December 2007

Livestock and Range Research Laboratory

Fort Keogh Researcher

In cooperation

with

Introduction

It has been a long time now since we have put together a Fort Keogh Newsletter. In fact, as I look back, it has been a little over a year (November, 2006) since the last one and two years (December, 2005) since the one before that. I hope we are able to move the schedule for this newsletter back to twice a year.

There have been a lot of changes at Fort Keogh in the past year. After more than 16 years as the Research Leader, Rod Heitschmidt retired on December 31st of last year. In the interim, we have had three different scientists serve as Acting Research Leader and are hopeful that we will find a candidate among the applicants for the Research Leader within the next couple of months. It is a busy time of year to try to plan interviews and winter travel in Eastern Montana does not help. Other retirements include Dave Phelps, (December 2006) Research Assistant for the Physiology Crew, Gene Life (July, 2007), our Safety Officer, and Jim Howard (November, 2007), a member on our Farm Crew. Dr. Elaine Grings has also left Fort Keogh (December, 2007), after serving as a Nutritionist here since 1991 and has taken a position with the International Livestock Research Institute. Her new office will be in Nigeria, Africa. Once we get a new Research Leader on board, we will begin to fill Elaine's vacancy. Jack Attig, our Administrative Officer for the past 4 years resigned his position at Fort Keogh to return to Kansas with the USDA-NRCS.

We have also been fortunate to hire some outstanding individuals within the last year. Alan Mason, a graduate of Montana State University and a Colorado native was hired during the spring to fill a vacancy on our Physiology/Nutrition Cowboy crew. Dennis Logan, from Ismay, Montana, has recently filled a similar position on our Genetics Cowboy crew. Kurt Reinhart was hired early in 2007 to fill the Ecologist. Position. Kurt began work here in July. Kurt plans to pursue soil-plant biota interactions as they relate to fire recovery and weed invasions. The administrative officer vacancy was filled by Meribeth Wuertz, a Montana Native who was the Human Resources Director for the Park Service (Yellowstone) for many years. Hopefully it won't be long before all of our new employees are settled in and things are operating smoothly.

Tom Geary
Acting Research Leader

All of the staff here at Fort Keogh wish all of you a very Happy Holiday Season and hope the New Year is full of joy and excitement.

Inside this issue:

Retirements

Dr. Rod Heitschmidt, Research Leader, retired December 31, 2006, after 16+ years with ARS.

Rod and Sue are staying in Miles City for now. Rod intends to remain professionally active in the rangeland science profession through his work with the Society for Range Management and occasional consulting/ advisory opportunities.

Dave Phelps, Research Assistant for the Physiology Crew, retired after 25 years at Fort Keogh.

Dave and his wife, Debbie, continue to live at Kinsey, outside of Miles City. Dave is taking care of the home place while Debbie continues to work at the high school. Their daughter, Natalie, is attending college in Grand Forks, North Dakota.

Gene Life, Safety and Occupational Health Officer, retired June 30, 2007, after 7 years at Fort Keogh.

Gene and his wife, Linda, moved to Moorhead, Minnesota. They also have a great spot on Round Lake where they park their 5th wheel and enjoy the fishing!

Jim Howard, Research Assistant Farm/Feedlot retired November 30, 2007, after more than 35 years of service.

Jim will still be around town working his firewood business and doing other odds and ends.

New Ideas on Development of Replacement Heifers

Andy Roberts
Research Animal Scientist

Feed resources used to develop replacements can have a major influence on long-term profitability of a cattle operation. The direct expense of either purchasing or developing heifers is often obvious for producers, however, the impact that the management system used for rearing heifers has on lifetime productivity is much less obvious and more difficult to assess.

When considering how to feed replacement heifers for proper development, most attention has been placed on providing sufficient feed resources during the postweaning period to ensure that a maximum number of heifers will attain puberty prior to breeding, with much less concern towards nutritional influences prior to weaning. Research in other species indicates that type and level of nutrition that animals are exposed to throughout life, as well as exposure to different substances in the environment can influence genetic expression in future offspring. These are referred to as epigenetic effects, and they can persist from one generation to the next. Furthermore, it is now becoming obvious that the nutrient environment that a cow is exposed to during pregnancy can have lifelong effects on the calf, even in the absence of noticeable effects on the cow. A long term research project at Fort Keogh is investigating potential impacts of winter nutritional environment that heifers experience while in utero and differences in levels of nutrition provided during postweaning development on lifetime productivity. While it will take several more years to complete this research, the remaining portion of this article summarizes some of the findings concerning results from feeding heifers at different levels during the postweaning development period.

Concern or attention towards postweaning management of replacement heifers originated several decades ago when producers began to shift from breeding heifers at 2 years of age to breeding them at 1 year of age. Research conducted here at Ft. Keogh and elsewhere during the late 1960s through the early 1980s established guidelines that replacement heifers should be fed to achieve 60 to 66% of their expected mature body weight by the time breeding starts to ensure attainment of puberty. The basis behind this recommendation was that onset of puberty was determined to be a function of both age

New Ideas on Development of Replacement Heifers (cont.)

and body weight. Thus, a heifer could become pubertal by 14 months of age if she achieved a sufficient body weight. While the recommended target weights have served the industry well over time, it appears that genetic change in cattle over the last several decades may allow heifers to be developed to lighter breeding weights, while still achieving acceptable breeding rates. In the mid-1980's, researchers identified an association between scrotal circumference in bulls and age of puberty in their female offspring. Since that time, scrotal circumference has been used as an indicator trait for puberty. An appraisal of the change that has occurred in scrotal circumference from 1985 to the present indicates substantial progress has been made, and a similar response in age of puberty would be expected. Indeed, the ability of heifers to attain puberty prior to breeding may not be as problematic as precocious puberty has become in today's cow herd.

Research conducted over the last 5 years at Fort Keogh evaluated puberty and pregnancy rates of heifers developed with either unlimited or restricted access to feed during 140 days of the postweaning period. Results obtained so far indicate a potential to reduce target weights when developing replacement heifers, and thereby decrease input of harvested feeds. Figure 1 provides a brief description of the experimental protocol and illustrates the growth rates of heifers developed under the two levels of feeding. Over the course of the 140-day treatment period, restricted heifers were fed 27% less feed than the control heifers provided unlimited access to feed, which resulted in lower average daily gain (ADG) (1.14 vs. 1.5 lb/d) for restricted fed heifers during the 140-day period. Efficiency of body weight gain during the 140-day period, was greater for restricted heifers (0.12 lb gain/lb feed) than control heifers (0.11 lb gain/lb feed). After the 140-day trial, restricted heifers were fed the same as the unrestricted controls. Although there was substantial variation over the years (see top panel of Figure 2), average weight for restricted and control fed heifers at the last weight measurement prior to initiating breeding at 14 months of age was equivalent to 57% (698 lbs) and 60% (740 lbs) respectively, of their predicted mature weight of 1230 lbs. The proportion of heifers that had achieved puberty prior to breeding varied substantially over the 5 years of the study, with a low of 27% and a high of 100% (see 2nd panel of Figure 2). The average proportion of heifers achieving puberty prior to breeding over the 5 years evaluated was less in the restricted heifers (55%) than the control fed heifers (67%). Of those heifers that achieved puberty prior to breeding, there was no difference in age at puberty (overall average 380 d), but weight of heifers at time of puberty was less in restricted (667 lb) than control (713 lb) fed heifers. These average weights of heifers at time of puberty correspond to 54 and 58 % of the expected 1230 lbs for mature weight of cows in this herd. These results indicate that reaching a sufficient age was more critical for achieving puberty than reaching a sufficient weight.

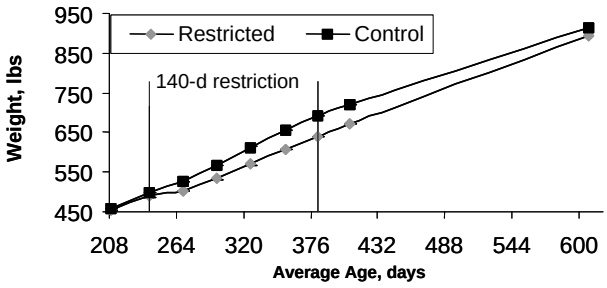

Figure 1. Growth rates of heifers developed on either ad libitum (Control) or restricted levels of feeding during a 140-day period (shown between vertical lines) between weaning at about 6 months of age and breeding at about 14 months of age. At weaning (~ 1st week in October), heifers were placed in a feedlot and were given ~1 month to adapt to the feedlot, and a second month to establish level of feed intake (first 2 points in figure). Beginning in the 1st week of December (2nd time point in figure), the amount of feed provided to heifers assigned to be restricted was reduced by 20% of that consumed by control fed heifers of equivalent weight. After 140 days of restriction (last week of April), all heifers were fed the same. Heifers were weighed again prior to breeding at about 14 month of age (~ 1st week in June; second to last time point in figure) and at fall pregnancy diagnosis in late November or early December (last time point).

After the 140-day feeding trial, heifers from years 2002 to 2005 were maintained in a drylot for 30 to 40 additional days to facilitate implementation of an estrous synchronization and AI protocol. These heifers were then placed with bulls for a total of 48- to 53-day breeding season. Because additional harvested feed and labor resources are required to maintain heifers in a drylot setting for AI, the protocol was changed for heifers from 2006 to evaluate response when heifers were placed directly on pasture after the 140-day feeding period. After about 40 days on pasture, heifers from 2006 were subjected to a 62-day natural breeding season. As with weight and percent pubertal at the onset of breeding, pregnancy rate to AI (2002 to 2005) varied across years (see 3rd panel of Figure 2). In contrast to the reductions in weight and percent pubertal at the start of breeding that resulted from restricted feeding, there was not consistent difference in AI pregnancy rate between feeding treatments (3rd panel of Figure 2). When AI pregnancy rates for years 1-4 were averaged with the first 21-day of natural breeding (year 2006), no difference was observed between restricted (45.8%) or control (46.4%) fed heifers. Likewise, final pregnancy rates did not differ between feeding treatments over the 5 years (bottom panel of Figure 2), with an

New Ideas on Development of Replacement Heifers (cont.)

overall average pregnancy rate of 90%. A visual comparison of the year to year variation in weight at breeding with the variation in percentage achieving puberty and AI pregnancy rates shown in Figure 2 indicates that there was not the expected association among these traits over the years (i.e., year with lowest weight at breeding was not year with lowest proportion reaching puberty or lowest AI pregnancy rate). Likewise, the consistent reduction in weight and proportion pubertal at start of breeding observed in restricted fed heifers did not correspond to a consistent reduction in pregnancy rates. These results indicate that the decades old industry recommendations that heifers should be fed to achieve 60 to 66 % of their expected mature weight by the beginning of the breeding season may need to be revised. A factor that needs to be considered when interpreting the results from this research, is that the heifers studied were from the CGC composite herd of cattle developed at Ft Keogh (1/2 Red Angus, ¼ Charolais and ¼ Tarentaise), and therefore the results may be affected by the high level of heterosis that exists in these and other crosses or composite cattle. Additionally, heifers in years 1-3 received an estrous synchronization protocol that is capable of inducing estrous cycles, whereas in year 4 (2005), heifers received a protocol that does not induce estrous cycles. Heifers born in 2006 did not receive any estrous synchronization protocol and were turned out on pasture immediately after the 140-day treatment period, resulting in several less workings and greater opportunity to take advantage of spring green up prior to breeding.

Year to year variation in the ADG from the end of the 140-day period to time of breeding contributed to some of the variation in weight prior to breeding that is evident in the top panel of Figure 2. When averaged over the years, ADG during this time was greater in restricted heifers (1.6 lb/day) than control heifers (1.3 lb/day). During the period from the beginning of breeding to the fall pregnancy diagnosis, when all heifers were grazing native range, ADG was also greater in heifers that had been developed on the restricted feeding level than control heifers (1.15 vs. 0.96 lb/d). The increased gain among restricted heifers during both of these periods may place these heifers in a more positive energy balance that improves fertility. However, restricted heifers still remained about 25 lbs lighter than control heifers at the fall pregnancy diagnosis (last point on Figure 1). Thus, in addition to a decrease in direct cost associated with developing heifers on limited nutritional inputs which improved efficiency during the winter feeding period, the greater rates of gain while grazing after the winter feeding period and lighter weights going into the winter are also indicative of improved efficiency. These results indicate an opportunity to decrease cost of production by decreasing amount and/or quality of harvested feeds used for heifer development and improving efficiency. A question we will try to answer with our data set is whether the improved efficiency of restricted fed heifers is maintained over the course of their lifetime.

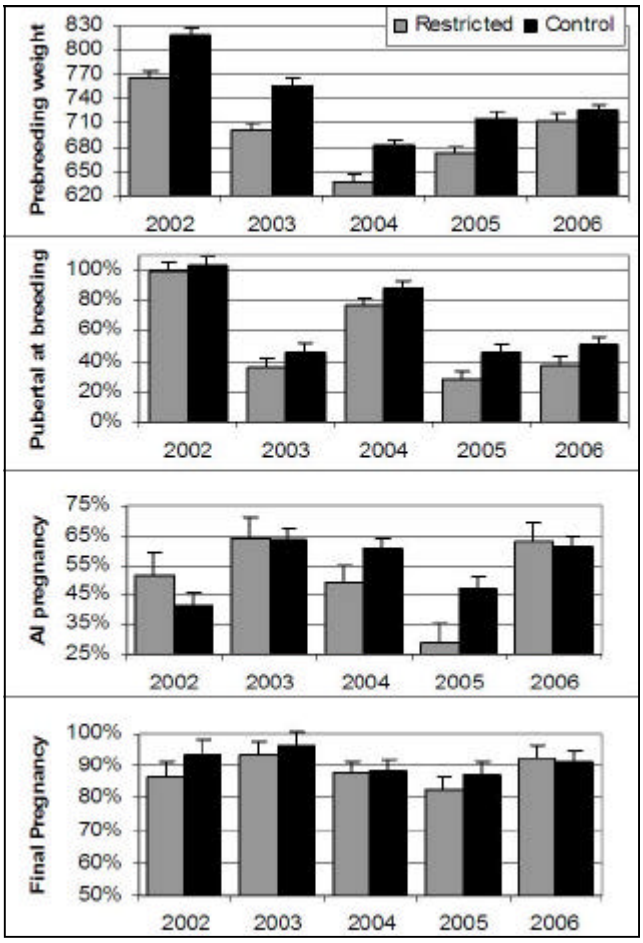

Figure 2. Prebreeding weights and reproductive performance of heifers from 5 years (birth year shown on x axis) that were provided ad libitum (Control) or restricted access to feed during 140 days of the postweaning period (see caption of Figure 1 for more details on feeding). Heifers from 2002 were fed in pens of 25 to 30 animals, whereas heifers from subsequent years were individually fed during the postweaning period. For 30 to 40 days between the end of the feeding trial and breeding, heifers from 2002 to 2005 were maintained in a drylot setting to allow for a synchronized AI. These heifers were then placed on pasture for natural mating for the remainder of a 52-day breeding season. Heifers from 2006 were put on pasture after the trial and subsequently exposed to bulls for a 62-day breeding season.

Summary

The genetic composition and method used for developing replacement heifers can have major impacts on efficiency and lifetime productivity. Nutritional influences on replacement heifers begin *in utero* and continue throughout life. Genetic changes in age and weight of puberty achieved over the last several decades may provide opportunities to reduce cost of developing heifers by decreasing the industry guidelines for heifer weights at time of first breeding. Developing heifers on lower levels of nutrient input can improve efficiency and may alter longevity, as has been shown in other species. Although a large number of traits exist for producers to choose from, reproductive traits have the largest influence on

productivity in commercial cow-calf enterprises, as these traits culminate in more pregnant cows, older calves at weaning, increased longevity and decreased replacement rate of younger animals. However, feeding to maximize reproductive performance or any other trait may not equate to the most efficient productivity. In this respect, greater efficiency is probably achieved by not feeding to maximize reproductive performance, but feeding to optimize reproductive performance. This approach may help select for females that better match a nutrient limited environment rather than altering the management (increase feed inputs) to support changes resulting from genetic selection for increased productivity.

Award

The Beef Reproduction Task Force, in cooperation with the Beef Reproduction Leadership Team, was proud to dedicate the proceedings of the Applied Reproductive Strategies in Beef Cattle Workshop in recognition of the combined contributions of three pioneering scientists in the field of bovine reproductive biology and management: Dr. Robert A. Bellows, Dr. Robert E. Short, and Dr. Robert B. Staigmiller.

The three Bobs were the epitome of a finely tuned research team. The legacy of these three scientists persists as a result of their individual and collective scientific contributions during the 20+ years they worked together at the USDA-ARS Fort Keogh Livestock and Range Research Laboratory. Together, these three scientists published over 600 scientific and popular articles on beef cattle reproductive physiology, endocrinology, and management. This is a truly enviable level of scientific productivity, and even more amazing, they did it together as friends! Their sustained and outstanding productivity in basic and applied beef cattle reproductive research and the development and transfer of associated technology to the American beef cattle industry was exemplary. Their combined efforts spanned the spectrum of reproductive related topics of significant economic importance to the beef cattle industry, and topics related to pregnancy, puberty, parturition and the postpartum period.

Each of these scientists received their Ph.D. degrees under the supervision of Dr. L.E. Casida at the University of Wisconsin in Madison. Dr. Casida's graduate program is recognized internationally as the pioneering program for the field of reproductive physiology and endocrinology.

The Bobs' collective approach to research was comprehensive, including basic studies on the endocrine and physiological basis of reproductive processes in addition to studies that demonstrated ways in which basic knowledge may be used to improve the efficiency of production in beef cattle herds. Each scientist served as lead investigator and team member, but, in addition, cooperated with other scientists, post docs, and graduate students at Fort Keogh and other institutions throughout the U.S. and abroad.

Animal scientists, veterinarians, allied industry and beef producers are indebted to these three individuals for their efforts in advancing our understanding of the major reproductive processes in beef cattle.

APPRECIATION IS EXPRESSED TO
Robert A. Bellows, Ph.D.
Robert E. Short, Ph.D.
Robert B. Staigmiller, Ph.D.

For their significant individual and collaborative research which contributed to "*new knowledge*"
For their significant contributions to increased efficiency of "*beef cattle reprod*uction"
For their significant contributions to scientists and ranchers through "*collaboration and mentoring*"
BEEF REPRODUCTIVE LEADERSHIP TEAM
Applied Reproductive Strategies in Beef Cattle Workshop
Billings, Montana
September 11-12, 2007

Dr. Robert Bellows

Dr. Robert Short

Dr. Robert Staigmiller

New Employees

Kurt Reinhart joined the staff on July 23, 2007. His approach to science is relatively diverse and incorporates a range of topics relevant to ecology, ecological systems and interactions, and experimental and descriptive methodologies. Preceding the start of his Ph.D. research, he conducted research relevant to fire ecology, plant ecophysiology, etc. which resulted in his coauthoring five peer-reviewed scientific journal articles. Kurt's Ph.D. research at The Univeristy of Montana and post-doctoral research at Indiana University focused on three topics: 1) the mechanisms non-native and invasive species use to impact natural systems, 2) the importance of plant-soil biota interactions in facilitating the invasion of non-native species, and 3). the impact of soil biota in regulating patterns of diversity, productivity, and invasive success. Kurt's future research will continue to explore topics relating to the impacts and dynamics of invasive plants, plant community change, and plant-soil biota interactions while incorporating aspects of fire ecology and herbivory. Recent honors include, as principle investigator, grants funded by the USDA-NRI and National Parks Ecological Research Fellowship program, two nationally competitive grant programs.

Kurt is always interested in starting new collaborations. He has successfully collaborated with scientists on a range of projects in this country and abroad. Although collaborations can develop among people with similar expertise, Kurt finds they are often most productive when a synergy develops among scientists with different backgrounds and expertise.

Kurt Reinhart
Ecologist

Maribeth Wuertz
Administrative Officer

Maribeth Wuertz joined the staff as Administrative Officer on November 13, 2007. Maribeth comes to Fort Keogh from Emigrant, Montana, where she worked for the Park Service as the Human Resources Director.

Alan Mason
Physiology Cowboy Crew

Alan Mason joined the staff as a Research Assistant on the Physiology/Nutrition Cowboy crew in June 2007. Alan is a Colorado native and a graduate of Montana State University.

Dennis Logan
Genetics Cowboy Crew

Dennis Logan joined the Genetics Cowboy Crew in August of 2007. Dennis has been ranching most of his life and comes from the Ismay area.

Olivia
Mapholi
Grad Student

In April Ntanganedzeni "Olivia" Mapholi Tshipuliso, from the Agricultural Research Council in South Africa, came to Fort Keogh in pursuit of her master's degree. She studied ways of using genomic technology as tools to improve livestock production. Additionally, she analyzed fatty composition in meat searching for genetic traits affecting the relative amounts of saturated, monounsaturated and polyunsaturated fatty acids in progeny from Wagyu bulls mated to Limousin dams. She evaluated what happens to the gene known for what's called white spotting in the Line 1 Hereford herd when those cattle were crossed with another population that does not carry or express the gene. These studies helped design a series of experiments in South Africa with the goal to use molecular technology to empower the South African (SA) emerging farmer by helping them improve their livestock production and meet market needs.

Recent Publications

Alexander, L.J., Geary, T.W., Snelling, W.M. and MacNeil, M.D. 2007 Quantitative trait loci with additive effects on growth and carcass traits in a Wagyu-Limousin F2 population. Animal Genetics 38:413-416.

Alexander, L.J., MacNeil, M.D , Geary, T.W., Snelling, W.M. Rule, D.C. and Scanga, J.A. 2007 Quantitative trait loci with additive effect on palatability and fatty acid composition of meat in a Wagyu-Limousin F2 population. Animal Genetics 38:506-513.

Branson, D.H. and Vermeire, L.T. 2007. Grasshopper egg mortality mediated by oviposition tactics and fire intensity. Ecological Entomology 32:128-134.

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Grings, E.E., T.W. Geary, R.E. Short, and M.D. MacNeil. 2007. Beef heifer development within three calving seasons. Journal of Animal Scientist 85:2048-2058.

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Roberts, A.J., Paisley, S.I., Geary, T.W., Grings, E.E., Waterman, R.C., MacNeil, M.D. 2007. Effects of restricted feeding of beef heifers during the postweaning period on growth, efficiency and ultrasound carcass characteristics. Journal of Animal Science 85:2740-2745.

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Waterman, R.C., Grings, E.E., Geary, T.W., Roberts, A.J., Alexander, L.J., MacNeil, M.D. 2007. Influence of seasonal forage quality on glucose kinetics of young beef cows. Journal of Animal Science 85:2582-2595.

Livestock and Range Research Laboratory

243 Fort Keogh Road
Miles City, MT 59301-4016

Phone: 406-874-8200
Fax: 406-874-8289

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