

SAES ANNUAL REPORT

Multistate Project (NCERA57): Swine Reproductive Physiology

Date of Annual Meeting: May 19-20, 2015

Period the Report Covers: October 1, 2014 – September 30, 2015

Participant List

Participant members: John Parrish (WS), Jean Feugang (MS), Jeff Clapper and Student (SD), Kara Stewart (IN), Jason Ross (IA), Tim Safranski (MO), Brett White (NE), Duane L Davis (KS), Mark Diekman (IN), Dave Miller (IL), Lea Rempel (USDA/ARS-USMARC), Deb Hamernik (Administrator Advisor, UNEL, NE).

New members: Dr. Kara Stewart is welcomed by the group; a declared member from USDA/ARS-NEA, ABBL, Beltsville, MD, Dr. Le Ann Blomberg, could not come but submitted their station report.

Visitor students: Amy Desaulniers (UNEL, NE), Jodi Morton and H. Frobose (KSU, KS), and Eric Jolitz (SDU, SD)

Brief Summary of Minutes of Annual Meeting

The NCERA-57 group was welcomed by Dr. Duane Davis (local organizer), Dr. Ernie Minton, Associate Director Of Research, College of Agriculture, and Dr. Ken Odde, Department Head of Animal Sciences and Industry of Kansas State University. Dr. Ken Odde also provided relevant statistics for the department, having approximately 1,250 students with 100 graduate students taught by 50 tenure and 5-6 non-tenure tract faculty members.

NCERA57 previous conducted symposia on: Seasonal Infertility, in 2002 (NE); Boar Stud Management and A.I., in 2004 (IA); Reproductive Inefficiency of Small Litter Sizes, in 2006 (NC); Sow Longevity, in 2008 (IN); Gilt Development, in 2010 (IL); Artificial Insemination Technology, in 2012 (IA); Increased Litter Size and Environmental Effects on Pig Quality, in 2014 (NE).

Topics for the next symposium in 2016 were discussed. The following proposition is “temporarily” kept for final decision in mid Fall 2015: ***Interaction of health and reproduction***. This title is intended to include various issues such as gilt isolation, Hepa filters, impact of gilt/sow longevity, biosecurity, boar fertility, disease transmission through semen, etc.

Timeline:

- *By September-October, 2015:* Propositions for issues of potential interest should be received,
- *By November, 2015:* Propositions for Invited Speakers should be received,
- *By January-February 2016:* Advertisement of the symposium should be ready to be sent out, Each NCERA-57 member is encouraged to (or should) contribute to aforementioned activities and contact any potential participants such as stakeholders, swine professionals, etc.
- *Follow-up is expected by March-April 2016.*

Drs. Tim Safranski, Jason Ross, Kara Stewart, and Bret White agreed to organize the 2016 symposium in Columbia, MO. The symposium should be before Memorial Day and before or after the 2016 annual

meeting of NCERA-57. The NCERA57 committee decided to charge a registration fee to cover expenses for the symposium.

Deb Hamernik (Administrative Advisor) reminded members about the official NCERA-57 project and the new five-year plan (http://nimss.org/lgu_v2/homepages/outline.cfm?trackID=16036).

Members are notified that a report of any/all funding received by each individual researcher (NCERA-57 members) should be provided, just as the publication and other reports.

Dr. Hamernik also mentioned a new funding opportunity that was launched in 2014 by the USDA NIFA: the Critical and Applied Research and Extension (or CARE) program in the 2015 AFRI Foundational Programs RFA.

The committee unanimously thanked the local organizer, Dr. Duane Davis, assisted by his graduate student, Ms. Jody Morton.

The 2016 meeting will be held at the University of Missouri, with Dr. Tim Safranski being the host and local organizer. This choice is confirmed by unanimous vote by the participant members.

The NCERA57 committee thanked Dr. Mark Diekman from Purdue University for his longtime service to the group.

Dr. Jean Feugang and Dr. Lea A Rempel are elected by unanimous vote of the participant members as, Chairman and Secretary for the upcoming year, respectively.

Both the official pointer and gavel were, once more, “reunited” for the meeting and were given to Dr. Jason Ross to have them available for the next meeting in Missouri.

STATION REPORTS

1. USDA/ARS-USMARC , NE, presented by Dr. Lea A Rempel

The presentation emphasized an ongoing collaboration with Dr. Parrish (WS) on sperm research using Fournier Harmonic Analysis (FHA).

2. Wisconsin (WS), presented by Dr. John Parrish

The presentation focused on both research and educational activities. Discussion involved the need to diversify the agriculture sciences background and academy. Especially, developing ways to recruit and better incorporate students from non-Ag background (e.g., suburbs), improve communications between faculty and students, attract women and minorities to faculty positions who would become models to facilitate increased diversity in classes, at graduations, and future academic job positions.

3. Purdue (IN), presented by Dr. Kara Stewart

Dr. Stewart presented her research project evaluating the effects of boar diets supplemented with betain on semen production and quality during summer.

4. South Dakota (SD), presented by Eric Jolitz, Dr. Jeff Clapper’s student

Eric did a nice presentation of his research work on Kisspeptin, a potential gatekeeper of puberty...
Dr. Jeff Clapper updated the group on the progress for the new Swine unit enhancement project and construction at SDSU.

5. Mississippi (MS), presented by Dr. Jean Feugang

Dr. Feugang presented their recent and ongoing basic (Relaxin) and applied (Nanotechnology) research in swine reproduction. The work focusses on the fertility improvement of boar semen.

6. Illinois (IL), presented by Dr. Dave Miller

Dr. Miller presented their work that aims at understanding the complex molecular interactions and regulations of sperm binding to oviduct cells. Presentation focused on the contribution of glycans ligands and its receptors, and progesterone for regulation.

7. Missouri (MO), presented by Dr. Timothy Safranski

Dr. Safranski presentation focused on the impact of heat stress on gestational pigs and evaluation of associated costs. The highly underestimated costs of heat stress in pig operations was revealed, which is confirmed by different observations of swine industry professionals. There is a need for a new report to update the current reference published in 2003 (St Pierre et al., 2003).

8. Iowa (IA), presented by Dr. Jason Ross

Dr. Ross presented an interesting two-step study that aimed at screening and characterizing high and low heat stress tolerant pigs through *in vivo* and *in vitro* studies. Selected pigs are used for further investigations.

9. Nebraska (NE), presented by Dr. Brett White

Their current work on GnRH2 and its receptors (GnRH-R1 and GnRH-R2) was presented. It was shown that GnRH2 binds with high affinity to GnRH-R2, which is highly expressed in the testis than the pituitary gland/hypothalamus. The GnRH-R2 is also found in the epididymis, accessory glands, mature spermatozoa, and seminal plasma of boars.

10. Kansas, presented by HL Frobose, Dr. Duane Davis's student

His eloquent talk focused on the development of effective strategies to allow early breeding of lactating sows (day 18 vs. 3 weeks post-partum), leading to reduced weaning-to-estrus interval. Strategies such as alternative weaning (ALT), split-weaning (SW), 12h-separation (SEP), and 24h-separation (24HR) were tested.

Accomplishments

1. Committee members have been highly productive in terms of publications related to reproduction in swine. Only full papers (63 accepted or published) are provided in the current minutes. Numerous abstracts were presented at various professional and (inter)national scientific meetings.
2. Further characterization of miRNA signatures and roles during oocyte maturation and embryonic development are provided.

3. Lewis X trisaccharides of oviduct glycans contribute to the sperm-oviduct binding process.
4. Nanotechnology is proposed as a new and viable approach to apply in swine reproduction.
5. Studies support the new miniature swine model of retinitis pigmentosa as a viable animal for biomedical research.
6. The Fourier Harmonic Analysis could be used for uncompensable trait measurements (sperm nuclear shape variations), in relation to male fertility.
7. Two gene products transcribed into functional proteins are identified in pig tissues: the gonadotropin releasing hormone receptor 2, in testis and germ cells and interleukin-1 beta 2, in elongating conceptus.
8. Various thermal stress conditions are identified to investigate the pre- and post-natal effects of heat stress on swine productivity parameters.

Impact Statements

1. A potential role of estrogen in fetal organogenesis leading to intrauterine growth retardation is suggested (USDA/ARS-NEA).
2. Acceptable pregnancy rates and litter sizes can be obtained with 2 billion frozen-thawed boar spermatozoa. However, the combination of traditional and novel laboratory assays for sperm function is necessary for effective prediction of the fertility of cryopreserved boar spermatozoa (IL).
3. Alternatives for efficient management practices of sow/gilt productivity (e.g., split-suckling, regulation of uterine capacity) are developed (KS, USDA/ARS-USMARC).
4. Attachment of post-thawed boar spermatozoa to oviduct cells may be more indicative of in vitro sperm function than tradition motility and acrosome integrity (IL).
5. Data show that efficient management and better (hormonal) control of reproductive events improve gilt and sow reproductive performances (IL).
6. Gestational and transgenerational effects of heat stress are demonstrated on various measurements of swine productivity parameters (IA, MO).
7. In utero fetal growth development is influenced by sex status of adjacent fetuses, which could be potential source of variations in post-natal behavioral and reproductive differences (USDA/ARS-USMARC).
8. It is shown that season (warm vs. cool) and cryopreservation affect the sperm nuclear shape, while the motility of frozen-thawed spermatozoa of both seasons remains comparable (USDA/ARS-USMARC, WI).
9. Large- and small-scale profiling studies interrogate porcine reproductive tissues, gametes, or embryos for further description of the effects of environmental factors on gene expression (IA, MS, NE).
10. Oviduct fluid and epithelium ligands have important regulatory effects on boar sperm function before fertilization (IL).
11. The utilization of nanotechnology tools is provided as novel approaches to investigate gametes quality and male fertility (MS).
12. Various research- and farm management-based data are generated for decision-making to reduce weaning-to-estrus interval in sows (IL, KS).

Publications

A. Improve boar performance... (IL; MO; MS)

1. Daigneault B, McNamara K, Purdy P, Krisher RL, Knox RV, Miller DJ. 2014. Novel and traditional traits of frozen-thawed porcine sperm related to in vitro fertilization success. *Theriogenology* 82:266-273.
2. Daigneault B, McNamara K, Purdy P, Krisher RL, Knox RV, Rodriguez-Zas SL, Miller DJ. 2015. Enhanced fertility prediction of cryopreserved boar sperm using novel sperm function assessment. *Andrology*. DOI:10.1111/andr.12035.
3. Feugang JM, Liao SF, Crenshaw MA, Clemente H, Willard ST, and Ryan PL. 2015. Lectin-Functionalized Magnetic Iron Oxide Nanoparticles for Reproductive Improvement. *JFIV Reprod Med Genet* 3:2.
4. Feugang JM, Rodriguez-Munoz JC, Dillard DS, Crenshaw MA, Willard ST, and Ryan PL. 2015. Beneficial effects of relaxin on motility characteristics of stored boar spermatozoa. *Reprod Biol Endocrinol* 13:24
5. Gonzalez-Pena Fundora, D., R. Knox, J. Pettigrew, and S. L. Rodriguez-Zas. 2014. Impact of pig insemination technique and semen preparation on profitability. *J. Anim. Sci.* 92:72-84.
6. Knox, R., J. Salak-Johnson, M. Hopgood, L. Greiner, and J. Connor. 2014. Effect of day of mixing gestating sows on measures of reproductive performance and animal welfare. *J. Anim. Sci.* 92:1698-707.
7. Knox, R.V. 2014. Impact of swine reproductive technologies on pig and global food production. In: *Advances in Experimental Medicine and Biology* 752:131-60.
8. Knox, R.V. and B.M. Yantis. 2014. The effect of numbers of frozen-thawed boar sperm and addition of prostaglandin F2 α at insemination on fertility in pigs. *Anim. Reprod. Sci.* 151:194-200.
9. Knox, R.V., J.M. Ringwelski, K.A. McNamara, M. Aardsma, and M. Bojko. The effect of extender, method of thawing and duration of storage on in-vitro fertility measures of frozen-thawed boar sperm. *Theriogenology* (epub ahead of press).
10. Petruska P, Capcarova M, Sutovsky P (2014) Antioxidant supplementation and purification of semen for improved artificial insemination in livestock species. *Turkish J Vet Anim Sci*, 38:643-652. *Special Issue on Recent Advances in Animal Reproduction*, Keith Inskip & Robert Dailey Editors,
11. Sutovsky P (2015) New approaches to boar semen evaluation, processing and improvement. *Reprod. Dom. Anim.* In press.

B. Improved sow and gilt performance... (IA; IL; MO; NC; SD)

1. Clapper, J. and Paulson, C. 2015. Effects of short term administration of genistein on hypothalamic and anterior pituitary hormones in ovariectomized gilts. *Open Journal of Animal Sciences*. 5:163-173.
2. Bohrer, B., Flowers, W.L., Kyle, J.M., Johnson, S.S., King, V.L., Spruill, J.L., Thompson, D.P., Schroeder, A.L., and Boler, D.D. 2014. Effect of gonadotropin releasing factor (GnRF) suppression with an immunological on growth performance, estrus activity, carcass characteristics, and meat quality of market gilts. *J. Anim. Sci.* 92, 4719-4724.
3. Cruzen, S.M., Boddicker, R.L., Graves, K., Johnson, T.P., Arkfeld, E.K., Baumgard, L.H., Ross, J.W., Safranski, T.J., Lucy, M.C., Lonergan, S.M. 2015 Carcass composition of market weight pigs subjected to heat stress in utero and during finishing. (Accepted: *Journal of Animal Science*).
4. Johnson, J.S., Sanz-Fernandez, M.V., Patience, J.F., Ross, J.W., Gabler, N.K., Lucy M.C., Safranski, T.J., Rhoads, R.P., Baumgard, L.H. 2015 Effects of in utero heat stress on postnatal body composition in pigs: I. Growing Phase. *Journal of Animal Science*; 93:71-81.

5. Johnson, J.S., Sanz-Fernandez, M.V., Gutierrez, N.A., Patience, J.F., Ross, J.W., Gabler, N.K., Lucy M.C., Safranski, T.J., Rhoads, R.P., Baumgard, L.H. 2015 Effects of in utero heat stress on postnatal body composition in pigs: II. Finishing Phase. *Journal of Animal Science*; 93:82-92.
6. Boddicker, R.L., Siebert, J.T., Johnson, J.S., Pearce, S.C., Selsby, J.T., Gabler, N.K., Lucy, M.C., Safranski, T.J., Rhoads, R.P., Baumgard, L.H., Ross, J.W. 2015 Gestational heat stress alters postnatal offspring body composition indices and metabolic parameters in pigs. *PLOS One* 9:e110859.
7. Knox, R.V., C.F. Shipley, G.E. Bressner, and V.L. Jarrell. 2014. Mortality, morbidity, and fertility after accidental electrical shock in a swine breeding and gestation barn. *J. Swine Health Prod.* 22:300-305.
8. Knox, R.V., J.N. Taibl, S.M. Breen, M.E. Swanson, and S.K. Webel. 2014. Effects of altering the dose and timing of triptorelin when given as an intravaginal gel for advancing and synchronizing ovulation in weaned sows. *Theriogenology* 82:379-86.
9. Johnson, J.S., M.V. Sanz Fernandez, N.A. Gutierrez, J.F. Patience, J.W. Ross, N.K. Gabler, M.C. Lucy, T.J. Safranski, R.P. Rhoads, L.H. Baumgard. Effects of in utero heat stress on postnatal body composition in pigs: I. Growing phase. 2015. *J. Anim.Sci.* 93: 71-81.
10. Johnson J.S., M.V. Sanz Fernandez, J.F. Patience, J.W. Ross, N.K. Gabler, M.C. Lucy, T.J. Safranski, R.P. Rhoads, L.H. Baumgard. 2015. Effects of in utero heat stress on postnatal body composition in pigs: II. Finishing phase. *J. Anim. Sci.* 93:82-92.
11. Boddicker R.L., J.T. Seibert, J.S. Johnson, S.C. Pearce, J.T. Selsby, N.K. Gabler, M.C. Lucy, T.J. Safranski, R.P. Rhoads, L.H. Baumgard, J.W. Ross. 2014. Gestational heat stress alters postnatal offspring body composition indices and metabolic parameters in pigs. [PLoS ONE](#) Article number e110859
12. S. M. Cruzen, R. L. Boddicker, K. Graves, T. P. Johnson, E. K. Arkfeld, L. H. Baumgard, J. W. Ross, T. J. Safranski, M. C. Lucy, S. M. Lonergan. Carcass composition of market weight pigs subjected to heat stress in utero and during finishing. *J. Anim. Sci.* (In press).
13. Jay S. Johnson, M. Victoria Sanz Fernandez, Jacob T. Seibert, Jason W. Ross, Matthew C. Lucy, Tim J. Safranski, Theodore H. Elsasser, Stanislaw Kahl, Robert P. Rhoads, Lance H. Baumgard. In utero heat stress increases postnatal core body temperature in pigs. *J. Anim. Sci.* (In press).

C. Increase the basic knowledge... (IA; IL; IN; MO; MS; NE; USDA/ARS-MUSMARC)

1. Desaulniers, A.T., R.A. Cederberg, G.A. Mills, J.J. Ford, C.A. Lents, and B.R. White. 2015. LH-independent testosterone secretion is mediated by the interaction between GnRH2 and its receptor within porcine testes. *Biol. Reprod.* July 1, 2015, doi:10.1095/biolreprod.115.128082.
2. Feugang JM, Greene JM, Sanchez-Rodriguez HL, Stokes JV, Crenshaw MA, Willard ST, and Ryan PL. 2015. Profiling of relaxin and its receptor proteins in boar reproductive tissues and spermatozoa. *Reprod Biol Endocrinol*; 13(1):1-15
3. Feugang JM, Youngblood RC, Greene JM, Willard ST, and Ryan PL. 2015. Self-illuminating quantum dots for non-invasive bioluminescence imaging of mammalian gametes. *J Nanobiotechnology*; 13(1):38
4. Geisert R.D., Lucy, M.C., Whyte, J.J. Ross, J.W., Mathew, D.J. 2014 Cytokines from the pig conceptus: Roles in conceptus development in pigs. *Journal of Animal Science and Biotechnology*; 5:51.
5. Geisert RD, Johnson GA, Burghardt RC. 2015. Implantation and Establishment of Pregnancy in the Pig. In: Regulation of Implantation and Establishment of Pregnancy in Mammals: Tribute to 45 Year Anniversary of Roger V. Short's "Maternal Recognition of Pregnancy". Eds. R.D. Geisert and F.W. Bazer. *Advances in Anatomy, Embryology and Cell Biology*, Springer, (In press).
6. Geisert RD, Lucy MC, Whyte, Ross JW, Mathew DJ. 2014. Cytokines from the pig conceptus: Roles in conceptus development in pigs. *Journal of Animal Science and Biotechnology* 5:51

7. Geisert RD. 2015 Introduction. In: Regulation of Implantation and Establishment of Pregnancy in Mammals: Tribute to 45 Year Anniversary of Roger V. Short's "Maternal Recognition of Pregnancy". Eds. R.D. Geisert and F.W. Bazer. Advances in Anatomy, Embryology and Cell Biology, Springer, (In press).
8. Hamm, J., K. Tessanne, C.N. Murphy, R.S. Prather. 2014. Transcriptional regulators TRIM28, SETDB1 and TP53 are aberrantly expressed in porcine embryos produced by in vitro fertilization in comparison to in vivo derived and nuclear transfer derived embryos. Molecular Reproduction and Development 81:552-566. doi: 10.1002/mrd.22324. Epub 2014 Apr 16. PMID: 24659575.
9. Lee, K., C. Wang, L.D. Spate, C.N. Murphy, R.S. Prather, Z. Machaty. 2014. Gynogenetic activation of pig oocytes. Cellular Reprogramming 16:121-129. doi: 10.1089/cell.2013.0074. PMID: 24661186
10. Lee, K., J. Teson, K. Whitworth, L.D. Spate, K.-W. Park, C.N. Murphy, R.S. Prather. 2014. Dynamics of the TET family in porcine preimplantation embryos is related to the zygotic genome. Developmental Biology 386: 86-95. Dx.doi.org/10.1016/j.ydbio.2013.11.024. PMID 24315853.
11. Lee, K., Wang, C., Spate, L., Murphy, C.N., Prather, R.S., Machaty, Z. 2014. Gynogenetic activation of porcine oocytes. Cell Reprogram 16:121-129.
12. Lents CA, Cushman RA, Freking BA. 2014. Measures of the ovaries and uterus during development of gilts selected for differences in uterine capacity. Journal of Animal Science 92(6):2433-2439.
13. Machado S, Kadirvel G, Daigneault B, Korneli C, Miller P, Bovin N, Miller DJ. 2014. Lewis^X-containing glycans on the porcine oviductal epithelium contribute to formation of the sperm reservoir. Biol Reprod 91:140, 1-9 DOI 10.1095/biolreprod.114.119503.
14. Mao, J., M.-T. Zhao, K.M. Whitworth, L.D. Spate, E.M. Walters, C. O'Gorman, K. Lee, M.S. Samuel, C.N. Murphy, R.S. Prather. 2015. Oxamflatin treatment enhances cloned porcine embryo development and nuclear reprogramming. Cellular Reprogramming 17:28-40. doi: 10.1089/cell.2014.0075. Epub 2014 Dec 30. PMID: 2548976
15. Mathew DJ, Newsom EM, Guyton JM, Tuggle CK, Geisert RD, Lucy MC. 2015. Activation of the transcription factor nuclear factor-kappa B in uterine luminal epithelial cells by interleukin 1 Beta 2: a novel interleukin 1 expressed by the elongating pig conceptus. Biology Reproduction 92 (4) 107, 1-13.
16. Miller DJ. 2015. Regulation of sperm function by oviduct fluid and epithelium. Reprod Domestic Anim (Suppl). Accepted.
17. Mtango NR, Latham KE, Sutovsky, P. (2014) Deubiquitinating enzymes in oocyte maturation, fertilization and preimplantation embryo development. In: Sutovsky, P., Editor, *Posttranslational Modifications in the Reproductive System*, Springer Science +Business Media LLC, *Adv Exp Med Biol.* 2014;759:89-110
18. Nteeba, J., Sanz-Fernandez, M.V., Rhoads, R.P., Baumgard, L.H., Ross J.W., Keating, A.F. 2015 Heat stress alters ovarian insulin mediated phosphatidylinositol-3 kinase and steroidogenic signaling in gilt ovaries. Biology of Reproduction [Epub ahead of print].
19. Regulation of Implantation and Establishment of Pregnancy in Mammals: Tribute to 45 Year Anniversary of Roger V. Short's "Maternal Recognition of Pregnancy". 2015. Eds. RD Geisert and FW Bazer. Advances in Anatomy, Embryology and Cell Biology, Springer, (In press).
20. Sargus-Patino CN, Wright EC, Plautz SA, Miles JR, Vallet JL, Pannier AK. 2014. *In vitro* development of preimplantation porcine embryos using alginate hydrogels as a three-dimensional extracellular matrix. Reproduction, Fertility and Development 26(7):943-953.
21. Schatten, H., Q.-Y. Sun, R.S. Prather. 2014. The impact of mitochondrial function/dysfunction on IVF and new treatment possibilities for infertility. Reproductive Biology and Endocrinology. 12:111.
22. Silva E, Kadirvel G, Jiang R, Bovin N, Miller DJ. 2014 Multiple proteins from ejaculated and epididymal porcine spermatozoa bind glycan motifs found in the oviduct. Andrology 2:763-771. (DOI: 10.1111/j.2047-2927.2014.00249.x).

23. Spate, L.D., A. Brown, B.K. Redel, K.M. Whitworth, C.N. Murphy, R.S. Prather. 2014. Dickkopf-related protein 1 inhibits the WNT signaling pathway and improves pig oocyte maturation. *PLoS One*. doi: 10.1271/journal.pone.0095114. PMID: 24739947
24. Vallet JL, Rempel LA, Miles JR, Webel SK. 2014. Effect of essential fatty acid and zinc supplementation during pregnancy on birth intervals, neonatal piglet brain myelination, stillbirth, and preweaning mortality. *Journal of Animal Science* 92(6):2422-2432.
25. Yi Y-J, Sutovsky M, Song W-H, Sutovsky P (2014) Protein deubiquitination during oocyte maturation influences sperm function during fertilization, anti-polyspermy defense and embryo development. *Reprod. Fert. Dev.*, 759:89-110.
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D. Increase the utilization of the rapidly advancing technology... (IN; MO; USDA/ARS-USMARC).

1. Andersson L, Archibald AL, Bottema CD, Brauning R, Burgess SC, Burt DW, Casas E, Cheng HH, Clarke L, Couldrey C, Dalrymple BP, Elsik CG, Foissac S, Giuffra E, Groenen MA, Hayes BJ, Huang LS, Khatib H, Kijas JW, Kim H, Lunney JK, McCarthy FM, McEwan JC, Moore S, Nanduri B, Notredame C, Palti Y, Plastow GS, Reecy JM, Rohrer GA, Sarropoulou E, Schmidt CJ, Silverstein J, Tellam RL, Tixier-Boichard M, Tosser-Klopp G, Tuggle CK, Vilkki J, White SN, Zhao S, Zhou H. 2015. Coordinated international action to accelerate genome-to-phenome with FAANG, the Functional Annotation of Animal Genomes project. *Genome Biology* 16(1):57.
2. Du Z.Q., Eisleay, C.J., Onteru, S.K., Madsen, O., Groenen, M.A.M., Ross J.W., Rothschild M.F. 2014 Identification of species-specific novel transcripts in pig reproductive tissues using RNA-seq. *Animal Genetics* 45:198-204.
3. Gu T., Zhu, M.J., Schroyen, M., Qu, L., Nettleton D., Kuhar, D., Lunney, J.K., Ross J.W., Zhao, S.H., Tuggle, C.K. 2014 Endometrial gene expression profiling in pregnant Meishan and Yorkshire pigs during peri-implantation. *BMC Genomics* 15:156.
4. Hale B.J., Yang C.X., Ross J.W. 2014 Small RNA Regulation of Reproductive Function. *Molecular Reproduction and Development*; 81:148-5.
5. Hale, B.J., Keating A.F., Yang, C.X., Ross J.W. 2015 Small RNAs: Their possible roles in reproductive failure. In: *The Male Role in Pregnancy Loss and Embryo Implantation Failure*. Ed. Richard Bronson. Springer Publishing.
6. Li, G., Q. Jia, J. Zhao, X. Li, M. Yu, M.S. Samuel, S. Zhao, R.S. Prather, C. Li. 2014. Dysregulation of genome-wide gene expression and DNA methylation in abnormal cloned piglets. *BMC Genomics* 15:811. Sep 24;15:811. doi: 10.1186/1471-2164-15-811. PMID: 25253444.
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10. Whitworth, K.M., K. Lee, J.A. Benne, B.P. Beaton, L.D. Spate, S.L. Murphy, M.S. Samuel, J. Mao, C. O’Gorman, E.M. Walters, C.N. Murphy, J.P. Driver, A. Mileham, D. McLaren, K.D. Wells, R.S. Prather.

2014. Use of the CRISPR/Cas9 system to produce genetically engineered pigs from in vitro derived oocytes and embryos. *Biology of Reproduction*. doi: 10.1095/biolreprod.114.121723. Epub 2014 Aug 6. 91:78, 1-13. PMID: 25100712.

11. Zhao, M., J.J. Whyte, G.M. Hopkins, M.D. Kirk, R.S. Prather. 2014. Methylated DNA immunoprecipitation and high-throughput sequencing (MeDIP-seq) by using low amounts of genomic DNA. *Cellular Reprogramming* 16:175-184. doi: 10.1089/cell.2014.0002. Epub 2014 Apr 28. PMID: 24773292

E. Provide unique mechanisms for open scientific exchange and dialogue... (IA; MO; NC).

1. Levis, D., Baker, B., Estienne, M., Flowers, W., Knauer, M., Knox, R., Safranski, T., Singleton, and Stalder, K. 2014. National Swine Reproduction Guide. U.S. Pork Center of Excellence. (<http://www.usporkcenter.org/Projects/507/NationalSwineReproductionGuide.aspx>)

F. Development of innovative teaching methods for undergraduate education... (WI, MO, KS, NC).

1. JJ Parrish, MF Smith, RD Geisert, DL Davis, ME Wilson, WL Flowers. 2015. How to communicate with undergraduate students that lack an Animal Science or agricultural background. *Animal Frontiers* 5(3):54-59.