e eficiência.

REFERÊNCIAS

ABIPECS 2013, Associação brasileira da indústria produtora e exportadora da carne suína – relatório 2012 – Disponível em: <www.abipecs.com.br/relatorio_2012.pdf>. Acesso em: 19 jul. 2013.

ALMEIDA, L.M.A.; Rigolin, T.B. **Tipos de Clima**. In: Guizzo, J. (Eds) Geografia, série novo ensino médio. São Paulo: Editora Ática, 2004. cap. 10, p. 48-53.

ABREU, P.G. DE; ABREU, V.M.N.; MAZZUCO, H. Uso de resfriamento evaporativo (adiabático) na criação de frangos de corte. Concórdia: EMBRAPA-CNPSA, p. 50, 1999

BARBARI, M.; CONTI, L. Use of Different Cooling Systems by Pregnant Sows in Experimental Pen. Biosystem Eng.. v. 103, p. 239-244, 2009.

BERTHON, D.; HERPIN, P.; DUCHAMP, C.; DAUNCEY, M.J.; LE DIVIDICH, J. Modification Of Termogenic Capacity In Neonatal Pigs By Changes In Thyroid Status During Late Gestation. **Journal of development physiology.** v. 19, p. 252-261, 1993

BLOEMHOF, S.; VAN DER WAAIJ, E.H.; MERKS, J.W.M.; KNOL, E.F. Sow Line Differences in Heat Stress Tolerance Expressed in Reproductive Performance Traits. **Journal of Animal Science** v. 86, p. 3330-3337, 2008.

FARMER, C.; DEVILLERS, N.; WIDOWSKI, T.; MASSE, D. Impacts of a Modified Farrowing Pen Design on Sow and Litter Performances and Air Quality During Two Seasons. **Livestock. Science**. v. 104, p. 303-312, 2006.

FERREIRA, R.A. Avaliação da redução da proteína bruta da ração com suplementação de aminoácidos para suínos dos 15 aos 60 kg mantidos em diferentes ambientes térmicos. 67f. 2001. Dissertação (Doutorado em Zootecnia). Universidade Federal de Viçosa. Viçosa, 2001.

FERREIRA, A.L.; AZIS, W.G.A.; SILVA, B.A.N.; BATISTA, R.M. Nutrição e manejo da alimentação de porcas na gestação e lactação em momentos críticos. *In:* VII SEMINARIO DE AVES E SUÍNOS. Belo Horizonte: AveSui Regiões, 2007.

FRASER, D.; PHILLIPS, P.A. Lethargy and Low Water-Intake by Sows During Early Lactation—A Cause of Low Piglet Weight Gains and Survival. **Appl. Animal Behaviour Science.** v. 24, p. 13–22, 1989.

HANNAS, M.I.; OLIVEIRA, R.F.M.; DONZELE, J.L. Efeito da temperatura ambiente sobre parâmetros fisiológicos e hormonais de leitões dos 15 aos 30 kg. *In:* REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 36. Porto Alegre. 1999. p. 226

HARTMAN, P.E.; SMITH N.A.; THOMPSON M.J.; WAKEFORD C.M.; ARTHUR P.G. The Lactating Cycle In The Sow. Physiological And Management Contradiction. **Livestock Production Science.** v. 50, p. 75-87, 1997.

JEON, J.H.; YEON, S.C.; CHOI, Y.H.; MIN, W.; KIM, S.; KIM, P.J.; CHANG. H.H. Effects of Chilled Drinking Water on the Performance of Lactating Sows and their Litters During High Ambient Temperatures Under Farm Conditions. **Livestock Science**. v.105, p. 86–93, 2006.

MORALES, O.E.S. Aspectos Produtivos de Fêmeas Suínas e suas Leitegadas em Diferentes Sistemas de Ambiência na Maternidade. 52f. 2010. Dissertação (Mestrado em Ciências Veterinárias). Universidade Federal do Rio Grande do Sul. Porto Alegre. 2010.

MESSIAS DE BRAGANÇA, M.; PRUNIER, A. Effects of Low Feed Intake and Hot Environmenton Plasma Profiles of Glucose, Nonesterified Fatt Yacids, Insulin, Glucagon, and Igf-I in Lactating Sow. **Domestic animal endocrinology**. v.16(2), p.89-101, 1999.

MOURA D.J. Ventilação na suinocultura. *In:* SILVA I.J.O. **Ambiencia e qualidade na produção industrial de suínos**. Piracicaba: FEALQ, 1999. p. 149-179.

NÄÄS, I.A. **Princípios do conforto térmico na produção animal**. São Paulo: Editora Icone, 1989. p. 183 .

OLIVEIRA Jr, G.M.; FERREIRA, A.S.; OLIVEIRA, R.F.M.; SILVA, B.A.N.; FIGUEIREDO, E.M.; SANTOS, M.. Behaviour and Performance of Lactating Sows Housed in Different Types of Farrowing Rooms During Summer. **Livestock Science.** v. 141, p. 194-201, 2011.

PRUNIER, A.; DE BRAGANÇA, M.M.; LE DIVIDICH, J.. Influence of High Ambient Temperature on Performance of Reproductive Sows. **Livestock Production Science.** v. 52, p. 123-133, 1997.

QUINIOU, N.; NOBLET, J.. Influence of High Ambient Temperatures on Performance of Multiparous Lactating Sows. **Journal of Animal Science**. v. 77, p. 2124-2134, 1999.

RENAUDEAU, D.; NOBLET, J. Effects of Exposure to High Ambient Temperature and Dietary Protein Level on Sow Milk Production and Performance of Piglets. **Journal of Animal Science.** v. 79, p. 1540-1548, 2001.

RENAUDEAU, D.; ANAÍS, C.; NOBLET, J. Effects of Dietary Fiber on Performance of Multiparous Lactating Sows in a Tropical Climate. **Journal of Animal Science.** v. 81, p. 717-725, 2003.

REVELL, D.K.; WILLIANS, I.H.; MULLAN, B.P.; RANFORD, J.L.; SMITHS, R.J. Body Composition at Farrowing and Nutrition During Lactation Affect the Performance of Primiparous Sows. I. Voluntary Feed Intake, Weight Loss, and Plasmametabolites. **Journal of Animal Science**. v.76, p.1729-1737, 1998.

ROBERTSHAW, D. **Dukes: fisiologia dos animais domésticos.** Rio de Janeiro: Rio de Janeiro Guanabara Koogan, 2006. p. 897-908.

SAMPAIO, C.A.P.; CRISTIANI, J.; DUBIELA, J.A.; BOFF, C.E.; OLIVEIRA, M.A. Avaliação Do Ambiente Térmico Em Instalação Para Crescimento e Terminação de Suínos Utilizando os Índices de Conforto Térmico nas Condições Tropicais. **Ciência Rural,** Santa Maria, v. 34, p. 785-790, 2004

SAINBURY, D.W.B. Climatic environment and pig performance. In: COLE, D.J.A. (Ed.). Pig Production. London: Butterworths, 1972. p.91-105.

SILVA, B.A.N.; OLIVEIRA, R.F.M.; DONZELE, J.L.; FERNANDES, H.C.; ABREU, M.L.T.; NOBLET, J.; NUNES, C.G.V.. Effect of Floor Cooling on Performance of Lactating Sows During Summer. **Livestock Science.** v. 105, p. 176-184, 2006.

SILVA, B.A.N.; OLIVEIRA, R.F.M.;DONZELE, J.L.; FERNANDES, H.C.;LIMA, A.L.; RENAUDEAU,D.; NOBLET, J. Effect of Floor Cooling and Dietary Amino Acids Content on Performance and Behaviour of Lactating Primiparous Sows During Summer. **Livestock Science.** v. 120, p. 25-34, 2009.

SORENSEN, P.H. Influencia del ambiente climatico en la production del cerdo. *In:* MORGAN, J.T. **Nutricion de aves y cerdos**. Zaragoza Acribia, 1964. p.97–116.

ST-PIERRE, N.R.; COBANOV, B.; SCHNITKEY,G. Economic Losses From Heat Stress By US Livestock Industries. **Journal of Dairy Science**. v. 86, p. 52-77, 2003.

THAKER, M.Y.C.; BILKEI, G. Lactation Weight Loss Influences Subsequent Reproductive Performance of Sows. **Animal Reproduction Science.** v. 88, p. 309–318, 2005.

TOLON, Y.B.; NÄÄS, I.A. Avaliação de Tipos de Ventilação em Maternidade de Suínos. **Engenharia Agricola**. v. 25, p. 565-574, 2005.

ANEXO: artigo a ser submetido à revista científica.

Effect of an evaporative adiabatic cooling system conducted by ducts on performance of lactating sows and their litters

J. Perin[a], T.S. Gaggini[a], S. Manica[a], D. Magnabosco[a], M.L. Bernardi[b], I. Wentz[a], F.P. Bortolozzo[a*]

[a] *Universidade Federal do Rio Grande do Sul (UFRGS) – Faculdade de Veterinária – Setor de Suínos, Av. Bento Gonçalves 9090, CEP 91540-000, Porto Alegre, RS – Brazil*

[b] *UFRGS – Faculdade de Agronomia– Departamento de Zootecnia, Av. Bento Gonçalves, 7712, CEP 91540-000, Porto Alegre, RS – Brazil*

ABSTRACT

The aim of the study was to evaluate the influence of different temperature control systems on the voluntary feed intake (VFI), percentage of weight loss and performance of lactating sows as well as on the weight of their piglets. Two systems were used: traditional system of temperature control (TTC) with curtain management and adiabatic evaporative cooling system (AECS) conducted by ducts. The study was conducted during the summer. After farrowing and at the 18th day of lactation, 241 sows were weighed to evaluate the percentage of weight loss during lactation. Sows housed in TTC facilities lost more weight ($P < 0.05$) than sows housed in the AECS system (5.3±0.9% and 2.2±0.9%, respectively). The VFI was measured at intervals of four days in 32 primiparous and 39 multiparous sows. The sows in the AECS system had a higher VFI ($P < 0.05$) than those in the TTC system (5.8±0.2 and 4.8±0.2 kg/day, respectively). Primiparous sows had a lower VFI than multiparous sows (4.4±0.2 and 6.3±0.2 kg/day, respectively; $P < 0.05$) regardless of the system of temperature control. Primiparous sows in the TTC system had a longer weaning-to-oestrus interval (WOI) than primiparous in the AECS system (10.9±1.3 and 7.0±1.2 days, respectively; $P < 0.05$). Subsequent litter size tended to be higher ($P= 0.095$) in AECS than in TTC sows (12.0±0.5 and 10.9±0.6 piglets born, respectively). Litters housed in AECS facilities were heavier ($P < 0.05$) at weaning than litters in TTC facilities (65.3±1.4 and 60.7±1.4 kg, respectively). In conclusion, AECS system results in higher feed intake and lower weight loss of sows during lactation and higher weight gain of their piglets compared to TTC system. The AECS system favoured primiparous sows by reducing their weaning-to-oestrus interval.

Keywords: Heat stress, Piglet's weight, Primiparous, Temperature control, Voluntary feed intake.

1. Introduction

Subtropical climate is characterized by cold winters and hot summers which may have marked thermal amplitude, reaching up to 10°C. Subtropical regions have approximately six months of heat, with temperature often exceeding 30°C. This temperature is far from the Thermal Comfort Zone (TCZ) of sows, which is between 12 and 22°C (Bloemhof *et al*. 2008). When environmental temperature is above the TCZ, reproductive and productive performance of sows may be impaired. High temperatures can have direct and indirect consequences on herd performance. Pronounced decrease in voluntary feed intake (VFI), with consequent loss of body weight (Farmer *et al*. 2006; Prunier et. al. 1997; Quiniou and Noblet, 1999), increase in water intake (Renaudeau *et al*., 2003b), decrease in milk production (Bragança et. al. 1998; Quinou and Noblet, 1999; Renaudeau and Noblet, 2001) and also failures in subsequent reproductive performance of sows, such as reduction in farrowing rate and decrease in the total number of piglets born (Thaker and Bilkei, 2005), can be observed as direct consequences. Indirect consequences are related to increased mortality by crushing and decreased weight gain of piglets (Martins *et al.* 2008) because sows exposed to high temperatures remain more time in the water nipple, and less time in lateral decubitus, which make suckling more difficult.

Production losses due to thermal stress can be avoided by using some systems created to minimize the effects of high environmental temperature. There are systems of forced ventilation with the use of fans (Barbari and Conti, 2009; Tolon and Naas, 2005), adiabatic evaporative cooling system (Tolon and Naas, 2005), drip systems (Barbari and Conti, 2009) and systems with cooled floor (Oliveira Junior *et al.* 2011).

This study aimed to compare the influence of a traditional temperature control system (curtains-side), widely used in Brazilian swine production, with a cooling system, which lead cold air through ducts inside the facilities, on body temperature, feed intake, percentage of weight loss, and subsequent reproductive performance of sows as well as the weight gain of their litters.

2. **Material and Methods**

2.1. Facilities and animals

The study was conducted in a pig farm with 5500 sows located in the city of Papanduva. The city is located at 26º22'13" south and 50º08'40" west, on the upland north of Santa Catarina State, Brazil. The climate in this region is subtropical and the study was conducted during the summer, in January and February months. Evaluated sows belonged to Agroceres PIC® genetic (AG1062 and AG1010). Pluviometric precipitation during the period of the study was 244.5 mm. Temperatura e umidade relativa da época??? Ver no INMET como estavam aqueles dias

The farm had a total of 16 farrowing rooms with capacity to accommodate 64 sows per room. Four farrowing rooms were used during the study, two with a system of adiabatic evaporative cooling conducted by ducts (AECS) and two with a traditional system of temperature control (TTC) (Figure 1). In the AECS system the air was conditioned by evaporative cooling pads, located externally, on the west end of the room (Figure 2), connected to a curtain-like plastic duct with 1.0 m in diameter (Figure 3) (DuctoFan, Cumberland®, Marau, RS). The cooled air coming from the evaporation cooling pad was pushed, by means of an axial fan, into the duct and thus conducted to the interior of the rooms. Inside the AECS facilities, this duct was split into two independent ducts of the same diameter, located 3.0 m above the floor, one for each two rows of crates (Figure 4). From the two ducts, terminal ducts of 12 cm in diameter ended on each farrowing crate, through which the air reached sow’s neck (Figure 5A e 5B). The AECS was automatically turned on when the temperature of the facility became higher than 20^{o}C. Together with this system, the management of curtains was also used. In the TTC system only curtains management was used and the criteria for raising or lowering the curtains depended on the standard operating procedure of the farm. It takes into account the perception of the employee in relation to aspects such as light, thermal sensation, wind speed, age of the piglets, air quality and amount of gases. The cages had plastic floor, automatic feeders and water nipples. For the piglets there were creep boxes with heated floor and water nipples.

2.2 General management practices

Farrowing assistance was performed from the birth of the first piglet until the expulsion of foetal membranes. Between 12 and 36 h after birth, piglets were cross-fostered and each sow received piglets with approximately the same weight. At the third day of life an intramuscular injection of dextran iron (2 ml) was performed and anti-coccidial (1 mL) was orally supplied to the piglets. All the piglets were weaned at 18 ± 0.1 days of lactation, enabling the execution of the all in all out disinfection procedure.

After weaning, sows were transferred to gestation facilities, in individual crates which were equipped with slatted concrete floor, automatic feeders and water nipples. Oestrus detection was performed twice a day by the standing reflex in the presence of a mature boar. Sows were inseminated at 0, 24 and at 48 h after oestrus onset until they were in standing oestrus. They were inseminated through intracervical deposition of doses containing 3 x 10^9 sperm cells diluted in BTS extender (Minitüb®).

2.3 Data collection

From 249 sows housed, 8 were excluded from the analysis (six sows discarded by agalactia, one death, and one by rectal prolapse). Thus, 241 sows were weighed at postpartum and at weaning to calculate their weight loss. The experiment was run in two periods which started with a week apart. One-hundred-twenty sows were housed in the first period (59 in the TTC system and 61 in the AECS system) whereas 121 were housed in the second period (63 and 58 sows in TTC and AECS systems, respectively).

Rectal temperature of 24 females was monitored during the lactation period (12 sows housed in the AECS system and 12 in the TTC system). Parity of selected sows ranged from 1 to 8 and their disposition in the different rooms was defined similarly. The measurement was performed daily between 16:00 and 17:00 p.m., with a digital thermometer model Med Term®.

Seventy two sows were evaluated for the voluntary feed intake (VFI) and performance of their litters. One sow died during the study, remaining 71 sows for this analysis (32 primiparous and 39 sows of parities 4 and 5). Control of feed intake started immediately after birth. Sows had *ad libitum* access to water and feed, a corn-soybean diet (18.5% crude protein, 5.86% ether extract, 1% lysine and 3400 kcal DE/kg). Automatic feeders were used to store and control the amount of feed provided to the sows. These automatic feeders had a reservoir with a capacity of approximately 8 kg of feed. The reservoir was filled manually, twice a day, between 7:00 and 8:00 a.m., and between 16:00 and 17:00 p.m. If necessary, more feed was weighed and placed in the reservoir. The amount of feed consumed and feed refusal were measured on days 4, 8, 12 and 16 of lactation.

Piglets were identified with a tattoo number and were individually weighed after cross-fostering and at weaning. Piglets did not receive feed during lactation. The weaning was carried out at the eighteenth day of lactation. Subsequent reproductive performance of sows was evaluated, being the following data collected: weaning-to-oestrus interval (WOI) and the total number of piglets born.

Environmental temperature was measured in rooms with maximum and minimum thermometers Incoterm® (DotDigital) in three periods of the day: morning (at 8:00), noon (12:30) and afternoon (17:00). Relative humidity (ARU) was measured with a digital thermohygrometer Incoterm® (DotDigital).

2.4 Statistical analysis

All statistical analyses were performed using SAS software (SAS, 2005). Rectal temperature and feed intake of sows were analysed as repeated measures using the MIXED procedure with a model containing fixed effects of treatment, parity order, day of lactation and the interaction between these factors. Percentage of weight loss of sows during lactation, weaning-to-oestrus interval (WOI), piglet weight and the number of piglets at weaning were analysed using the MIXED procedure. The models contained fixed effects of treatment, parity order and the interaction between these two factors. For litter weight analysis the litter was considered the experimental unit. Litter weight at cross-fostering and the number of piglets at cross-fostering were used as covariates in the analyses of litter weight and number of weaned piglets, respectively. For the temperature and relative humidity data, the analysis was performed using the MIXED procedure for repeated measures. The model included fixed effects of treatments, the time of the day and the interaction between these two factors. The experimental period was included as a random effect in all the models of analysis. LSMeans were compared by Tukey-Kramer, considering the level of 5% as significant and between 5 and 10% as a trend. Data are presented as means ± standard error of mean.

3. Results

The number of piglets and litter weight at cross-fostering were similar among treatments or parity order classes with overall averages of 12.8 ± 0.1 piglets per sow and 19.6 ± 0.3 kg, respectively.

Rectal temperature of sows was higher in sows housed in facilities with TTC than in sows housed in facilities with AECS ($P < 0.05$) in 16 out of 20 days of evaluation (Figure 1).

Feed intake was not affected ($P > 0.05$) by interactions between treatment, parity order and day of lactation. Feed intake was lower ($P < 0.05$) in the TTC than in the AECS system (Table 1). There was an increase ($P < 0.05$) in feed intake from 4 to 16 days of lactation with a similar feed intake ($P > 0.05$) between 8 and 12 days of lactation. Primiparous sows had lower ($P < 0.01$) feed intake than multiparous sows, regardless of the system for the temperature control (Table 1).

Percentage of weight loss was not affected ($P > 0.05$) by the interaction between treatment and parity order. Sows housed in the TTC system lost more weight ($P < 0.001$) during lactation (5.3 ± 0.7%) than sows housed in the AECS system (2.2 ± 0.7%). Primiparous sows had a higher weight loss during lactation (6.3 ± 0.9%) than multiparous sows (1.2 ± 0.6%; $P < 0.0001$). There was no difference ($P > 0.05$) in the number of weaned piglets between treatments or parity order classes (Table 2). Litter weight at weaning was lower in TCC sows than in AECS sows ($P < 0.05$; Table 2). The WOI of the sows was affected ($P < 0.05$) by the interaction between treatment and parity order. Primiparous sows in TTC system had longer WOI than primiparous in the AECS system ($P < 0.05$; Table 3). Within the TTC system, WOI was longer ($P < 0.05$) in primiparous than in multiparous sows. Litter size was neither affected by the parity order nor by the interaction between treatment and parity order ($P > 0.05$). The number of piglets born tended to be higher ($P= 0.095$) in AECS sows than in TTC sows (Table 3).

Temperature or humidity values were not affected ($P > 0.05$) by the interaction between treatment and the moment of the day. There were no differences ($P > 0.05$) in average and maximum temperature values and in humidity (average, minimum and maximum) between TTC and AECS systems (Table 4). Minimum temperature was higher ($P < 0.05$) in AECS than in TTC system. Temperature values were higher in the afternoon than in the morning ($P < 0.05$). Average and maximum humidity values were lower ($P < 0.05$) in the afternoon compared to noon and morning values. Minimum humidity was higher ($P < 0.05$) in the noon than in the morning or the afternoon.

4. Discussion

Sows of the present study were exposed to temperatures above the TCZ, which is between 12 and 22°C (Bloemhof *et al.* 2008) and those housed in the TTC system presented rectal temperature higher than those in the AECS system. In other studies, significant increase in rectal temperature was also observed when environmental temperature was above the TCZ (Quiniou and Noblet, 1999; Williams *et al*. 2013) or when sows were exposed to 28°C compared to 20°C (Renaudeau *et al*. (2003b). In swine species, the temperature is regulated by neural mechanisms of feedback related to the thermoregulatory center in hypothalamus. This is triggered by temperature detectors and receptors located in extremities and inside of the body (Guyton and Hall, 2002). Temperature close to sows' body was not measured but it is likely that the cooled and humidified air released from ducts of the AECS system on sows' neck provided them a better thermal sensation, helping their thermoregulation and increasing the heat loss.

The gradual increase in feed intake over the lactational period is in agreement with results of previous studies (Koketsu *et al.* 1996; Mosnier *et al.* 2010ab; Bergsma and Hermesch, 2012; Williams et. al. 2013). This pattern can be explained by a gastrointestinal limitation of sow, because of the feed restriction during the gestational phase, and by the fact that digestive tract needs time to adapt to a large amount of feed (Eissen *et al.* 2000). Another explanation for the lower feed intake can be related to the insulin resistance in primiparous (Mosnier *et al.* 2010a) or to the insulin-glucose ratio in multiparous sows (Mosnier et. al. 2010b), in the beginning of lactation.

The lower feed intake of TTC sows corroborates the negative effect of increasing temperature on sows feed intake, which has been extensively described (Quiniou and Noblet, 1999; Renaudeau *et al.* 2003a; Spencer et. al. 2003; Gourdine *et al.* 2006 Williams *et al.* 2013). According to Black et. al. (1993), the voluntary feed intake decreases 0.17 kg per each 1 °C plus in environmental temperature, when it is above 16 °C. Despite the fact that there was no difference between the two systems in the temperature inside the rooms, the lower body temperature of AECS sows probably explains their higher feed intake. Sows probably reduce their feed intake in an attempt to decrease internal heat production (Williams *et al.* 2013). The lower feed intake of primiparous sows compared to multiparous sows, when exposed to heat stress was also observed by Rosero *et al.* (2012). In addition to their gastrointestinal limitation (Eissen *et al.* 2000), primiparous sows are more sensitive to high temperature compared to older sows (Black et. al. 1993).

The higher percentage of weight loss in TTC than in AECS sows agrees with results of several studies in which sows exposed to high temperatures lost more weight (Prunier *et al.* 1997; Quiniou and Noblet, 1999; Spencer et. al. 2003; Farmer et. al. 2006; Gourdine *et al.* 2006). Weight loss during lactation is common, mainly in hiperprolific sows, because feed intake is not sufficient to attend the energetic demands for maintenance and milk production (Koketsu *et al.* 1996; Eissen *et al.* 2003). Sows need to mobilize their body reserves to fulfill the demands for milk production (Kim and Easter, 2001). Weight loss during lactation is negatively correlated with insulin concentration (Hoving *et al.* 2012) and negatively correlated with triiodothyronine (T3) concentration, when sows are exposed to high temperatures (Ferreira, 2001). Lower plasma concentration of T3 has been reported in lactating sows exposed to high temperatures (Messias de Bragança *et al.* 1998; Renaudeau *et al.* 2003b). Low concentration of T3 reduces the intestinal motility hence reducing the digestibility and absorption of nutrients.

The WOI is not necessarily influenced by high environmental temperatures (Renaudeau *et al.* 2001; Renaudeau *et al.* 2003a; Williams *et al.* 2013), but it is affected by higher percentages of weight loss (Hoving *et al.* 2012), showing that environmental temperature can have an indirect effect on this variable. This aspect probably explains the beneficial effect of the AECS system in reducing the WOI of primiparous sows since they lost more weight than multiparous sows. Primiparous are indeed more sensitive to weight loss because their WOI is increased if they lose >5% whereas multiparous sows have an increase in WOI when they lose >10% of body weight (Thaker and Bilkei, 2005).

The better growth performance of AECS piglets confirms previous observations that heat stressed sows had piglets with lower weaning weight than sows exposed to a thermoneutral temperature (Bragança *et al.* 1998; Farmer *et al.* 2006; Johnston *et al.* 1999; Williams et. al. 2013). A lower milk production and consequent lower weaning weight of piglets was reported by Renaudeau and Noblet, (2001) in sows exposed to high temperature (29 °C) compared to those exposed to thermoneutral temperature (20 °C). In a study in which a cooled floor was used to reduce heat stress, piglets that were nursed by sows kept in facilities with cooled floor were heavier than piglets nursed by sows maintained in traditional crates (Silva et. al. 2006).

When animals are exposed to thermoneutral temperature, the ideal humidity is between 60 and 80% (Nienaber *et al.* (1987). Renaudeau *et al.* (2003a) discuss about the possibility of heat stress be further accentuated by high humidity more easily in lactating sows than in growing pigs. Although the average relative humidity was within the ideal range, the fact that maximum relative humidity values exceeded 80%, suggests that at a certain extent feed intake of sows could be reduced by a combined effect of high temperature and high humidity.

5. Conclusions

The system of adiabatic evaporative cooling conducted by ducts contributed to the reduction in the rectal temperature, the increasing of food intake, the reduction of weight loss of sows, and the better growth performance of their litters. A beneficial effect of this system on reducing the weaning-to-oestrus interval was observed in primiparous sows but not in multiparous sows. Overall, the better performance of sows kept in facilities with an adiabatic evaporative cooling system, even without a reduction in environmental temperature, probably occurred because in this system a microclimate was created close to the head's sows.

Conflict of interest statement

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

Acknowledgements

The authors are grateful to CNPq and CAPES, from Brazilian Government, and Agroceres PIC® group, for the financial support, and to Master Company for providing the facilities to perform this study.

5. REFERENCES

BARBARI, M.; CONTI, L. Use of Different Cooling Systems by Pregnant Sows in Experimental Pen. Biosystem Eng. v. 103, p. 239-244, 2009.

BERGSMA, R.; HERMESCH, S. Exploring Breeding Opportunities for Reduced Thermal Sensitivity of Feed Intake in the Lactating Sow. **Journal of Animal Science.** v. 90, p. 85-98, 2012.

BLACK, J.L.; MULLAN, M.L.; LORSCHY, M.L.; GILES, L.R.. Lactation in the Sow During Heat Stress. **Livestock Production Science.** v. 35, p. 153-170, 1993.

BLOEMHOF, S.; VAN DER WAAIJ, E.H.; MERKS, J.W.M.; KNOL, E.F. Sow Line Differences in Heat Stress Tolerance Expressed in Reproductive Performance Traits. **Journal of Animal Science** v. 86, p. 3330-3337, 2008.

BRAGANÇA, M.M.; MOUNIER, A.M.; PRUNIER, A. Does Feed Restriction Mimic the Effects of Increased Ambient Temperature in Lactating Sows? **Journal of Animal Science.** v. 76, p. 2017-2024, 1998.

EISSEN, J.J.; KANIS, E.; KEMP, B. Sow Factors Affecting Voluntary Feed Intake During Lactation. Livestock Production Science. v. 64, p. 147-165, 2000.

EISSEN, J. J.; APELDOORN, E. J.; KANIS, E.; VERSTEGEN, M. W. A.; DE GREEF, K. H. Importance Of a High Feed Intake During Lactation of Primiparous Sows Nursing Large Litters. Journal of Animal Science. v. 81, p. 594-603, 2003..

FARMER, C.; DEVILLERS, N.; WIDOWSKI, T.; MASSE, D. Impacts of a Modified Farrowing Pen Design on Sow and Litter Performances and Air Quality During Two Seasons. **Livestock. Science**. v. 104, p. 303-312, 2006.

FERREIRA, R.A. Efeitos do Clima Sobre a Nutrição de Suínos, *In:* CELANT, T.M.B. Embrapa Suínos e Aves Memórias. Encontro Técnico ABRAVES, Concórdia, 2001. p.1-15.

GOURDINE, J.L., BIDANE, J.P., NOBLET, J., RENAUDEAU, D. Effects of Season and Breed on the Feeding Behavior of Multiparous Lactating Sows in a Tropical Humid Climate, 2006.

GUYTON, A.C.; HALL, L.E. **Tratado de fisiologia médica**, 10 ed. Guanabara Koogan, Rio de Janeiro, 2002.

HOVING, L.L.; SOEDE, N.M.; FEITSMA, H.; KEMP, B. Lactation Weight Loss in Primiparous Sows: Consequences for Embryo Survival and Progesterone and Relations With Metabolic Profiles. **Reproduction Domestic Animal.** v. 47, p. 1009 – 1016, 2012.

JOHNSTON, L.J.; ELLIS, M.; LIBAL, G.W.; MAYROSE, V.B.; WELDON, W.C. NCR-89 Committee on Swine Management. Effect of Room Temperature and Dietary Amino

Acid Concentration on Performance of Lactating Sows. **Journal of Animal Science**. v. 77, p. 1638-1644, 1999.

KIM, S.W.; EASTER, R.A. Nutrient Mobilization From Body Tissues as Influenced by Litter Size in Lactating Sows. **Journal of Animal Science.** v. 79, p. 2179-2186, 2001.

KOKETSU, Y.; DIAL, G.D.; PETTIGREW, J.E.; MARSH, W.E.; KING, V.L. Characterization of Feed Intake Patterns During Lactation in Commercial Swine Herds. **Journal of Animal Science**. v.74, p. 1202-1210, 1996.

MARTINS, T.D.D.; COSTA, A.N.; SILVA, J.H.V. Postura e Comportamento Lactacional de Matrizes Suínas Mantidas Sob Condições de Temperatura Ambiente Elevada. **Revista Biotemas**. v. 21, p. 137–145, 2008.

MESSIAS DE BRAGANÇA, M.; MOUNIER, A.M.; PRUNIER, A. Does Feed Restriction Mimic the Effects of Increased Ambient Temperature in Lactating Sows? **Journal of Animal Science**. v. 76, p. 2017–2024, 1998.

MOSNIER, E.; ETIENNE, M.; RAMAEKERS, P.; PÈRE, M.C. The Metabolic Status During the Peri Partum Period Affects the Voluntary Feed Intake and the Metabolism of the Lactating Multiparous Sow. **Livestock. Scienc**e. v. 127, p. 127-136, 2010b.

MOSNIER, E.; LE FLOC'H, N.; ETIENNE, M.; RAMAEKERS, P.; SEVE, B.; C. PÈRE, M. Reduced Feed Intake of Lactating Primiparous Sows is Associated With Increased Insulin Resistance During the Peripartum Period and is not Modified Through Supplementation With Dietary Tryptophan. **Journal of Animal Science.** v. 88, p. 612-625, 2010a.

NIENABER, J.A.; HAHN, L.G.; YEN, J.T. Thermal Environment Effects on Growing-Finishing Swine, Part I-Growth, Feed Intake and Heat Production. Trans. Am. Soc. Agric. Eng. v. 30, p. 1772-1775, 1987.

OLIVEIRA Jr, G.M.; FERREIRA, A.S.; OLIVEIRA, R.F.M.; SILVA, B.A.N.; FIGUEIREDO, E.M.; SANTOS, M.. Behaviour and Performance of Lactating Sows Housed in Different Types of Farrowing Rooms During Summer. **Livestock Science.** v. 141, p. 194-201, 2011.

PRUNIER, A.; DE BRAGANÇA, M.M.; LE DIVIDICH, J.. Influence of High Ambient Temperature on Performance of Reproductive Sows. **Livestock Production Science.** v. 52, p. 123-133, 1997.

QUINIOU, N.; NOBLET, J.. Influence of High Ambient Temperatures on Performance of Multiparous Lactating Sows. **Journal of Animal Science**. v. 77, p. 2124-2134, 1999.

RENAUDEAU, D.; NOBLET, J. Effects of Exposure to High Ambient Temperature and Dietary Protein Level on Sow Milk Production and Performance of Piglets. **Journal of Animal Science.** v. 79, p. 1540-1548, 2001.

RENAUDEAU, D.; ANAÍS, C.; NOBLET, J. Effects of Dietary Fiber on Performance of Multiparous Lactating Sows in a Tropical Climate. **Journal of Animal Science.** v. 81, p. 717-725, 2003a.

RENAUDEAU, D.; NOBLET, J.; DOURMAD, Y.J. Effect of Ambient Temperature on Mammary Gland Metabolism in Lactating Sows. **Journal of Animal Science.** v. 81, p. 217-231, 2003b.

ROSERO, D.S.; VAN HEUGTEN, E.; ODLE, J.; CABRERA, R.; ARELLANO, C.; BOYD, R. D.. Sow and Litter Response to Supplemental Dietary Fat in Lactation Diets During High Ambient Temperatures. **Journal of Animal Science.** v. 90, p. 550-559, 2012.

SAS Institute. 2005. SAS User's Guide, Release 9.1.3. Cary. SAS Institute.

SILVA, B.A.N.; OLIVEIRA, R.F.M.; DONZELE, J.L.; FERNANDES, H.C.; ABREU, M.L.T.; NOBLET, J.; NUNES, C.G.V.. Effect of Floor Cooling on Performance of Lactating Sows During Summer. **Livestock Science.** v. 105, p. 176-184, 2006.

SPENCER, J.D.; BOYD, R.D.; CABRERA, R.; ALLEE, G.L. Early Weaning to Reduce Tissue Mobilization in Lactating Sows and Milk Supplementation to Enhance Pig Weaning Weight During Extreme Heat Stress. **Journal of Animal Science.** v. 81, p. 2041-2052, 2003.

THAKER, M.Y.C.; BILKEI, G. Lactation Weight Loss Influences Subsequent Reproductive Performance of Sows. **Animal Reproduction Science.** v. 88, p. 309–318, 2005.

TOLON, Y.B.; NÄÄS, I.A. Avaliação de Tipos de Ventilação em Maternidade de Suínos. **Engenharia Agricola**. v. 25, p. 565-574, 2005.

WILLIAMS, A.M.; SAFRANSKI, T.J.; SPIERS, D.E.; EICHEN, P.A.; COATE, E.A.; LUCY, M.C.. Effects of a Controlled Heat Stress During Late Gestation, Lactation, and After Weaning on Thermoregulation, Metabolism, and Reproduction of Primiparous Sows. **Journal of Animal Science.** v. 91, p. 2700-2714, 2013.

LIST OF TABLES

Table 1 - Feed intake during lactation according to the temperature control system (TTC or AECS) and the parity order of sows (LSmeans ± SEM).

Variables	TTC (n= 36)	AECS (n= 35)	Mean
Feed intake according to the lactation day, kg/day			
4	3.80	4.24	4.02 ± 0.16x
8	4.86	5.91	5.38 ± 0.19y
12	5.20	6.27	5.73 ± 0.16y
16	5.50	6.91	6.20 ± 0.16z
Mean	4.83 ± 0.18a	5.83 ± 0.18b	
Feed intake per parity group, kg/day			
Primiparous	3.84 (n= 16)	4.90 (n= 16)	4.37 ± 0.19x
Multiparous	5.83 (n= 20)	6.77 (n= 19)	6.30 ± 0.17y

a, b in the same row indicate statistical differences ($P < 0.05$).

x, y, z in the same column indicate statistical differences ($P < 0.05$).

TTC = traditional system of temperature control using curtain management.

AECS = adiabatic evaporative cooling system.

Table 2 - Number of weaned piglets and litter weight at weaning according to the temperature control system (TTC or AECS) and the parity order of sows (LSmeans ± SEM).

Variables	TTC (n= 36)	AECS (n = 35)	Primiparous (n= 32)	Multiparous (n= 39)
Piglets weaned/sow	11.5 ± 0.27	11.7 ± 0.27	11.8 ± 0.28	11.4 ± 0.26
Litter weight at 18 d, kg	60.7 ± 1.40a	65.3 ± 1.43b	61.6 ± 1.52	64.4 ± 1.33

a, b in the same row indicate statistical differences ($P < 0.05$).

TTC = traditional system of temperature control using curtain management.

AECS = adiabatic evaporative cooling system.

Table 3 - Weaning-to-oestrus interval (WOI) and total number of piglets born according to temperature control systems (TTC or AECS) and parity order of the sows (LSmeans ± SEM).

Variables	Number of sows	TTC	AECS
		(n= 107)	(n= 112)
WOI - Primiparous sows, days	54	10.9 ± 1.3ax	7.0 ± 1.2b
WOI - Multiparous sows, days	165	4.7 ± 0.7y	5.0 ± 0.7
Number of piglets born	171	10.9 ± 0.6c (n= 83)	12.0 ± 0.5d (n= 88)

a, b in the same row indicate statistical differences (P < 0.05).

c, d in the same row indicate a tendency to be statistically different (P < 0.10).

x, y in the same column indicate statistical differences (P < 0.05).

TTC = traditional system of temperature control using curtain management.

AECS = adiabatic evaporative cooling system.

Table 4 - Temperature and relative air humidity (RAU) measured in traditional system of temperature control (TTC) and in adiabatic evaporative cooling system (AECS) during the lactation period.

Variables	TTC	AECS	Morning	Noon	Afternoon
Average temperature, °C	25.8±0.3	26.1±0.3	23.3±0.3a	26.1±0.3b	28.5±0.4c
Minimum temperature, °C	23.2±0.2a	23.5±0.2b	22.1±0.2a	22.5±0.2b	25.4±0.3c
Maximum temperature, °C	28.3±0.3	28.5±0.3	28.9±0.4a	26.3±0.3b	29.8±0.3c
Average RAU, %	73.9±1.2	75.1±1.2	82.4±0.6a	75.9±1.0b	65.3±1.6c
Minimum RAU, %	63.8±1.6	66.0±1.6	62.4±1.7a	73.3±0.9b	59.0±1.6a
Maximum RAU, %	82.8±0.8	83.9±0.8	85.7±0.6a	86.6±0.6a	77.9±1.0b

a, b, c in the same row indicate statistical differences according to the temperature control system or the moment of the day ($P < 0.05$).

TTC = traditional system of temperature control using curtain management.

AECS = adiabatic evaporative cooling system.

LIST OF FIGURE

Figure 1 - Traditional system of temperature control - Management Curtains

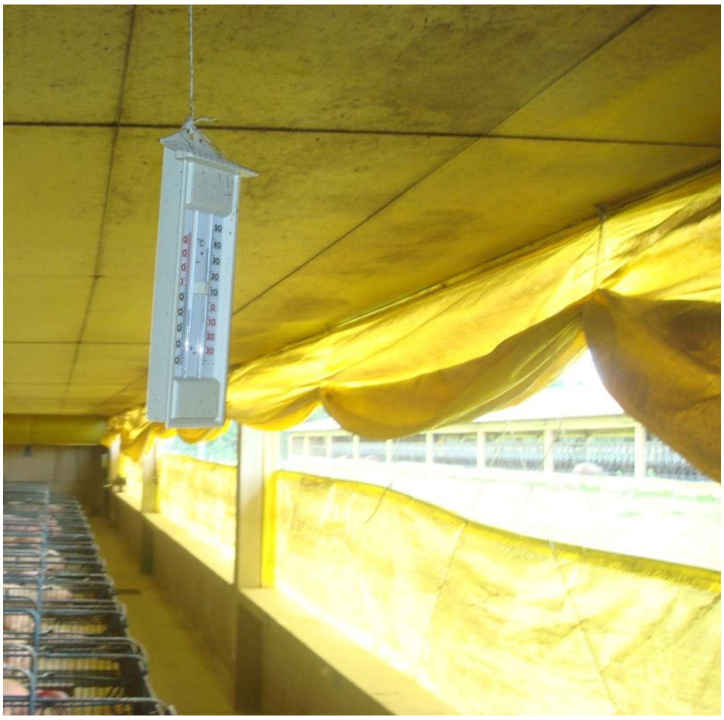


Figure 2 - Cooling System air (evaporative) located on the outside of the farm

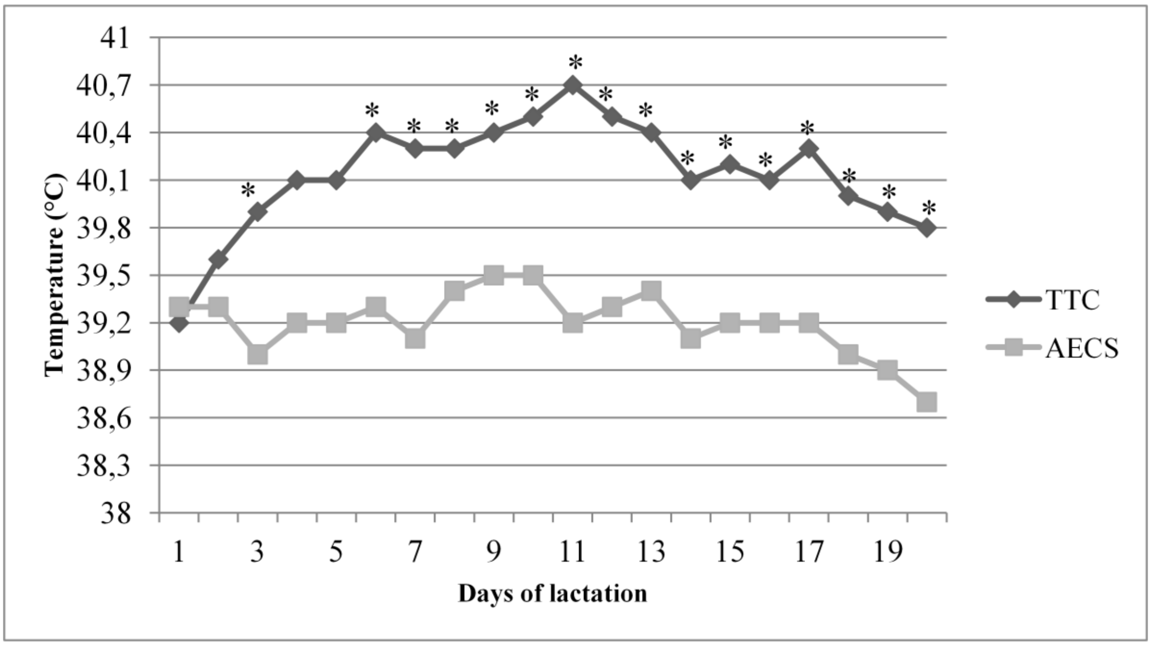
Figure 3 - Curtains tubular plastic (duct) connected to the system cooling air

Figura 4 - Ducts independent distribution of cooled air the two lines of cells

Figura 5A - Terminal ducts directing air cooled on the neck of sows

Figura 5B - Terminal ducts directing air cooled on the neck of sows

Figure 6 - Effect of different temperature control systems (TTC and AECS) on the rectal temperature of sows during lactation.



TTC = traditional system of temperature control using curtain management (n= 12).

AECS = adiabatic evaporative cooling system (n= 12).

*= Indicate statistical difference in the day