NC-1201 - Methods to Increase Reproductive Efficiency in Cattle

Date of Annual Report: September 30, 2017

Annual Meeting Dates: August 17-18, 2017 (Portland, OR)

Period of Report: October 1, 2016 through September 30, 2017

Participant Attendance at Annual Meeting
Cameron Locke – University of Missouri
Dave Patterson – University of Missouri
Emma Knickmeyer – University of Missouri
George Smith – Michigan State University
Jamie Larson – Mississippi State University
Jeff Stevenson – Kansas State University
Jordan Thomas – University of Missouri
Maria Haag – University of Missouri
Nicky Oosthuizen – University of Florida
Paul Fricke – University of Wisconsin
Pedro Fontes – University of Florida
Reinaldo Cooke – Oregon State University
Richard Pursley – Michigan State University
Rick Funston – University of Nebraska
Teresa Steckler – University of Illinois
Vitor Mercadante – Virginia Tech

Absent from the meeting
Turzillo, Adele – USDA-NIFA
Carl Dahlen – North Dakota State University
George Perry – South Dakota State University
Robert Cushman – USDA-MARC

Minutes of Annual Meeting
Please see the attached document of Annual Meeting Minutes.

Accomplishments
<u>Objective 1: To determine mechanisms that regulate reproductive processes impacting production efficiency in cattle.</u>

Florida
- *Bos taurus* recipients exposed to an energy and protein restriction during early gestation experienced greater embryonic loss when compared to *Bos indicus* influenced cows.
- *Bos taurus* embryos had greater embryonic loss when the dam underwent feed restriction during early gestation.

Kansas

- Proportions of lactating dairy cows exposed to presynchronization treatments before first postpartum artificial insemination with complete luteolysis are greater for cows treated with the 7-day vs. 5-day Ovsynch program regardless of frequency-dose of PGF2α (1 x 50 mg dose vs. 2 x 25 mg doses 24 h apart).

Michigan

- Circulating concentrations of P4 during ovulatory follicle wave development affected diameter of the ovulatory follicle and rate of double ovulations. Cows with a history of double ovulation during pre-treatment had a greater probability of double ovulation regardless of treatment; however, induction of high P4 during ovulatory follicular development appears to reduce the risks of double ovulation in these cows. The hormonal environment of the growing pre-ovulatory follicle is a regulator of subsequent pregnancy loss. Low P4 during growth of the pre-ovulatory follicle created greater losses during post-attachment period to 35 to 117 d post-AI. Most losses post-attachment were likely due to unilateral twins.
- Cows with greater body condition score (BCS) loss during the initial 30 days of lactation had greater rates of metritis, retained placenta, ketosis, and displaced abomasum. One of the best predictors for fertility was previous calving interval. Quartiles of cows with a previous calving interval between 343 and 362 and 363 to 407 days in milk (DIM) had less BCS loss compared to cows that had 408 to 433 and 434 to 619 DIM in previous calving interval, a greater % of cows that maintained or gained during the 30-d period, and a greater chance for pregnancy at 1st AI. The percentage of cows pregnant before 133 DIM was not different between groups of cows that ranged from maintaining or gaining to losing BCS during the 1st month of lactation. In summary, previous calving interval was predictive of BCS loss and future level of fertility.

Missouri

- Endocrine parameters, ovarian dynamics, and pregnancy rates to fixed-time artificial insemination were evaluated following the 9-day CIDR-PG protocol in comparison to the 14-day CIDR-PG protocol in postpartum beef cows.
    - Serum estradiol concentrations, follicle size, and estrous response did not differ based on treatment, however cows assigned to the 9-day CIDR-PG protocol tended to achieve greater FTAI pregnancy rates than cows assigned to the 14-day CIDR-PG protocol (62% versus 52%).
    - The 9-day CIDR-PG protocol is an effective protocol for synchronization of estrus among mature beef cows
- Pregnancy rates were evaluated following natural service and fixed-time artificial insemination and on the basis of estrus synchronization with melengestrol acetate or a controlled internal drug release in *Bos indicus*-influenced heifers.
    - Pregnancy rates were compared on 21, 30 and 60 d of the breeding period based on pretreatment weight, pubertal status, and treatment. Pregnancy rate was influenced by pretreatment pubertal status and weight at all three time points, with higher pregnancy rates observed among heifers that weighed more and were pubertal prior to treatment initiation.

- There was no difference among treatments with regard to pregnancy rate at day 21 or day 60 of the breeding season, although by day 30, the CIDR + NS treatment resulted in higher pregnancy rates as compared to both FTAI treatments
- These data can be used as a basis for considering various breeding management strategies for *Bos indicus*-influenced beef heifers, and highlight the importance of prebreeding evaluations to ensure adequate heifer growth and pubertal status prior to the start of the breeding period.

Mississippi

- Duration of progesterone exposure did not change hepatic enzymes involved in progesterone metabolism in beef females.
- Moderate exercise among grazing dairy cows does not, positively or negatively, impact milk parameters nor blood flow during pregnancy.

North Dakota

- An effort to study fetal and placental growth through the first trimester of pregnancy in beef heifers yielded valuable baseline data for future studies and images for future textbooks, and also demonstrated the successfully application of our ovariohysterectomy method to study fetal and placental growth up to d 90 of gestation.
- Evaluation of transcript abundance in d 50 fetuses revealed alterations in genes impacting production efficiencies in fetal liver, muscle, and cerebrum as a result of moderate nutrient restriction beginning at the time of breeding
- We demonstrated that concentrations of glucose and fructose present in amniotic and allantoic fluid are altered by maternal nutrition or an interaction between maternal nutrition and day of gestation, respectively.

Nebraska

- Lower input heifer development systems are successful in two breeding seasons.
- Yearling heifer pregnancy rates are decreased in later breeding seasons in the NE Sandhills.
- Earlier birth in the calving season and greater pre-weaning growth are associated with desirable reproductive response in replacement beef heifers.

Oregon

- Estrus expression and intensity, estimated by physical activity after CIDR removal, impacted fertility parameters and pregnancy success in Angus × Nelore cows.
- *B. indicus* cows with excitable temperament had reduced reproductive performance and overall productivity compared to cohorts with adequate temperament when exposed to timed-AI + natural breeding.

South Dakota

- Neither time nor conceptus effected glucose concentrations in beef cows, while cows that exhibited estrus tended to have decreased glucose concentration. There was no correlation between uterine and plasma glucose concentrations, therefore the increased uterine glucose concentration among estrus cows on d16 is most likely due to changes in specific glucose transporter expression in the uterine endometrium.
- There was no difference between the rate of apoptosis in the trophectoderm of day 16 conceptuses collected from cows that did or did not have an elevated preovulatory rise in

estradiol. Thus, differences in pregnancy success between cows that do and do not exhibit estrus likely occurs after maternal recognition of pregnancy.
- Method of heifer development can impact future performance of the calf that is in utero as determined by birth weight and weaning weight, and this change in performance may be regulated through DNA methylation.

USDA-ARS USMARC
- Uterine environment of beef heifers with diminished numbers of antral follicles is less conducive to supporting early embryonic survival.
- Dystocia during the first parity decreases lifetime productivity in beef cattle, the PA system is present at both the transcript and protein level in the bovine plactentome during parturition, and proteolytic activity is localized to the caruncular aspect of the placentome.
- Anti-Müllerian hormone (AMH) did not inhibit the formation of follicles. Immunohistochemical localization of AMH showed that it is not present in fetal ovaries until the third trimester, when it was localized to the granulosa cells of secondary and small antral follicles.
- Elevated levels of cytokine transcripts after PGF2α and predicted activation of cytokine pathways implicate inflammatory reactions early in PGF2α-mediated luteolysis.

Virginia
- Although follicular fluid improves cumulus cell expansion during maturation in vitro, it does not result in higher rates of cleavage or blastocyst development regardless of oestradiol content.
- Short-term bicarbonate supplementation appears to be a promising strategy to eliminate negative production responses associated with endophyte-infected fescue consumption; however, additional research is needed to fully understand why this benefit was not sustained over the full experimental period and how the strategy would translate to traditional pasture systems where animals can self-select a bicarbonate supplementation level.
- Mature bovine oocytes can successfully be activated through incubation with the zinc chelator TPEN, where a treatment of 100 μM TPEN for 45 minutes provides the greatest blastocyst yield

Wisconsin
- Estrus synchronization strategies for dairy heifers may interfere with the accuracy of activity monitoring systems for detection of increased physical activity associated with estrus.

<u>Objective 2: To increase the efficiency and predictability of sustainable reproductive management programs for cattle.</u>

Florida
- Presynchronization with PGF2α 7-day prior to initiation of the 7-day CO-Synch+CIDR protocol alters estrus expression, but fails to enhance pregnancy rates to fixed-time AI in beef heifers.
- Use of a high concentrate, subcutaneous dose of PGF compared to a conventional 25 mg dose of PGF does not alter estrus response or pregnancy rates in replacement beef heifers exposed to the 7-day+CO-Synch protocol.

- Use of estrus synchronization and fixed-time AI in *Bos indicus* beef heifers increased the percentage of heifers pregnant early in the breeding season compared to heifers not exposed to estrus synchronization and TAI.
- Administration of bST prior to artificial insemination increases IGF-1 at fixed-time AI, but fails to increase fetal growth and decreases pregnancy rates to fixed-time AI in beef heifers.
- Administration of bST to beef heifers during the first trimester of gestation increased concentrations of IGF-1 which resulted in an increase in extraembryonic fluid, a decreased quantity of placentomes, and greater umbilical diameter, but failed to alter fetal development.

Kansas

- Split-time artificial insemination of suckled beef cows at 65 and 85 h after the PGF2α dose in a 7-day CO-Synch + CIDR program produced more pregnancies than a split time combination of 55 and 75 h.
- Administering 10 mg of PGF2α at the time of insemination failed to increase pregnancy risk in lactating dairy cows but tended to increase multiple ovulation and twinning.

Michigan

- Administering both PGF2α and GnRH on the same day, 7 days before the start of Ovsynch (PG + G) may offer a reasonable alternative to more complex fertility programs to enhance P/AI for first and subsequent services. The protocol PG + G appeared to provide sufficient ovulatory response to the first GnRH of Ovsynch and concentrations of progesterone at the time of PGF2α of Ovsynch. The increase in the percent of cows in the PG + G treatment that ovulated during the 5 days before the first GnRH of Ovsynch is a concern, and need to be further investigated.
- Administering both PGF2α and GnRH on the same day, 7 d prior to the startof Ovsynch (PG+G), can achieve similar P/AI compared to Presynch-10. Percentage of cows with functional CL, serum concentrations of P4 and number and size of CL and follicles at time of PGF2α of Ovsynch appear to be similar to other fertility programs. Thus, PG+G may offer a reasonable alternative to more complex fertility programs to enhance P/AI for first service. This program may be a good strategy for farms that want to limit the number of d in the week cows are handled.

Missouri

- Fertility of SexedULTRATM sex-sorted semen was compared to conventional, non-sex-sorted semen among beef heifers in conjunction with split-time AI following the 14-d CIDR-PG protocol.
    - Pregnancy rates to AI across locations tended to be higher for heifers inseminated with conventional semen (60%) compared to sex-sorted semen (52%).
    - SexedULTRATM sex-sorted semen can be used effectively for timed AI of beef heifers when split-time AI is performed following the 14-d CIDR-PG protocol.

North Dakota

- Feed intake, time spend eating, and number of meals consumed was reduced on the day of standing estrus in beef heifers.

Nebraska

- Similar AI pregnancy rates were achieved with a fixed time insemination protocol vs. estrus detection, thus decreasing labor required.
- Implanting yearling heifers with Revalor G significantly decreases pregnancy rates.
- The two concentrations and corresponding administration routes of PG were similar in efficacy in synchronizing estrus in yearling beef heifers.

Oregon

- Post-AI supplementation with Ca salts of soybean oil (CSSO) to beef cows increased pregnancy rates compared with non-supplemented cows, which can be attributed to increased mRNA expression of *interferon-tau* by the conceptus and blood mRNA expression of interferon-stimulated genes when CSSO is supplemented during early gestation.
- Supplementing *B indicus* beef cows with melengestrol acetate (MGA) post-AI increased pregnancy rates compared with non-supplemented cows, and this outcome was independent of period and length of MGA supplementation, gonadotropic stimulus, cow BCS status, and estrus expression during the synchronization protocol.

South Dakota

- Vaccinating well-vaccinated beef cows and heifers with a Modified Live Vaccine vaccine pre-breeding (28 to 89 d) decreased AI conception rates compared to a Combined Chemically Altered/Inactivated vaccine.
- Administering 5μg of GnRH at CIDR removal tended to decrease interval to estrus and increase estrus expression among heifers but not cows.
- Animals administered 5 μg of GnRH at CIDR removal and 5 μg of GnRH 12 hours later had improved pregnancy success of beef cattle subjected to a fixed-time AI protocol.

USDA – ARS USMARC

- The calving rate for individual sires is not homogeneous and there is a large difference between bulls siring the greatest and least number of calves. More research is needed to determine how rank changes over multiple breeding years and its association with dominance, libido, and fertility.

Virginia

- Suckled beef cows enrolled in the 7-d CO-Synch+CIDR estrus synchronization protocol that are detected in estrus prior to the time of AI have greater pregnancy rates compared to cows that are not detected in estrus and receive an injection of GnRH and AI at 66 h after CIDR removal. Furthermore, delaying insemination after GnRH injection failed to increase pregnancy rates of cows not detected in estrus.
- Plastic sheath for AI with three semen outputs decreased the percentage of AI sheaths with signs of semen reflux, but failed to increase fixed-time AI pregnancy rates of beef heifers.
- Addition of the EFI cocktail (containing epidermal growth factor, fibroblast growth factor-2, and insulin-like growth factor 1d uring bovine embryo culture improved the percentage of transferable embryos but did not correct the retarded fetus growth observed at day 56 of pregnancy. The growth factor treatments may, however, have minimized early deviation in circulating PAG concentrations between male and female fetuses.

Wisconsin

- Adding a second PGF2α treatment 24 h after the first within a Resynch protocol tended to increase P/AI by tending to increase the proportion of cows undergoing complete luteal regression, whereas treatment with a double dose of PGF2α at a single time did not.
- Delaying PGF2α treatment by 24 h during the Breeding-Ovsynch portion of the Double-Ovsynch protocol resulted in decreased fertility due to delayed luteal regression before timed-AI.
- Delaying PRID removal by 24 h during a 5-day PRID-synch protocol decreased the incidence of estrus before scheduled TAI without affecting P/AI thereby decreasing the need for detection of estrus during the synchronization protocol.

Impacts

- A technique of tissue collection to study early pregnancy has been successfully conducted through the first trimester of pregnancy.
- A variety of options exists for heifer development in earlier breeding seasons when nutrient quality isn't limiting. Feeding to increased target weights at breeding does not improve pregnancy rates in spring calving systems.
- Administering 5μg of GnRH at CIDR removal tended to decrease interval to estrus and increase estrus expression among heifers but not cows.
- Animals administered 5 μg of GnRH at CIDR removal and 5 μg of GnRH 12 hours later had improved pregnancy success of beef cattle subjected to a fixed-time AI protocol
- Beef cattle producers have the option to utilize a conventional intra muscular (i.m.) injection of PGF or a newly developed sub cutaneous (s.c.) high concentrate dose of PGF without a decrease in estrus response or pregnancy rates to TAI.
- Bioinformatic pipelines are being developed to improve management and handling and merging of large physiological and genomic data sets with production data. Identifying gene networks regulating hormonal responses will improve the efficiency of protocols to synchronize estrus and induce ovulation.
- Bull siring capacity is probably more influenced by dominance and libido than gamete quality in multi-sire pastures. Investigating behavioral and physiological measurements in bulls that pass breeding soundness exams but have low capacity to sire calves will aid in improving the standards for these exams.
- Cattle temperament has direct implications on overall production efficiency in cow-calf system based on *B. indicus* females.
- Complete luteal regression during synchronization protocols limits fertility to timed AI. Adding a second PGF2α treatment 24 h after the first within a Resynch protocol tended to increase P/AI by tending to increase the proportion of cows undergoing complete luteal regression, whereas treatment with a double dose of PGF2α at a single time did not. Delaying PGF2α treatment by 24 h during the Breeding-Ovsynch portion of the Double-Ovsynch protocol resulted in decreased fertility to first AI due to delayed luteal regression before TAI.
- Concentrations of glucose in the allantoic fluid are reduced in pregnancies of nutrient restricted dams
- Continued development of fertility programs for dairy cows increase pregnancies per AI and on-farm profit through decreased involuntary culling, increased herd level milk production, and increased calves born annually.

- Controlling calving interval with fertility programs reduces the percentage of cows with unhealthy body condition at time of parturition. Thus, fewer cows have metabolic and uterine problems following calving.
- Duration of exposure to progesterone did not alter the progesterone-clearing enzymes in the liver; however, differences in hepatic enzymes did exist between beef heifers and cows.
- Earlier birth in the calving season and greater preweaning growth are associated with desirable reproductive response in replacement beef heifers.
- Establishing synchronization and artificial insemination systems that require less labor will increase the adoption of such technologies. Incorporating an orally active progestin for synchronization decreases animal handling and this research has demonstrated similar pregnancy rates with no estrus detection.
- Estrus synchronization of *Bos indicus* heifers increases the percentage of heifers conceiving in the first 21 days of the breeding season, thereby potentially altering the calving distribution to ensure that more heifers calve early during the subsequent calving season.
- Feed intake, time spend eating, and number of meals consumed was reduced on the day of standing estrus in beef heifers
- Fertility programs decrease double ovulation rate, pregnancy loss, and subsequent twinning in lactating dairy cows. Decreasing pregnancy loss reduces variation in herd calving interval. Decreasing twinning increases milk production per cow and decreases involuntary culling and death.
- For first-service timed artificial insemination programs, a single large dose (50 mg) of PGF2α promotes effective luteolysis and similar pregnancy risk equivalent to using 2 x 25 mg doses of PGF2α administered 24 h apart.
- For suckled beef cows, a split timed artificial program that maximizes pregnancy risk when a 65 + 85 h combination is employed.
- Grazing dairy cows walking more than control animals did not differ in milk production, milk quality, or blood flowing to the uterus during late pregnancy.
- Heifers with increased numbers of antral follicles have a uterine environment that is more supportive to early embryonic development.
- Increased IGF1, through administration of bST, at the time of AI decreases pregnancy rates in replacement beef heifers.
- Management and/or selection to favor expression of high-intensity estrus should be explored and adopted to enhance pregnancy success in *B. taurus* × *B. indicus* beef cows
- Maternal nutrition alters transcript abundance of genes impacting production efficiencies by d 50 of pregnancy.
- Melengestrol acetate supplementation post-AI appears to be a feasible strategy to increase reproductive efficiency in *B. indicus* beef cows.
- Nutrient restriction during early gestation affects embryonic loss differently in *Bos taurus* and *Bos indicus* influenced recipients, with *Bos taurus* animals having greater embryonic loss when submitted to a restriction in nutrient intake.
- Nutritional changes around the time of insemination can impact future performance of the calf that is in utero as determined by birth weight and weaning weight
- Pregnancy rates among *Bos indicus* beef heifers were influenced on 21, 30 and 60 d of the breeding period by pretreatment pubertal status and weight. These differences highlight the importance of prebreeding evaluations to ensure adequate heifer growth and pubertal status

prior to the start of the breeding period among *Bos indicus* influenced heifers that are exposed for breeding as yearling aged heifers.
- Screening embryo recipients when feasible and choosing those with increased numbers of antral follicles may improve pregnancy rates.
- Selecting only cows that have exhibited estrus before timed artificial insemination can improve pregnancy success.
- SexedULTRATM sex-sorted semen can be used effectively for timed AI of beef heifers when split-time AI is performed following the 14-day CIDR-PG protocol.
- Suckled beef cows enrolled in the 7-d CO-Synch+CIDR estrus synchronization protocol that are detected in estrus prior to the time of AI have greater pregnancy rates compared to cows that are not detected in estrus. Furthermore, delaying insemination after GnRH injection failed to increase pregnancy rates of cows not detected in estrus.
- Supplementing Ca salts of soybean oil for 21 d beginning at AI is an alternative to enhance pregnancy establishment and overall reproductive performance of *B. taurus* beef cows.
- The 9-day CIDR-PG protocol is an effective protocol for synchronization of estrus among mature beef cows, and pregnancy rates to FTAI tended to be improved through use of the 9-day CIDR-PG compared to the 14-d CIDR-PG protocol.
- The first approved subcutaneous prostaglandin product (Lutalyse HiCon) has similar efficacy in synchronizing beef heifers when compared to the original intramuscular labeled product (Lutalyse).
- Vaccinating well-vaccinated beef cows and heifers with a Modified Live Vaccine vaccine pre-breeding (28 to 89 d) decreased AI conception rates compared to a Combined Chemically Altered/Inactivated vaccine.
- We have demonstrated that mature bovine oocytes can successfully be activated through incubation with the zinc chelator TPEN, where a treatment of 100 μM TPEN for 45 minutes provides the greatest blastocyst yield.
- When dairy cow mothers were exposed to heat stress around the time of insemination and conception, it affected their resulting offspring. Those offspring produced less milk than their peers. This discrepancy in milk production could have a substantial impact on whole-farm profitability and sustainability as return on investment is reduced.
- Young calves exposed to tamoxifen (a selective estrogen receptor modulator) exhibit altered development of their reproductive tract. Although current experiments did not follow those animals to adulthood, it is likely that the observed alterations in development reduce future fertility.

Publications

Book Chapters

Fricke, P. M. 2017. Reproductive programs to maximize fertility in dairy cows. In: Large Dairy Herd Management (3rd Ed.) D. K. Beede (Ed.). Elsevier Inc., Philadelphia, PA, pp. 503-519.

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Abel, JM, BE Bishop, JM Thomas, MR Ellersieck, SE Poock, MF Smith, and DJ Patterson. 2017. Comparing strategies to synchronize estrus and ovulation prior to fixed-time artificial

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Bishop, BE, JM Thomas, JM Abel, SE Poock, MR Ellersieck, MF Smith, and DJ Patterson. 2017. Split-time artificial insemination in beef cattle: III. Comparing fixed-time artificial insemination to split-time artificial insemination with delayed GnRH administration in postpartum cows. Theriogenology. 99: 48-52.

Bishop, BE, JM Thomas, JM Abel, SE Poock, MR Ellersieck, MF Smith, and DJ Patterson. 2017. Split-time artificial insemination in beef cattle. II. Comparing pregnancy rates among non-estrous heifers based on administration of GnRH at AI. Theriogenology. Volume 87, Number 1: 229-234.

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Brown, B.M., Stallings, J.W., Clay, J.S. and Rhoads, M.L. (2016). Periconceptional heat stress of Holstein dams is associated with differences in daughter milk production and composition during multiple lactations. PLoS One 11:e0150049

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Crouse, M. S., K. J. McLean, M. R. Crosswhite, L. P. Reynolds, C. R. Dahlen, B. W. Neville, P. P. Borowicz, and J. S. Caton. 2016. Nutrient transporters in bovine utero-placental tissues on days 16 to 50 of gestation. J. Anim. Sci. doi: 10.2527/jas.2016-0857.

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Extension Reports/Publications

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Albright, L.D., R.S. Gates, K.G. Arvanitis and A. E. Drysdale. 2001. Control strategies for plant shoot and root environments on Earth and in space. IEEE Control Systems Magazine: Agriculture and the Environment 21(5):28-47.

Cooke, R. F. 2017 Is there value in supplementing trace minerals to pregnant beef cows. In: Progressive Cattleman, August 2017, issue 8 pp. 46-48.

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Lamb, G.C. 2016. Repro Tracks – Breeding soundness examinations. Angus Journal (April 2016:142-143)

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Pursley, J. R. Updated 2017. www.dairycattlereproduction.com website. Features a resource guide for bovine veterinarians and dairy producers to enhance their knowledge on the management of reproduction of dairy cattle. Included are 3D animations/videos of ovaries throughout an estrous cycle and during fertility programs. Impact past 3 years: >46,000 views on website. Added "Adventures of Blaze and Star" – videos that help to explain importance of reproduction on dairies.

Pursley, James R. 2016. Twenty years of Ovsynch. Progressive Dairyman, April 18.

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Rhoads, M., and T. Safranski. 2016. "Emerging evidence expands our understanding of the true impact of heat stress." National Hog Farmer; November Issue.

Stevenson, J. S. 2016. Activity monitors continue to bring value. Hoard's Dairyman 141:477. August 10, 2016.

Stevenson, J. S. 2016. Extending age at first calving is extremely costly. Hoard's Dairyman 161:703. November, 2016.

Stevenson, J. S. 2016. Ketosis can be a reproduction buster. Hoard's Dairyman 161:538. September 10, 2016.

Stevenson, J. S. 2016. What makes Bossy bawl? Hoard's Dairyman 161:626. October 10, 2016.

Stevenson, J. S. 2017. Breeding is a lot like hunting. Hoard's Dairyman 162:172. March 10, 2017.

Stevenson, J. S. 2017. Cool those dry cows. Hoard's Dairyman 162:407. June 2017.

Stevenson, J. S. 2017. Good preg rates start with semen handling. Hoard's Dairyman 162:249. April 10, 2017.

Stevenson, J. S. 2017. Some farms improved conception rates by 5 percent. Hoard's Dairyman 162:327. May 10, 2017.
Stevenson, J. S. 2017. We have come a long way on cow fertility. Hoard's Dairyman 162:90. February 10, 2017.
Stevenson, J. S. 2017. What is your major reproduction bottle neck. Hoard's Dairyman 162:3. January 10, 2017.

Scientific and Outreach Oral Presentations

G. C. Lamb – Florida and Texas

Management of reproduction to enhance production efficiency in beef cattle operations, Wakulla County Cattlemen's Association, Wakulla, FL
Reproductive Management for Beef Cattle (18 presentations in KS, MO, MT, NE, OK, SD). ABS Global Inc. technical service training.
Use of estrus synchronization to enhance profitability of beef cattle operations (5 presentations in Australia)
Overview of estrus synchronization protocols. Washinton County Cattlemen's Assciation, Chipley, FL
Opportunities for fetal growth development and the interaction with breed. Merial Technical Service Meeting, Crystal River, FL
Synchronizing strategies for beef females. Zoetis Technical Consultants, Chico Hot Springs, MT
Donor and recipient management to optimize embryo technology success. Applied Reproductive Strategies in Beef Cattle Symposium, Des Moines, IA
Reproductive Management strategies to enhance efficiency of beef cattle operations. Big River Cattlemen's Association, Live Oak, FL
Reproduction for beef cattle producers in Georgia, Ocilla, GA
Use of estrus synchronization for enhanced beef production. Tifton Beef Cattle Field Day, Alapaha, GA
Development of heifers to remain in the herd. Florida Heifer Development Program Workshop, Marianna, FL
Strategies to improve reproductive efficiency in beef cattle operations. Tennessee Cattlemen's Convention, Murfreesboro, TN
Developing heifers for the long haul. NCBA Convention, Nashville, TN
Essential reproductive management considerations. Panhandle Beef Conference, Marianna, FL
30-day game changer to enhance beef cattle productivity. XXI Conference focusing on enhancing production and reproduction in beef cattle, Uberlandia, Brazil
Advantages of current and future reproductive technologies for world-wide beef cattle production. XXI Conference focusing on enhancing production and reproduction in beef cattle, Uberlandia, Brazil
Control of the estrous cycle for cattle operations in the US. Texas Large Animal Continuing Education Conference, College Station, TX
Utilization of reproductive management to enhance economic viability of beef cattle operations. Texas Large Animal Continuing Education Conference, College Station, TX
Assessment of What Works and Does Not Work for Embryo Transfer Donors and Recipients. Texas Large Animal Continuing Education Conference, College Station, TX

J. S. Stevenson - Kansas

Hoard's Dairyman Webinar, January 9, 2017
Dairy Cattle Reproduction Council Webinar, August 25, 2017
Applied Reproductive Strategies in Beef Cattle Workshop, August 29-30, 2017
Kansas Dairy Days, January 31 and February 2, 2017, Seneca and Whitesides

J. R. Pursley - Michigan

Nestle Dairy Farming Institute dairy cattle reproduction workshop. Seven lectures and three laboratory sessions during a 5 d period. Shaungcheng, China.
Faculty and graduate student lecture. Factors that affect fertility of dairy cows. 2017. Shanxi Agricultural University, Taigu, Shanxi, China.
Bovine Reproduction and Education Workshop for veterinary students. 2017. Federal University of Mato Grosso, Sinop, MG, Brazil.
What will be your role in feeding the growing world population. 2017. Undergraduate lecture. Federal University of Mato Grosso, Sinop, MG, Brazil.
Reproductive management strategies for dairy cows using GlobalSync Dairy. 2017. Cooperative Resources International Brazil meeting.
Pregnancy loss in lactating dairy cows. ANEMBE (national bovine veterinarian conference), 2017. Pamplona, Spain.
Factors that affect fertility of dairy cows. ANEMBE (national bovine veterinarian conference), 2017. Pamplona, Spain.
Managing cows for greater fertility. 2017. Bovine Veterinarian meeting. Hilmar, CA
Managing cows for greater fertility. Bovine Veterinarian meeting. 2017. Tulare, CA
Managing cows for greater fertility. Bovine Veterinarian meeting. 2017. Sunnyside, WA
Managing cows for greater fertility. Bovine Veterinarian meeting. 2017. Lyndon, WA
Ovulation Synchronization Programs: An Update. Dairy Cattle Reproduction Conference (DCRC). 2016. Columbus, OH.
Higher Profits Demand Smart Herd Reproductive Management Choices. Professional Dairy Producers of Wisconsin Herdsperson Conference. 2016. Chilton, WI.
Higher Profits Demand Smart Herd Reproductive Management Choices. Professional Dairy Producers of Wisconsin Herdsperson Conference. 2016. Eau Claire, WI.
Higher Profits Demand Smart Herd Reproductive Management Choices. Professional Dairy Producers of Wisconsin Herdsperson Conference. 2016. Fennimore, WI.
Case Studies Workshop. Troubleshooting fertility problems in the lactating dairy herd. Professional Dairy Producers of Wisconsin Herdsperson Conference. 2016. Chilton, WI.
Case Studies Workshop. Troubleshooting fertility problems in the lactating dairy herd. Professional Dairy Producers of Wisconsin Herdsperson Conference. 2016. Fennimore, WI.
Case Studies Workshop. Troubleshooting fertility problems in the lactating dairy herd. Professional Dairy Producers of Wisconsin Herdsperson Conference. 2016. Eau Claire, WI.
Fertility programs for lactating dairy cows and the factors that are critical for their success. Brazilian Embryo Transfer Society (SBTE). 2016. Foz do Iguacu, Parana, Brazil.
Natural estrus equals poor fertility in dairy cows. Pre-conference workshop. Brazilian Embryo Transfer Society (SBTE). 2016. Foz do Iguacu, Parana, Brazil.
Factors that affect fertility of dairy cows. 2nd International Symposium on Advances in Bovine Reproduction. 2016. Guadalajara, Mexico.
First service synchronization programs that increase pregnancies per AI in lactating dairy cows. 2nd International Symposium on Advances in Bovine Reproduction. 2016. Guadalajara, Mexico.

Novel findings in the causes of pregnancy loss in dairy cows. 2nd International Symposium on Advances in Bovine Reproduction. 2016. Guadalajara, Mexico.

Programs to enhance fertility of lactating dairy cows. Shanxi Jiuniu Animal Husbandry Company, LTD. 2016. Taiyuan, Shanxi, China.

BRED Workshop. 1-day workshop aimed at enhancing reproductive performance of dairy cattle for dairy veterinarians. Michigan Veterinary Conference. 2016. Lansing, MI.

BRED Workshop. 2-day workshop aimed at enhancing reproductive performance of dairy cattle for dairy veterinarians. 2016. Montebello, Quebec, Canada.

D. J. Patterson - Missouri

Control of the bovine estrous cycle with progestin-based protocols. January 19 – February 2, 2017. Veterinary CE, United Kingdom; England, Northern Ireland, Scotland.

University of Missouri Extension Beef Cattle ReproGene Meeting. Taking the next steps in beef cattle reproduction and genetics. Jackson, MO. March 28, 2017.

University of Missouri Extension Beef Cattle ReproGene Meeting. Taking the next steps in beef cattle reproduction and genetics. Springfield, MO. March 16, 2017.

American Society of Animal Science Midwest Meetings. Young Scholar Invited Presentation: Effective use of SexedUltra sex-sorted semen for timed artificial insemination of beef heifers. Omaha, NE. March 14, 2017.

University of Missouri Extension Beef Cattle ReproGene Meeting. Taking the next steps in beef cattle reproduction and genetics. Macon, MO. March 11, 2017.

University of Missouri Extension Beef Cattle ReproGene Meeting. Taking the next steps in beef cattle reproduction and genetics. Kingsville, MO. March 9, 2017.

University of Missouri Extension Beef Cattle ReproGene Meeting. Taking the next steps in beef cattle reproduction and genetics. Maryville, MO. March 7, 2017.

Genex Field Staff Update Webinar. University of Missouri beef reproduction research update. Web-based. March 2, 2017.

Select Sires MidAmerica Field Staff Update. Beef reproduction update. Columbia, MO. February 16, 2017.

Southwest Missouri University of Missouri Extension Beef Cattle Conference. Beef reproduction update and the latest from the Show-Me-Select Replacement Heifer Program. Stockton, MO. January 26, 2017.

International Embryo Transfer Society Annual Conference. Sunrise Sponsor Session: Effective use of SexedUltra sex-sorted semen for timed artificial insemination of beef heifers. Austin, TX. January 17, 2017.

Genex CRI Beef Large Herd Summit. Split-time AI: Using Estrotect in conjunction with timed artificial insemination. New Orleans, LA. October 6, 2016.

United States Department of Agriculture Foreign Agricultural Service. Cochran Program for Ecuadorian Livestock Management Practices: Control of estrus and ovulation in beef cows. Columbia, MO. September 14, 2016

J. E. Larson - Mississippi

Reproduction in the dairy cow. Dairy Field Day, 2017. Mississippi State, MS

R. N. Funston - Nebraska

Applied reproductive strategies in beef cattle symposium. Des Moines, IA. Beef heifer development systems and lifetime productivity.

Grazing Livestock Systems Class. Beef systems research.

State of Beef Conference. North Platte. Strategies for breeding high risk beef females.
Ranching for Profit Series. Synchronization systems and reproductive management.
Missouri Veterinary Medical Association Annual Meeting. Increasing production efficiency through reproductive management.
Missouri Veterinary Medical Association Annual Meeting. Heifer development before and after birth.
Kansas Veterinary Medical Association Annual Meeting. Increasing production efficiency through reproductive management.
Kansas Veterinary Medical Association Annual Meeting. Heifer development before and after birth.
Montana youth tour. North Platte, NE. Beef Systems Research.
Morrill County Cattlemen's meeting. Bridgeport, NE. Increasing production efficiency through reproductive management.
Harrisonville, MO Veterinary Meeting. Increasing production efficiency through reproductive management.
Springfield, MO Producer Meeting. Increasing production efficiency through reproductive management.
Rush Creek manager meeting. Beef Systems Research.
Leadership Lincoln County. North Platte. Beef systems research.
Angus Boot Camp. Lincoln, NE. Increasing production efficiency through reproductive management.
Shattuck, OK, Veterinary Producer Meeting. Increasing production efficiency through reproductive management.
Beef Summit Group meeting. Clay Center, NE. Beef Systems research.
Australian beef producer tour. Beef Systems research.
TN Cattle producer's tour. Gudmundsen Ranch. Beef Systems research.
Australian beef producer tour. Beef Systems research.
New faculty tour. North Platte. Beef Systems research.
Beef Cattle Short Course. TX A&M. Heifer development systems.

G. A. Perry – South Dakota

XXI Curso "Novos Enfoques na Producao e Reproducao de Bovinos" Uberlandia, MG, Brazil. 2017. Title "Role of estrus and preovulatory estradiol in pregnancy success."
XXI Curso "Novos Enfoques na Producao e Reproducao de Bovinos" Uberlandia, MG, Brazil. 2017. Title "Effects of peri-AI nutritional management on embryo development and pregnancy success."
Applied Reproductive Strategies in Beef Cattle Conference. 2016. Des Moines, Iowa Effects of peri-AI nutritional management on embryo development and pregnancy success."
The influence of elevated preovulatory estradiol on apoptosis in the trophectoderm of day 16 bovine conceptuse. Poster Society for the study of Reproduction annual meeting.
Influence of small doses of GnRH following CIDR removal on reproductive parameters in beef cattle subjected to a fixed-time AI protocol. Poster Society for the study of Reproduction annual meeting.
Estrous cycle regulatory mechanisms of the uterus are altered in cows that do not demonstrate behavioral estrus during an ovulation induction protocol. Poster Society for the study of Reproduction annual meeting.

Effects of Post-Insemination Dam Nutrition on Calf Performance and DNA Methylation. Oral presentation American Society of Animal Science annual meeting.

Influence of Vaccination with a Combined Chemically Altered/Inactivated BHV-1/BVD Vaccine or a Modified Live Vaccine on Reproductive Performance in Beef Cows and heifers. Oral presentation American Society of Animal Science annual meeting.

Effects of post-insemination dam nutrition on longevity and calf performance. Oral presentation American Society of Animal Science Midwest section annual meeting.

Influence of GnRH Supplementation at CIDR removal on estrus expression and interval to estrus in beef cattle. Oral presentation American Society of Animal Science Midwest section annual meeting.

Northrop, E.J., J.J.J. Rich, R.A. Cushman, and **G.A. Perry**. 2017. Impact of estrus expression and conceptus presence on plasma and uterine glucose concentrations up until maternal recognition of pregnancy in beef cattle. Poster presentation American Society of Animal Science Midwest section annual meeting.

R. F. Cooke - Oregon

Reproductive management in cow-Calf operations. In: Central Oregon Livestock Auction - Madras, OR (9/26/2016)

Reproduction in beef cattle. In: Cattlemen Toolbox Meeting – Redmond, OR (9/26/2016)

Supplementing omega-6 fatty acids to enhance reproductive performance in beef cows. In: Virginia Tech Animal Reproduction Seminar– Blacksburg, VA (11/11/2016)

Effects of temperament and animal handling on fertility. In: 2016 Applied Reproductive Strategies in Cattle – Des Moines, IA (9/6/2016)

R. A. Cushman – USDA-ARS MARC

Uruguayan Buitric Conference.

TransOva Summit Webinar.

V. R. G. Mercadante - Virginia

American Association of Bovine Practitioners Hands on Embryo Transfer School; Physiology of superovulation and synchronization. Instructor, Virginia-Maryland College of Veterinary Medicine,

ABS Global Beef Meetings, Plattsburg and Adrian, MO. Speaker: The economic advantages of implementing TAI.

VCE Webinar Series. Getting Ready for the Breeding Season. Organizer and Speaker: Strategies to Increase Reproductive Efficiency.

Master Cattleman Course. Reproduction Section, Abingdon, VA. Organizer and Speaker: Bovine Female Anatomy and Physiology. Current Reproductive Technologies for Cattle.

ASAS Southern Section. Extension Agent Training Webinar Series. Organizer and Speaker: Establishing an Estrus Synchronization Program.

P. M. Fricke - Wisconsin

Use of Chemical Pregnancy Tests for Managing Reproduction in Dairy Cattle. IDEXX meetings. August 7, 2017. Shandong, China

Development of Fertility Programs in High-Producing Dairy Cows. Total Dairy Seminar. June 14-15, 2017. Keele, United Kingdom.

Barriers to High Fertility. Total Dairy Seminar. June 14-15, 2017. Keele, United Kingdom.

Expression and Detection of Estrus in Dairy Cows. Total Dairy Seminar. June 14-15, 2017. Keele, United Kingdom.

Integration of Reproductive Programs and Technology to Improve Fertility. Total Dairy Seminar. June 14-15, 2017. Keele, United Kingdom.

Use of activity monitoring systems for managing reproduction in dairy cattle. Nedap. May 9-10, 2017. Groenlo, The Netherlands.

Veterinary Reproduction Workshop sponosored by Vetoquinol. April 28-30, 2017. Papagayo, Costa Rica.

Veterinary Reproduction Workshop sponsored by Ceva Sante Animale. April 11, 2017. Budapest, Hungary.

Effect of progesterone before and after timed AI on reproductive outcomes in lactating Holstein cows. Obihiro University Invited Lecture. February 7, 2017. Hokkaido, Japan.

Repro Workshop. Bovine Professionals Veterinary meeting. December 7-9, 2017. Hofheim, Germany.

Achieving high pregnancy rates in high producing dairy cows. Herdenmanagement client meeting, December 6, 2016. Hofheim, Germany.

Achieving high pregnancy rates in high producing dairy cows. Czech Republic dairy meeting. November 14, 2016. Kosetice, Czech Republic.

Achieving high pregnancy rates in high producing dairy cows. Merck Poland repro meetings. October 25-27, 2016. Wroclaw, Poland.

Methods for nonpregnancy diagnosis in dairy cows. China IDEXX meetings. September 19-22, 2016. Beijing and Hebei, China.

BRED Veterinary Workshop. June 9, 2016. Montebello, Quebec, Canada.

Managing Fertility in Expanding Dairy Herds. MSD Ireland dairy vet meetings, May 24-26, 2016. Armagh, Northern Ireland, Mullingar, Ireland, and Tipperary, Ireland.

Managing reproduction in dairy herds. AltaU UK, May 23, 2016. Bristol, U.K.

Repro update. Zoetis UK Westpoint Farm Vets meeting, May 21, 2016. Dorking, UK.

Repro update. CRI Distributor University, May 17, 2016. Mt. Horeb, WI.

Double-Vision: Management of twinning in dairy cows. Proc. Ontario Association of Bovine Practitioners, April 14, 2016. Guelph, ON.

Fertility programs to achieve high 21-d pregnancy rates in high-producing dairy herds. Proc. Ontario Association of Bovine Practitioners, April 14, 2016. Guelph, ON.

Fertility programs to achieve high 21-d pregnancy rates in high-producing dairy herds. Proc. Central Canadian Veterinary Conference, February 5, Winnipeg, 2016. MB.

Factors associated with pregnancy-associated glycoprotein levels in plasma and milk of Holstein cows during early pregnancy and their impact on the accuracy of pregnancy diagnosis. Proc. Central Canadian Veterinary Conference, February 5, Winnipeg, 2016. MB. Meetings for National and Regional Audiences

Veterinary Reproduction Workshop. Cornell Summer Dairy Institute. July 10, 2017. Ithaca, NY.

Use of activity monitoring systems to manage reproduction in dairy cattle. DeLaval International Training Meeting. June 29, 2017. Madison, WI.

Achieving high pregnancy rates in high-producing dairy herds. Agri Nutrition Consulting National Sales Conference. April 6, 2017. Madison, WI.

Achieving high pregnancy rates in high-producing dairy herds. Battenkill Veterinary Bovine client meeting. March 30, 2017. St. Greenwich, NY.

Achieving high pregnancy rates in high-producing dairy herds. Valleywide Veterinary Services client meeting. March 29, 2017. Middleburry, VT.

Achieving high pregnancy rates in high-producing dairy herds. Cold Hollow Vets client meeting. March 29, 2017. Enosburg Falls, VT.

Achieving high pregnancy rates in high-producing dairy herds. Northwest Veterinary Associates client meeting. March 28, 2017. St. Albans City, VT.

Development of Fertility Programs for High-Producing Dairy Cows. Northeast Dairy Production Medicine Symposium, March 18, 2017. Syracuse, NY.

Reproductive Technologies: Do's and Don'ts. Proc. 2017 Western Dairy Management Conference, March 2, 2017. Reno, NV.

Fertility programs to achieve high 21-d pregnancy rates in highproducing dairy herds. Proc. Renaisance Nutrition Conference, January 24-25, 2017. Altoona, PA.

Fertility programs to achieve high 21-d pregnancy rates in high-producing Holstein dairy herds. Proc. Miner Institute Dairy Day, December 13, 2016. Chazy, NY.

Managing reproduction in dairy cattle. Japanese dairy group, August 1, 2016. Madison, WI.

Managing reproduction in dairy cattle. Cornell Summer Dairy Institute, July 28, 2016. Ithaca, NY.

Managing reproduction using the latest technologies. Parnell dairy farmer and vet meetings, July 12-14, 2016. Napa Valley, CA.

Alta Dairy Showcase. June 17, 2016. Forestville, WI.

Fertility programs to achieve high 21-d pregnancy rates in high-producing dairy herds. Proc. Four-State Dairy Nutrition & Management Conference, June 15-16, 2016. Dubuque, IA.

Strategies for Nonpregnancy Diagnosis in Dairy Cows. Hoard's Dairyman Webinar, May 9, 2016.

Reproductive programs to maximize fertility in dairy cows. Proc. Large Dairy Herd Management Conference, May 2-4, 2016. Oakbrook, IL.

Barriers to high fertility in high-producing dairy herds. Zoetis Veterinarian Dairy Owner meeting, April 29, 2016. Madison, WI.

Fertility programs to achieve high 21-d pregnancy rates in high-producing dairy herds. Elanco Dairy Meetings, April 25-27, 2016. Decorah, IA, St. Cloud, MN, Red Wing, MN.

Fertility programs to achieve high 21-d pregnancy rates in high-producing dairy herds. Proc. Mid-Atlantic States Bovine Conference, April 1, 2016. Hagarstown, MD.

Repro update. Alta Genetics / VAS meeting, March 30, 2016. Tulare, CA.

Fertility programs to achieve high 21-d pregnancy rates in high producing Holstein dairy herds. Zoetis Pennsylvania Dairy meetings, March 7-10, 2016. Somerset, Strasburg, Spring Mills, Bedford, and Elliottsburg, Pennsylvania.

Pregnancy loss in dairy cows. Wisconsin Farm Technology Days. July 11, 2017. Algoma, WI.

Achieving High Preg Rates in High-Producing Dairy Cows. Parnell Reproduction Meetings. May 25, 2017. Mishicot, WI.

Achieving High Preg Rates in High-Producing Dairy Cows. Parnell Reproduction Meetings. May 24, 2017., Muscoda, WI.

Achieving High Preg Rates in High-Producing Dairy Cows. Parnell Reproduction Meetings. May 24, 2017. Ridgeway, WI.

Achieving High Preg Rates in High-Producing Dairy Cows. Zoetis Reproduction Meetings. April 6, 2017. Belmont, WI.

Achieving High Preg Rates in High-Producing Dairy Cows. Zoetis Reproduction Meetings. April 5, 2017. Sauk City, WI.

Achieving High Preg Rates in High-Producing Dairy Cows. Zoetis Reproduction Meetings. April 4, 2017. Monroe, WI.
Achieving High Preg Rates in High-Producing Dairy Cows. Kewaunee County Vet Meeting. March 23, 2017. Kewaunee, WI.
Achieving High Preg Rates in High-Producing Dairy Cows. Crossbreeding Peer Group meeting. March 14, 2017. Kewaunee, WI.
Managing Reproduction in Replacement Dairy Hiefers. UWEX Spring Heifer Meeting, March 8, 2017. Kimberly, WI.
Achieving High Preg Rates in High-Producing Dairy Cows. Valley Veterinary Clinic client meeting, January 19, 2017. Seymour, WI.
Achieving High Preg Rates in High-Producing Dairy Cows. UWEX East Metro Ag Agent Inservice Training, January 13, 2017. Appleton, WI.
Reproduction Research Update. Stateline Veterinary Clinic meeting, January 11, 2017. Delavan, WI.
Achieving High Preg Rates in High-Producing Dairy Cows. UWEX Cow College, January 10, 2017. Clintonville, WI.
Heat strees and reproduction podcast series with Liz Binversie. 2016.
Fertility programs to achieve high 21-d pregnancy rates in high producing dairy herds. Waupun Vet Service client meeting, April 7, 2016. Fairwater, WI.
Fertility programs to achieve high 21-d pregnancy rates in high producing dairy herds. Zoetis Dairy Peer Group meeting, March 3, 2016. Reedsburg, WI.
Repro update. UWEX Central Wisconsin Dairy Series, March 1, 2016. Sherry, WI.
Fine Tuning Reproduction. Zoetis Dairy Wellness Summit, February 18, 2016. Milwaukee, WI.

Funding (include grants and contracts)

Funding Agency	Value ($)	Years of funding	States Included
Church & Dwight	68,000	2017-2018	OR, VA
Church & Dwight	64,000	2017-2018	OR, VA
Diamond V	15,397	2016	KS
FDACS – FL Cattle Enhancement Fund	33,784	2016-2017	FL
FDACS – FL Cattle Enhancement Fund	33,100	2016-2017	FL
FDACS – FL Cattle Enhancement Fund	43,283	2016-2017	FL
FDACS – FL Cattle Enhancement Fund	36,449	2016-2017	FL
FDACS – FL Cattle Enhancement Fund	139,000	2015-2018	FL
FDACS – FL Cattle Enhancement Fund	95,788	2017	FL, MO
Kansas Dairy Commission	5,000	2017	KS
Kansas Dairy Commission	5,000	2017	KS
Select Sires	8,800	2017	KS
Sexing Technologies	20,000	2017	MO
Sexing Technologies	20,000	2016	MO
University of Missouri Thompson Research Center	15,000	2017	MO
USDA-AFRI	450,000	2015-2018	FL, VA
USDA-AFRI	480,000	2017-2020	FL, VA
USDA-AFRI	99,999	2017-2018	VA

USDA-Hatch RRF	10,000	2017	KS
USDA-NIFA	2,997,040	2013-2017	MO