The Roundup

Livestock and Range Newsletter
Kern, Tulare, and Kings

University *of* California
Agriculture and Natural Resources

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Happy Fall Everyone!

As always, I hope this issue of the Roundup finds all of you doing well! I have a couple of updates to share:

- UCANR has a new publication available to help with measuring water diversions. ANR publication 8490, Low-Cost Methods of Measuring Diverted Water is available for free online at: https://anrcatalog.ucanr.edu/. This publication is in response to the reporting requirements under SB 88. Information on measuring water volume in stockponds can be found at: http://cekern.ucanr.edu/Livestock/stockponds/
- In collaboration with Livestock and Range Advisors from other counties, I am looking into research opportunities on oaks. To that end, we developed a short survey to gain feedback from landowners on oak mortality. I would appreciate it very much if you would take the time to fill out the short survey. It should take about 5 minutes and it can be accessed here: https://ucanr.edu/survey/survey.cfm?surveynumber=25464

Inside this issue of the Roundup are a number of exciting and interesting topics:

- Cattle Genetics: from Range (or Dairy) to Lab and Back Again
- Ask the Advisor: California Corn Import Restrictions
- Mineral Status of California Beef Cattle
- Compost on Rangelands: State of the Science

If you would like information on a topic referenced in a link above, please call Julie at 661-868-6219 and she can provide a paper copy. I hope you all find something of interest in this edition of The Roundup.

Best,

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Cattle Genetics: From Range (or Dairy) to Lab and Back Again

By Rebecca Ozeran, UCCE Livestock and Natural Resources Advisor, Fresno and Madera Counties

San Joaquin Valley livestock are an important part of ongoing genetic research at UC Davis - even after they've gone to slaughter.

In the fall of 2018, I got a call from Dr. Alison Van Eenennaam, UC Davis Specialist, asking if I was interested in being part of a new genetics project. In particular, she wanted to know if I was up for a unique task: collecting cow ovaries.

Photo: a cow ovary, detached from the uterus. Based on my recent ovary collection experience, I estimate that this ovary measures about 2 inches long and 1 inch in diameter. Cow ovaries can be as small as a grape or nearly the size of one's hand, depending on the stage of follicle development and other factors.
Photo © University of Wisconsin Dept. of Animal Sciences, accessed at http://www.ansci.wisc.edu/jjp1/ansci_repro/lec/lec1/female_hist.html

Yes, ovaries.

As it turns out, UC Davis has had an agreement with the Cargill processing plant in Fresno for many years now, in which Cargill or a UC employee will collect ovaries from the cows that are processed, and then a UC Davis employee will drive the ovaries up to the university. Once in the lab, the ovaries provide oocytes (egg cells) for genetic research.

This is only possible because the Cargill plant receives hundreds of cull cows every day, which provide most of the lean meat used in their ground beef and some retail cuts of meat. Many of these cows come from nearby dairies and beef operations in the San Joaquin Valley, and some come from farther away to fill in gaps in local culls. While the carcasses are being processed and turned into beef cuts and byproducts, a Cargill employee or a researcher can collect ovaries off the reproductive tracts.

Dr. Van Eenennaam and the other researchers in her lab realized that the long drive made it difficult to keep the oocytes alive between Fresno and Davis. They saw fewer viable oocytes when the ovaries were transported in a large plastic bag than when they were transported in an insulated container - a thermos.

Why was this? Normal cow body temperature is similar to humans; a healthy cow should be around 37-38°C (98-101ºF). In the plastic bags, the ovaries were not being well insulated from the ambient air temperatures and after the 3-hour drive, they often cooled to around 26ºC (79ºF). As you can imagine, 26ºC is not a temperature that will keep cells alive if they normally thrive at 37ºC. If a live cow had a temperature of 26ºC, she would be hypothermic and might not be alive for much longer.

Because it takes an hour or two to collect the ovaries the lab needs, it isn't feasible for a UC Davis employee to drive down, collect ovaries, and return to Davis in a reasonable time to process the ovaries in the same day. However, when Cargill employees collect the ovaries on behalf of UC Davis, they can only put them in the large plastic bags. Cargill can't afford the extra time on the conveyor belt to trim the ovaries of excess tissue, either, which means more work for UC Davis researchers to access the oocytes.

That's where a local collaborator can be helpful. With a pair of scissors, I can collect ovaries without interrupting normal processing activities, trim the ovaries to remove unnecessary tissue, and place them into insulated containers with saline to limit the temperature change. By keeping the ovaries safely above 30ºC, the lab in Davis should reliably have higher numbers of oocytes to work with. These oocytes are ultimately fertilized to create embryos which can be transferred to recipient cows at UC Davis.

Photo: cow embryos at UC Davis, which were created using oocytes from ovaries collected at Cargill.
Photo © Joey Owen, 2018.

Why do they need so many oocytes?

In genetic research, the number of embryos that are still viable after the various kinds of manipulation - *in vitro* fertilization (IVF), gene editing, biopsy to sequence DNA, freezing, and so on - is a tiny fraction of the number of oocytes originally collected. Each time an embryo is handled, its probability of survival decreases. Even without gene editing, the rate of successful pregnancy from embryo transfer of fresh embryos is only 60-70%; frozen-thawed embryos have approximately 50% pregnancy rates[1]. Biopsy of embryos – often done so that a researcher can sequence the DNA, for example to see if edited genes were successfully integrated into the genome – can reduce pregnancy rates to as low as 23-31%[2,3,4] depending on biopsy method, stage of embryo development, and whether the embryo is also frozen and thawed after biopsy.

Thus, the more oocytes that are in good shape, the better chance of embryos that will result in a viable pregnancy. In genetic research projects, viable pregnancies are critical.

Photos: Thawing frozen embryos (left) to transfer into recipient cows (right). The cow outside the chute had already received an embryo and was probably offering moral support to her peer.
Photos © Rebecca Ozeran, 2018.


For example, graduate student Joey Owen is working with Dr. Van Eenennaam to test a new gene editing strategy called CRISPR/Cas9. (For more information about CRISPR/Cas9, visit: https://ghr.nlm.nih.gov/primer/genomicresearch/genomeediting.)

Below is Joey's research abstract:

> Animals engineered for improved health, nutrition, or production traits have the potential to positively impact the global food supply. However, current methods for inserting a gene into a targeted location in the genome need to be improved in order to efficiently generate such animals. Additionally, management practices to minimize associated physical and biological risks to the environment need to be developed. Some methods for environmental containment have been proposed, but recent advances in the field of gene editing, such as the discovery of the CRISPR/Cas9 system, may facilitate the development of animals that would present few or no new environmental risks. One such method would be to create a construct that renders animals carrying the transgene infertile, thereby containing the transgene to a single generation. Despite these containment issues, there is growing concern regarding our nation's role in fighting hunger and ensuring global food security. As worldwide demand for animal-source protein continues to rise, efficient and sustainable production of livestock is of growing importance. Increasing the proportion of male offspring that result from a terminal sire (i.e. a sire used to produce offspring specifically for slaughter) mating would result in improved efficiency of beef production since males finish at heavier weights, gain weight more quickly and efficiently than females, and are easier to manage due to lack of estrus behavior. It is hypothesized that a CRISPR/Cas9-mediated gene knock-in of SRY onto the X chromosome in cattle will produce fertile $X_{SRY}Y$ cisgenic bulls. When mated with XX females, these bulls will produce phenotypically all male offspring, half of which will be fertile XY males, and the other half of which will be infertile cisgenic XX_{SRY}phenotypic males. This would provide an approach for containment of transgenes that could be transferred alongside the X_{SRY}gene knock-in. The objectives of this project are to develop an efficient gene knock-in approach using the CRISPR/Cas9 system; to evaluate the effects of copy number variation in *SRY* on fertility; and to

determine if this single gene knock-in of the endogenous bovine *SRY* gene is sufficient and necessary to produce all phenotypically male offspring. This work could aid in the development of methods to efficiently create gene-edited animals using gene knock-in through the CRISPR/Cas9 system, which could ultimately address food supply and food security concerns by improving the efficiency of beef production. It may also provide a method for containment of transgenes by inserting the *SRY*gene into a region that does not undergo recombination, thereby limiting transmission of the transgene to sterile males.

In brief, his goal is to see if gene editing can produce bulls that will give only male offspring for terminal (market) crosses, by manipulating one of the key gene sequences that impact physical sex characteristics. If they are successful, although half of the offspring would have the XX genotype – which is normally a female genotype – they would have male physical characteristics because of the *SRY* gene insertion. If Joey's research does not result in viable pregnancies, then he will have no way of knowing whether this gene knock-in can be successfully used to breed fertile bulls with the edited gene. It will also take a second generation to know if the $X_{SRY}Y$ bulls indeed produce only (phenotypically) male offspring.

What is the value of this research to livestock operations?

To Joey, "the most important points are the benefit to producers that this technology (i.e. CRISPR) can have towards improving livestock health, welfare and production, as well as how safe and effective it can be."

Genetic research is complex and can often seem theoretical, especially when experiments require many years of making small steps forward before there is a production-ready genetic tool available. UC Davis is working on many projects like Joey's with a big-picture goal of a more productive and economically viable livestock industry, and livestock from the San Joaquin Valley are directly contributing to this exciting research.

Ask the Advisor – Restrictions on Corn Imports into California

Question: *I'm planning a roadtrip to the Midwest and I'm thinking about picking up some bags of feed while I'm in the corn belt, thinking the feed might be cheaper there? Are there any restrictions on bringing cattle feed into California?*

Answer: Yes, there are restrictions on corn imports into California. The California Department of Food and Agriculture has placed restrictions on corn imports due to the European Corn Borer. The European Corn Borer is not native to the US and has been an important pest in corn since the 1920's. The European Corn Borer at maturity is a moth. The larvae overwinter inside the corn stalk and feed on the whorl, stem, tassel and stalk. More information on the borer can be found at: https://extension.entm.purdue.edu/fieldcropsipm/insects/euro-cornborer.php and at: http://entnemdept.ufl.edu/creatures/field/e_corn_borer.htm

CDFA Code 3263 details the quarantine and the import restrictions. It is available here and at:

https://pi.cdfa.ca.gov/pqm/manual/htm/311.htm. The restriction applies to corn, corn broom, sudan grass, shelled grain, beans in the pod, pepper fruits and some species of flowers like dahlias, geraniums, and aster species (plants in the sunflower family). Imported corn is required to be have been treated for the borer in a manner approved by the Secretary of Agriculture (details are not specified, but it appears fumigation may be an option) or for the grain to have passed through a ½ mesh screen or smaller. The most straightforward way to determine if grain produced in another state is acceptable for import into California is to call the grain processor directly and ask if they meet California entry requirements.

Mineral Status of California Beef Cattle

Josh Davy – UC Livestock and Range Advisor – Tehama, Glenn, Colusa
Larry Forero - UC Livestock and Range Advisor – Shasta, Trinity

Mineral nutrition impacts the most important traits for managing beef cattle including reproduction and immune response. In reproduction, mineral levels influence overall conception, the timing of conception, abortion, and fetal skeletal development. Documented immune response to vaccination has shown a lower response in cattle that are mineral deficient compared to cattle with adequate levels. This is compounded in calf health as minerals are transferred from the cow to the calf through the placenta and colostrum. Cows that are mineral deficient are not able to transfer minerals to the calf resulting in calves with reduced immune response, lower vigor and possible deformities.

Cattle are commonly provided mineral supplement across California, but it's not largely know how well it's working. To answer this question, in 2017 and 2018 a project was conducted that documented current mineral levels in cattle across the state. Prior to this project the only mineral documented was selenium, and in that study, California was a small subset of a larger national survey. The Rustici Range Research Endowment funded the sampling cost for UCCE Livestock Advisors to sample cattle. Sampling occurred across the state and included 555 head from 50 herds. (10 hd per herd; Table 1). For analysis herd level factors including region, whether cattle were supplemented for each mineral, and forage source (irrigated vs dryland) were gathered to test their importance on mineral status.

Nearly all mineral levels were influenced by region, with the exception being manganese (Table 2). Manganese was low according to critical levels across all regions. Manganese is one of the least researched minerals sampled, particularly in California. Very little testing has been done even at the herd level. Further research defining the critical levels based on production responses to manganese in California is necessary. Limited research has found late or no conception and calf deformities with deficiency.

Copper deficiency increased from north to south, with 55% of Southern California cattle showing deficiency. Cattle supplemented with copper and manganese were substantially higher in serum levels than those that were not supplemented. Both bolus and loose salt copper supplementation worked very well. In loose salt mixture supplementing both manganese and copper with the oxide form appears low in bioavailability and efficacy, thus a sulfate or preferably chelated forms should be used.

Selenium deficiency was encouragingly low, meaning that deficiency is well recognized around the state, and supplemental methods typically used are working well. Selenium was one of the few minerals affected by forage source. Dryland range was slightly higher in selenium levels over irrigated pasture, but the difference was very small. Unlike copper, selenium deficiency was not seen in Southern California even though almost no herds in the area were supplemented. Non-supplemented cattle tended to be deficient further north, but non-supplemented herds were not commonly seen.

Although the severity of zinc deficiency varied by region, nearly all areas shown at least a quarter of sampled cattle as low. Supplementing zinc in a loose salt mixture significantly shown improvement in mineral levels and is recommended statewide. Zinc affects follicle development so correction is important in reproduction.

Magnesium, calcium, phosphorus, potassium, and sodium deficiencies were not seen in large numbers when compared to other minerals.

Often debated is the validity of serum blood testing (whole blood for selenium) used in this research versus liver biopsy. A liver biopsy is the most accurate method of testing as the liver stores most minerals, excluding manganese. Because the liver stores minerals a biopsy allows the detection of levels that are dropping more quickly, but of course is much more invasive than blood sampling. Serum testing requires the liver to be depleted before low mineral levels are detected in the blood. With this in mind *false adequate* tests are possible with serum samples, while *false low* readings are much less likely. Cattle in this trial were on the same forage and mineral supplement for 4-6 months prior to sampling to help balance these effects. In any case, the results reported are likely a best case scenario, meaning higher deficiency levels are possible. This is important for management consideration as 28% of cattle shown copper deficiency and 36% shown zinc deficiency statewide.

Correction of selenium deficiency in California has proven results. With the results of this survey, it seems further effort would prove useful in supplementing copper, zinc, and manganese appropriately. A free copy of the entire results can be downloaded online by simply googling “mineral status of California beef cattle in Translational Animal Science.”

Table 1. Beef cows sampled in each of the 14 California counties and associated regions

County	Head/County	Region	Herds/Region	Head/Region
San Joaquin	40	Central		
San Benito	50	Central	12	120
Alameda	30	Central		
Siskiyou	40	Intermountain	7	70
Shasta	50/30	Northern foothills/Intermountain[a]		
Humboldt	30	Northern foothills		
Yuba	10	Northern foothills	23	230
Tehama	90	Northern foothills		
Colusa	20	Northern foothills		
Glenn	30	Northern foothills		
Inyo	10	Southern		
Los Angeles	10	Southern	13	135[b]
Ventura	40	Southern		

Santa Barbara	75	Southern	
		Total 555	

[a]Higher elevations of Eastern Shasta County were counted as intermountain

[b]In Southern California 73 head were not sampled for manganese due to funding depletion

Table 2. Percentage of whole blood and serum samples below adequate levels

		Intermountain	**Northern foothills**	**Central**	**Southern**	**Statewide**
Mineral	*Adequate level*[1]		*% below critical level*			
Selenium	0.08 ppm	3%	4%	28%	2%	12%
Copper	0.8 ppm	1%	13%	31%	55%	28%
Zinc	0.8 ppm	47%	35%	23%	40%	36%
Magnesium	18 ppm	9%	3%	11%	7%	7%
Manganese	6 ppb	96%	90%	92%	97%	92%
Calcium	80 ppm	0%	1%	0%	3%	2%
Phosphorus	45 ppm	23%	11%	3%	4%	9%
Potassium	3.9 ppm	9%	18%	9%	18%	16%
Sodium	135 ppm	0%	8%	15%	9%	10%

[1]Adapted from: Puls, 1988; Wikse et al., 1992; Dargatz and Ross, 1996; kinkaid, 2000; and based on the recommendations of the California Animal Health and Food Safety Lab, UC Davis

Compost on Rangelands: State of the Science

By Julie Finzel and Shulamit Shroder

There's a lot of talk these days about how to sequester carbon and compost on rangelands is sometimes viewed as a promising method. But does it actually work? What are the other impacts to rangeland from compost application? And how in the world is compost application different from what cows are doing every day on rangelands?

Currently, there isn't a lot of research completed on this subject. The majority of the work comes from the Silver lab at UC Berkeley, and a project led by Jeff Borum, East Stanislaus Resource Conservation District. Research findings from the past 10 years from the Silver lab, led by Dr. Whendee Silver, indicated that a onetime application of compost resulted in increased carbon storage in rangelands soils and in increased plant productivity for all 3 years of the study. Plus, the onetime application of compost did not significantly affect the plant community structure. The Lab also modeled greenhouse gas fluxes and found that applying compost resulted in a net benefit to greenhouse gas emissions that lasted for decades. In contrast, a project in Marin County applied large amounts of un-composted manure to rangeland and the plant community changed from being mostly perennial grasses to mostly annual grasses. There were also significant nitrogen emissions, outweighing any potential benefits from carbon sequestration.

The study sites used by the Silver lab receive more precipitation than in the southern San Joaquin Valley, which is one reason Jeff Borum's project is of interest. Borum has 16 study sites across California, including one in Tulare County located on the Sequoia Riverlands Trust Kaweah Oaks Preserve. Borum's study is ongoing, however, preliminary results indicate that higher forage production is a likely outcome on 14 of the 16 study sites, specifically sites with lower annual rainfall.

A graduate student from UC Berkeley, Tracy Hruska, compiled a review of the science and had this to share:

> *Background Conditions*: Most rangelands in California, and some other sites globally, seem to be losing soil carbon at present; no one is sure why (Chou et al. 2008; Ryals & Silver 2013). This trend suggests that long-term storage of carbon in CA range soils may not be possible, at least under current land uses.
>
> *Effect of Adding Compost*: Adding compost to rangelands results in greater production of green vegetation and plant roots (Ryals & Silver 2013). The increase in plant production means that more carbon was stored in the soil, at least temporarily (Kowaljow et al. 2010; Ryals & Silver 2013). Sites treated with compost also expelled more CO_2 (carbon dioxide) into the atmosphere, but more carbon was stored in the soil than lost to the air (Ryals & Silver 2013). Adding compost has resulted in higher proportions of some problem grass species like ripgut brome (*Bromus diandrus*) and hare barley (*Hordeum murinum*), but also of some desirable native species like California brome (*Bromus carinatus*) (Ryals et al. 2016).
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> *Rangeland Carbon Sequestration Potential*: Carbon content in California grasslands has been found to be highly variable from site to site with no obvious driver of differences, though grasslands with scattered trees contain far more stored carbon than grasslands without trees (Silver et al. 2010). Carbon sequestration potential in most California rangelands is largely based on plant root production, as aboveground production is largely eaten by livestock. Productivity of California rangelands varies widely by site, precipitation, and vegetation (Compost amendments seem to have stronger effects on aboveground plant production than on root production; Ryals & Silver 2013), which may mean limited benefits on grazed grasslands.
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> *Total Carbon Benefits from Compost*: A lifecycle assessment revealed that the most of the benefit of a compost amendment program is from increasing the production of compost, not compost application to rangeland (DeLonge et al. 2013). Diverting food and green waste from municipal garbage systems and manure from dairy and feedlot operations for composting has a much greater benefit for reducing greenhouse gas emissions than does adding the compost to rangelands afterward.

In summary, the science is still undecided on the benefits of compost application on rangeland, but the method holds a lot of opportunity. If you are interested in applying compost to your rangelands the California Department of Food and Agriculture is offering grants through the Healthy Soils Initiative that will help pay for compost application on rangelands. For more information, contact Shulamit Shroder at 661-868-6218 or via email sashroder@ucanr.edu. Contact Julie for references cited above.