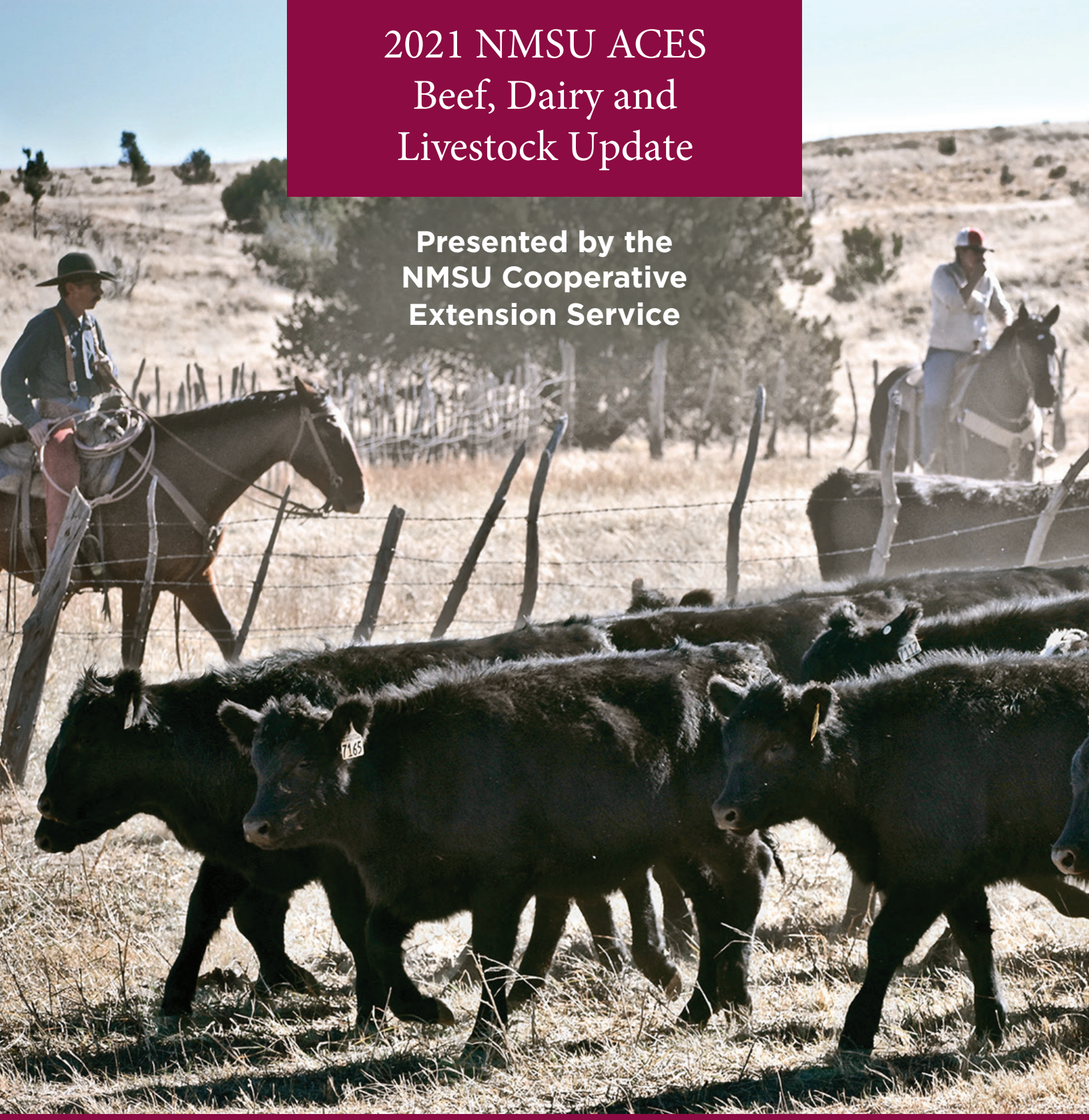
2021 NMSU ACES Beef, Dairy and Livestock Update

Presented by the NMSU Cooperative Extension Service



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BE BOLD. Shape the Future.
College of Agricultural, Consumer and Environmental Sciences
Cooperative Extension Service

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Facilitating knowledge exchange around strategies for sustainability

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Keywords
drought, sustainability, grass-fed beef, Criollo, adaptation, decision-support tools

Introduction

Economic and environmental stresses on cattle producers in the Southwest, already operating on very narrow margins, are predicted to intensify under a warmer, drier, future (Spiegal et al. 2020). Reduction in carrying capacity of some rangeland sites has already been documented (McIntosh et al. 2019), spurring the need to find new ways to adapt to old but intensifying problems of aridity and frequent drought in the region. Over the course of the past year, the Sustainable Southwest Beef Project's extension team has undertaken a number of activities to facilitate knowledge exchange around strategies which may enhance cattle production in the southwest under future conditions. Here we present highlights from these efforts. All products described here can be accessed at https://southwestbeef.org/.

Materials and Methods

Activities centered around three novel strategies, which are still under research: Raramuri Criollo heritage cattle, alternate supply chain pathways, and precision technology. We documented one rancher's transition to using heritage Raramuri Criollo in his cow/calf herd in a Case Study, "Heritage Genetics to Increase Cattle Resilience During Drought". With regard to supply chain options, we created an online interactive map showcasing 89 grass-fed beef producers located across the west (CA, NV, UT, AZ, NM, CO, KS, OK, TX). Next, we sent a survey to these producers to better understand current grass-fed operations in the Southwest, and 28 participated. Our team also conducted an extensive effort to locate existing decision support tools designed for the beef cattle industry. Tools were compiled into an online, accessible filter-based catalog called Tools for the Beef Industry (TOBI). Several webinars and podcast episodes were also produced to share information from researchers and service providers across a variety of media.

Raramuri Criollo Case Study

A producer reports changes he has observed at his ranch, including anecdotal attestation of reduced impact on forage and water resources during droughts. Also documented are lessons learned such as his trial and error arrival at the importance of using an Angus sire on Criollo cows to

produce marketable calves. Advice offered by this producer to others wishing to try this strategy is to start off small by replacing just a few of their cows with heritage cattle to test whether or not the biotype will be successful on their landscape and produce calves that fit their buyer's preferences.

Southwestern Grass-fed Beef Producers

Diversification was a significant strategy reported by those who responded to the survey. While nearly all respondents (96%) reported selling "freezer beef", 75% also reported marketing their product through more than one channel. Likewise, a variety of on- and off-ranch income diversification methods were reported, with the most common (53%) being to supplement with off-ranch income.

93% of respondents grazed their cattle at least part of their lives on rangeland or native grassland, but use of irrigated, non-irrigated planted, and improved pasture was also reported. 75% reported use of more than one feed/forage type, with the most common, after grass, being supplementation with hay (68%), and/or use of legumes (36%). The most commonly suggested barriers to adoption of raising grass-fed beef were lack of processor availability and drought (Figure 1). A follow-up survey is being developed to gather more detailed information about grass fed production, including a deeper dive into the challenges identified in the preliminary survey. Information will be used to develop models evaluating the economic and ecologic tradeoffs of grass-finishing in the southwest.

TOBI: Tools for the Beef Industry

We located over 550 decision support tools related to the beef cattle industry. Of these, 535 appeared to be designed for producers, 115 for researchers and technical service providers, 10 for consumers, with some overlap between audiences. Primary concerns addressed include: finance, livestock management, animal and feed performance, natural resource management, crop management, and weather and climate. We concluded that there are a plethora of decision support tools at the disposal of producers and that having a quick and centralized location to search for a tool of interest could be a valuable time-saver, hence the creation of TOBI https://webapps.jornada.nmsu.edu/livestock/. On April 29, 2021, we presented a walkthrough of TOBI during a webinar, and the recording is linked from the project's webpage (https://youtu.be/wTSiG1s70nY).

Webinars & Other Media

Four webinars were held and recorded for on-demand viewing. Highlighted topics included: precision livestock tools; tools for navigating drought; factors that affect meat quality; and sustainability incentive programs in beef supply chains. There are also several podcast episodes, one of which delves into the topic of virtual fencing with one of our Scottish collaborators. To date, there have been a total of 338 podcast downloads; 361 views of webinar recordings; and live webinars have had a collective 186 attendees, which included (self-reported) researchers, ranchers, students, and agency and business professionals.

Summary and New Mexico Impact

The Sustainable Southwest Beef Project extension team continues to conduct research to support the

development of user-friendly products to aid producers in their decision-making around strategies for enhanced sustainability. These products can help New Mexico cattle producers evaluate whether or not a strategy is right for their operation. Additionally, the materials can help inform consumers who are concerned about the production and sustainability of the beef they eat.

Acknowledgements
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University Approvals
The survey-based study was determined by NMSU IRB as not needing review due to being "not human subjects research". All other research was conducted using publicly available information gathered from reputable web or mobile app-store sources.

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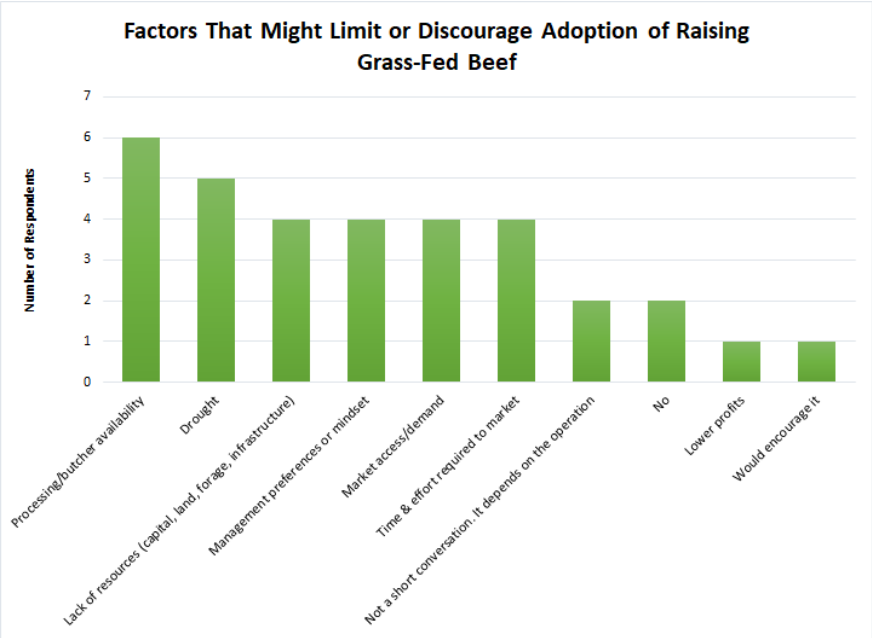

Figure 1. Perceived limitations to adoption of raising grass-fed beef by other producers in the respondent's area, as reported by survey respondents.

Rural veterinary shortage in New Mexico

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Keywords: Veterinary shortage, rural, policy

Introduction

There are roughly twelve counties in New Mexico that are underserved by a veterinarian (National Institute of Food and Agriculture). The consequences of this affect economic development of farmers and ranchers in the area. The few veterinarians who remain in these rural environments are forced to handle a large volume and variety of cases. The workload begins to affect job satisfaction and further reduces the number of practicing veterinarians. Average debt of a veterinarian entering the workforce can be up to $200,000 (American Veterinary Medical Association). Annual salaries for veterinarians are roughly $99,250 per year (U.S. Bureau of Labor Statistics, 2021). However, the lowest 10% make only $60,690 per year (U.S. Bureau of Labor Statistics). More incentive is required to persuade veterinarians to work in rural areas such as loan repayment programs and grants. The objective of this research is to gain an understanding of the effects of this shortage and what is being done to increase the number of veterinarians in a shortage area.

Materials and Methods

This report is a review of the programs available with the discussion of limitations.

Results and Discussion

In 2003, the National Veterinary Medical Service Act (NVMSA) was enacted. This is a part of the National Agricultural Research, Extension, and Teaching Policy Act of 1977. Its purpose is to develop loan repayment programs for food-animal veterinarians serving in shortage areas. Shortage areas are determined by annual nominations made by State Animal Health Officials. Nominations are evaluated by federal and state animal experts that are selected by National Institute of Food and Agriculture (NIFA) (National Institute of Food and Agriculture). The NIFA Administration will then evaluate the recommended areas and finalize designations.

The Veterinary Medicine Loan Repayment Program (VMLRP) is a program authorized by the NVMSA. The program assumes up to $25,000 per year of the veterinarian's student loan debt in exchange for service in a designated underserved area (National Institute of Food and Agriculture). Recipients can receive funding for up to three years. In 2020, the VMLRP allocated a total of $7,152,452 to seventy-six veterinarians practicing in 48 states (USDA, 2021). A portion of this includes funds allocated to offset taxes as this is considered taxable income. This may consist of up to 39%

of the funds allocated depending on the tax rate.

An additional program authorized by NVMSA is the Veterinary Services Grant Program. This program offers support and funding for more specialization in the veterinary field (National Institute of Food and Agriculture). The program provides funding for development and growth of rural veterinarian practices.

Western Interstate Commission on Higher Education (WICHE) is a state-run loan-for-service program. This program allows students to enroll in professional programs not offered in New Mexico for in state or reduced levels of tuition (New Mexico Higher Education Department). The state of New Mexico pays a certain portion of the students' admission costs. Students who receive WICHE funds are required to practice in New Mexico for a designated period of time. For every year that the provider practices in New Mexico, a portion of their loan is forgiven.

New Mexico Impact

Veterinary services are often inaccessible to livestock producers in New Mexico. Policies that promote rural veterinary practice will be vital in maintaining the health and productivity of livestock animals across the state. Understanding the effects of this shortage is key to directing research and policymaking in the future.

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Evaluation of the impacts of inconsistent consumption of insect growth regulator on filth fly population control in a simulated field environment

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Key Words: feed through, house fly, horn fly, insect growth regulator

Introduction

Livestock producers across the southwest make up approximately one third of the agricultural revenue in the six-state region. Cattle production is forecasted to represent about 17 percent of the $391 billion in total cash receipts for agricultural commodities (USDA, 2021). Unfortunately, horn flies alone, can cost the U.S. beef industry about $730 million per year, or approximately $1.75 billion per year, when adjusting for inflation (Cupp et al., 1998, Swiger and Payne, 2016). Both horn flies and house flies have the ability to impact cattle operations through reduced performance and potential litigation, respectively (Cupp et al., 1998 and Gerry, 2020). Understanding the pest is the first step to mitigating impacts associated with troublesome populations.

Byproducts associated with cattle production offer substantial opportunity for these pests to build in numbers. Fortunately, the same developmental cycle that utilizes these operational created opportunities is also vulnerable to available insecticidal products. As manure is a common growth media for the immature stages of these pests, insect growth regulators (IGR) can be an effective tool to reduce filth fly populations (Donahue et al., 2017).

Insect growth regulators can be administered through mineral bocks, loose mineral supplements, or pelleted grain supplements and have been shown to be highly effective against these pest species. However, anecdotal reports would suggest that field-based performance is not always consistent. Multiple factors including but not limited to fly immigration from neighboring communities or operations, utilization of secondary development substrates, and effective product delivery and consumption can all influence suboptimal population control. All of these factors should be considered and well understood prior to making assumptions regarding product performance.

The use of IGR presents a unique challenge as they are commonly offered as free choice to the animals. This affords individual animals the ability to miss out on key treatment events. Understanding the consequences of inconsistent product consumption as it relates to fly population control may better explain variable effects of IGR in field settings. Therefore, the objective of

this study is to assess the effects of inconsistent consumption.

Materials and Methods

All procedures and experimental protocols were approved by the New Mexico State University Institute Animal Care and Use Committee (IACUC #2020-017).

Twelve angus cross heifers were randomly selected from the Veterinary Entomology Research Lab herd at New Mexico State University and were held in dry lot pens (24' by 30'). All animals were offered a grain-based supplement and provided enough time to fully consume the grain pack supplement before being offered daily allotment of alfalfa hay cubes (CP 18.4% and TDN 58%).

Heifers were randomly assigned to four treatment groups; 1) an untreated control, 2) a treated group receiving diflubenzuron (DFB) every 24 h, 3) a treated group receiving DFB once every 48 h, and 4) a treated group receiving DFB every 72h. Diflubenzuron treatments were offered at 0.10mg/kg BW via topdressing on one pound of grain supplement.

Manure was collected each morning using the freshest pat in each animal's pen for 17 days and were frozen (~30°C) for a minimum of 48 hours. Collected samples were used for manure bioassays replicated in triplicate. Twenty-five horn fly and house fly eggs were introduced to each manure sample and allowed sufficient time to complete developmental cycle. Emerged flies were summated for each sample and averaged within treatment group to calculate efficacy and emergence.

Results and Discussion

Regardless of study day, control emergence for house flies and horn flies was 61.56 and 41.19%, respectively (Table 1 and Table 2). However, a large variability of emergence was observed for both species across study day when evaluating control performance. Despite control performance variation, fly emergence was decreased ($P \leq 0.0023$) by 37.49, 26.07, 16.43 ± 2.12% for 24, 48, and 72 h treatment groups, respectively, in comparison to control. These results would indicate that the presence of DBF is effective in reducing fly population associated with and developing in treated manure.

Importantly, when study day is taken into consideration, specifically as it relates to DFB offerings, both house fly and horn fly emergence increased ($P \leq 0.05$) alongside treatment administration schedules. In other words, inconsistent consumption of DFB leads to increased fly emergence. These results highlight the sensitivity of IGR delivery systems and emphasize an ability of these pest species to utilize opportunities presented through inconsistent consumption of a product delivered free-choice.

Summary and New Mexico Impact

This research further contributes to the overall knowledge and understanding of pest fly species in agricultural animal production systems and provides further information that can be used in Integrated Pest Management systems throughout the state of New Mexico.

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Table 1. Efficacy of diflubenzuron against susceptible house flies when treated at 24, 48, and 72-hour intervals for 17 days.

	Count/ (Efficacy[a])			
Days	Control	24 hour[b]	48 hour[b]	72 hour[b]
0	17.11	17.00 (0.65%)	17.22 (-0.65%)	13.44 (21.43%)
1	10.33	4.77 (53.76%)	2.66 (74.19%)	2.66 (74.19%)
2	16.00	3.77 (76.39%)	15.11 (5.55%)	15.55 (2.78%)
3	16.44	3.22 (80.41%)	9.22 (43.92%)	17.33 (-5.41%)
4	9.11	2.66 (70.73%)	8.00 (12.20%)	3.44 (62.20%)
5	10.77	2.44 (77.32%)	2.33 (78.35%)	5.22 (51.55%)
6	11.88	3.33 (71.96%)	11.22 (5.61%)	14.00 (-17.76%)
7	11.66	10.22 (12.38%)	4.11 (64.76%)	5.00 (57.14%)
8	18.33	3.11 (83.03%)	14.11 (23.03%)	13.88 (24.24%)
9	22.00	3.22 (85.35%)	8.00 (63.64%)	18.11 (17.68%)
10	12.22	2.88 (76.36%)	6.77 (44.45%)	3.11 (74.54%)
11	16.00	3.00 (81.25%)	4.22 (73.61%)	12.33 (22.92%)
12	18.77	5.55 (70.41%)	14.55 (22.49%)	12.66 (32.54%)
13	14.33	5.11 (63.37%)	6.55 (54.26%)	4.77 (66.67%)
14	21.66	4.55 (78.97%)	15.66 (27.69%)	16.88 (22.05%)
15	19.33	3.33 (82.76%)	4.88 (74.71%)	18.00 (6.90%)
16	13.11	12.44 (5.08%)	7.44 (43.22%)	11.55 (11.86%)
17	17.88	15.88 (11.18%)	15.00 (16.15%)	17.00 (4.97%)

[a] % Efficacy Equation

$$\% \text{ Efficacy} = \left(\frac{\text{Control Ave. Adult Emergence Counts - Treatment Ave. Adult Emergence Counts}}{\text{Control Ave. Adult Emergence Counts}}\right) 100$$

[b] 24-hour treatment groups received label recommended dosages every 24 hours.
48-hour treatment groups received label recommended dosages every 48 hours.
72-hour treatment groups received label recommended dosages every 72 hours.

Table 2. Efficacy of diflubenzuron against susceptible horn flies when treated at 24, 48, and 72-hour intervals for 17 days.

	Count/ (Efficacy[a])			
Days	Control	24 hour[b]	48 hour[b]	72 hour[b]
0	17.00	11.66 (31.37%)	14.88 (12.42%)	12.22 (28.10%)
1	7.88	0.55 (92.96%)	0.00 (100.00%)	0.00 (100.00%)
2	8.11	0.00 (100.00%)	6.55 (19.18%)	7.88 (2.74%)
3	7.22	0.11 (98.46%)	0.11 (98.46%)	10.22 (41.54%)
4	8.00	0.00 (100.00%)	2.66 (66.67%)	0.00 (100.00%)
5	7.33	0.00 (100.00%)	0.11 (98.48%)	4.77 (34.85%)
6	8.55	0.00 (100.00%)	8.22 (3.90%)	9.66 (-12.99%)
7	14.55	0.00 (100.00%)	0.11 (99.24%)	0.11 (99.24%)
8	15.44	0.00 (100.00%)	7.88 (48.92%)	10.77 (30.22%)
9	20.11	0.00 (100.00%)	0.33 (98.34%)	13.22 (34.25%)
10	9.66	0.00 (100.00%)	4.77 (50.57%)	0.00 (100.00%)
11	10.22	0.00 (100.00%)	0.00 (100.00%)	9.44 (7.61%)
12	9.22	0.00 (100.00%)	7.66 (16.87%)	8.22 (10.84%)
13	9.66	0.00 (100.00%)	0.22 (97.70%)	0.11 (98.85%)
14	8.33	0.22 (97.33%)	3.22 (61.33%)	3.33 (60.00%)
15	10.77	0.00 (100.00%)	0.00 (100.00%)	9.11 (15.46%)
16	7.66	3.33 (56.52%)	0.44 (94.20%)	7.22 (5.80%)
17	9.22	5.88 (36.14%)	6.77 (26.51%)	6.55 (28.92%)

[a] % Efficacy Equation

% Efficacy =

$$\left(\frac{\text{Control Ave. Adult Emergence Counts - Treatment Ave. Adult Emergence Counts}}{\text{Control Ave. Adult Emergence Counts}}\right)100$$

[b] 24-hour treatment groups received label recommended dosages every 24 hours.
48-hour treatment groups received label recommended dosages every 48 hours.
72-hour treatment groups received label recommended dosages every 72 hours.

Mobile Slaughter Units potential within New Mexico

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Acknowledgements:
The research was funded by the New Mexico Department of Agriculture and is based off interviews conducted by Jorgianna Calderon.

Keywords:
Meat, mobile slaughter, processors, itinerant slaughter

Introduction:
Livestock production within the state of New Mexico is vital to the agricultural sector contributing $3.44 billion (USDA-NMDA, 2020). As of 2019, the number of cattle produced in New Mexico through cow/calf operations was 1.45 million head whereas the number of beef cattle intended for slaughter were 480,000 head. With the fluctuating numbers of livestock produced across the nation in conjunction with the COVID-19 pandemic, slaughtering facilities have been under immense pressure to get meat processed in a timely manner. Federal inspection through USDA allows for the resale of the meat after processing. Any other meat processed outside of these USDA inspected facilities must be labeled as “NOT FOR SALE” or custom exempt which allows for small-scale livestock producers to process their animals in a quicker fashion for personal consumption.

This current market constraint leads to the idea of reinstating a mobile slaughter unit for the state of New Mexico. A mobile slaughter unit, henceforth referred to as ‘MSU’, is a livestock harvesting facility on-wheels. The idea of a mobile slaughter facility is to travel to livestock producers and perform slaughtering services on-site. Upon slaughter, the unit operator then transfers the carcasses to a brick-and-mortar facility to be aged and cut/wrapped, completing the slaughtering process. This is not a new idea and has experienced some success across the United States.

Through this research, we will assess the potential for a successful mobile slaughter unit operation within the state of New Mexico. Collecting qualitative data gathered from MSU’s across the United States will provide evidence of current successful MSUs and direction for similar operations in New Mexico.

Methods:
The method used in this research focused on qualitative responses from interviews of MSU operators from across the United States. This research assesses current MSU operations to identify operational trends and management strategies to direct potential MSU for New Mexico.

Utilizing Google search, 54 mobile slaughter units located in 24 states were identified as potential interview participants. An initial phone call was conducted to schedule the interview. Upon calling, it was noted that 9 of the 54 operations were either no longer in business or no longer

participating in mobile slaughter. Remaining 45 businesses were contacted via telephone to schedule an appointment for the interview, declined to participate or received a voicemail message. The final number of MSU operator interviews totaled 10; 9 currently operating, 1 no longer operating, and all participants were located in 9 different states. In total, there were 26 questions and average 35 minutes to complete. Questions asked during the interview were broken into three sections: Operation, Marketing, and Inspection questions.

Operational questions included length of operation, maximum travel distance and fees associated with travel. The different types of species slaughtered were also asked as well as services provided such as on-site slaughter, cut/wrap, specialty packaging, retail selling, and if wild game was an option for processing. The removal of waste, offal and other fluids, was also inquired upon.

Marketing questions included tactics the operators used to promote their businesses i.e., how do livestock producers get in contact with you? Inquiries about the MSU's average number of customers each unit provided services for as well as the types of sale avenues for those who sold meat for retail were included. With multiple options to market and sell meat, researchers were interested to see if specialty cuts, like boxed beef, were being employed within the industry.

Inspection questions were utilized to gain perspective on what level of inspection each MSU operated under.

Results and Discussion:

Responses were collected from MSU's that had been in operation for an average of 15 years; 38 years being the oldest and 4 months being the newest MSU. Results from the interviews identified several similarities between these MSU operations. The first similarity between the MSU's was the distance travelled. 67% of the MSU's travelled under 200 miles to and from slaughtering sites whereas the other 33% did not travel to the actual farm/ranch or had no restrictions on the distance they were willing to travel. Travel fees ranged from $0.35 to $1 per mile. 88% of the MSU's were open to processing multiple species, including beef, pork, sheep, and goats. Prices for harvesting services performed varied from $0.85 dress weight for cattle to a $200 flat fee for a yearling steer. A 20% retainer fee was common among the operations in order to set slaughter appointments.

All MSU's interviewed had the owner as an employee, 44% being solo operators and the other 56% included 2 additional employees who were responsible for assisting with various duties within the MSU. The capacity size of each MSU varied however 88% of those interviewed claimed to have the cooling capacity for at least one beef to hang for transport to a brick and mortar processing facility to age. 56% of the operations had brick and mortar facilities to age the carcass and of those, 80% aged them between 7 to 14 days. To dispose of the waste, 5 out of the 9 MSU's claimed the offal obtained while butchering would be used as compost, the other 44% would either sell the waste to rendering facilities, utilize the offal as bait, or even age the offal as part of the carcass for the customer. The breakdown of types of meat inspection included 67% were custom exempt, 22% were federally inspected

under USDA, and 11% were state inspection.

The discussion about marketing all responded with the importance of word of mouth, social media was also very prevalent. 6 of the 9 MSU's had a Facebook page and 4 of those also had an Instagram page. Only 3 of the 9 had a website. With several responding that social media was much easier to manage than a website. Many of these operations also advertise their services in regional agricultural based magazines.

Respondents also discussed their interest in specialty packaging of meat. Only 2 of the 9 operations currently resold retail or food service cuts of meat; while neither offered specialty cuts or assorted boxed beef; they sold retail cuts in bulk.

Summary and New Mexico Impact:
Meat processing facilities within New Mexico continue to stay at maximum capacity forcing New Mexican livestock producers to send their animals out of state for processing. In New Mexico there are nearly 30 meat processors, 8 being federally inspected and the remaining solely operating under the custom exempt inspection category (Parker-Sedillo, 2020). A new and operating mobile slaughter unit within the state proves that with the proper backing and direct connection with a processing facility, the MSU has potential to be a value-added service to the citizens of New Mexico.

Recommendations for potential MSU's in New Mexico are based off the research presented. The pricing as well as a 150-mile radius with a market focused on beef, pork, sheep, and goats could provide New Mexico livestock producers additional access to the timely harvest of their livestock. Appointment retainer fees, kill-fees per species, as well as travel fees are strongly recommended. Additional fees such as offal removal and mature/large animal processing may also generate additional income sources. The cost and number of employees ranged from 1 to 3 personnel but should be adjusted based on the harvest schedule and individual skill set. The level of compensation for employees ranged based on the employees skills and availability.

Each operation should consider the necessary regulations based on the type of inspection services; federal inspection requires MSU operations to have a USDA-Food Safety and Inspection Service inspector present during all slaughtering, written Standard Operating Procedures for Sanitation (SSOP), a written Hazard Analysis and Critical Control Point (HACCP) plan. Custom-exempt facilities in New Mexico require a Commercial Driver's License (NMDOT), Hazardous Material hauling permit (NM Environmental Department), SSOP's and HACCP plans. All levels of inspection require the employees to have some level training on proper animal handling, slaughtering, food handling and transportation.

University Approvals:
All interview questions were approved by NMSU's Internal Review Board #21800.

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Development of a large animal mass morality carcass management plan

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Acknowledgments:
This project is funded by USDA's Animal and Plant Health Inspection Service through the National Animal Disease Preparedness and Response Program.

Keywords:
Carcass, Disease, Emergency, Preparedness, Plan.

Introduction:

This project supports New Mexico agriculture in its efforts to prepare for and respond to a large animal mass mortality event, focusing on the priority area of animal disposal. Protecting the agricultural industries along the nation's southwest border is of critical concern to safeguarding the economic, environmental, and social wellbeing of the nation at large. Several characteristics of the New Mexico livestock industry make carcass management planning a critical issue, including dairy size, remote and rugged terrain, and a geographical and trade nexus with Mexico.

Catastrophic livestock losses from diseases or natural disasters represent a significant challenge for livestock producers and emergency responders. Animal losses often cause significant financial losses to the producers who rely on the income from these animals. Compounding the financial impact of these animal losses is the burden of responsibly disposing of the resulting animal carcasses. Improperly managed animal carcasses have the potential to spread disease and contaminate surface water and ground water supplies. The disposal process was specifically identified as one area where planning efforts were limited and where the environmental, financial, and emotional impacts were much higher than anticipated in previous disease and disaster incidents.

A large-scale animal mortality event could quickly overwhelm the current capacity of standard disposal methods. New Mexico has the largest dairy herd size in the nation, with 2,329 lactating cows per dairy (Census of Agriculture, 2017). The size and proximity of New Mexico's large animal agriculture industries increases the possibility that emergency managers would respond to an escalating event requiring disposal of more than 10,000 animals in excess of 1000 pounds during an animal disease outbreak or natural disaster.

In the beef sector, cattle are often spread across rugged terrain. Diversity in ownership type creates large variance in ability to respond to a crisis.

Of equal importance is the location along the Mexican border, and the

volume of imported animals that are destined for other states. For example, in 2020, over 1.4 million cattle were imported into the United States from Mexico, with over half making their way through New Mexico. This makes agricultural emergency response critical in this state.

Objectives
To achieve an effective response to a large animal mass mortality event, three key objectives were identified by a multidisciplinary team with emergency response and agricultural expertise:

Objective 1 - Develop a multi-agency unified plan that includes a farm level response capacity assessment for disposal of carcasses during large-scale high-consequence mortality event.

Objective 2 - Train and enhance regional and international coordination between response personnel, state and federal agencies, and industry to conduct a large-scale livestock carcass disposal response after a mass casualty event.

Objective 3 - Advance outreach, education, and communication efforts related to large-scale livestock disposal after mass casualty events.

Approach:
Developing a clear and concise plan for responding to carcass management concerns during emergency events that addresses regulatory, logistical, public health, and public relations concerns is a relevant need identified during emergency preparedness training and actual events.

One of the most challenging aspects of responding to a crisis is knowing where to start. Carcass management methods such as burial, rendering, incineration, composting, or transportation to a landfill each have strengths, weaknesses, and differing personnel and equipment needs.

It is important to note that any plan is destined to fail without incorporating local capacity and understanding local customs and methods into the final product. An on-going survey has been published to request crucial information from producers about their own capacity to manage a catastrophic event such as knowledge of disposal methods, owned equipment, and environmental limitations. This information will be invaluable to state and local emergency management personnel when prioritizing limited assets and resources.

Expected Outcomes:
A unified plan respecting local knowledge and developed with input from industry, state, federal, and tribal stakeholders is necessary to ensure a rapid and effective response to animal disease and natural disaster emergencies. However, development of a plan is only one aspect of emergency preparedness. Past training and subsequent incidents have shown that those who have trained and exercised together tend to be better prepared for handling an emergency. This is important for public agencies, but even more critical in the agriculture sector where almost all of the critical infrastructure needed for production, and subsequently emergency response is privately owned. The process of plan development, the plan itself, and

excising the plan will all serve to increase the preparedness of New Mexico Agriculture for a future emergency.

University Approvals: Studies were approved by NMSU's Internal Review Board. Project: #21337

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Using filter-paper and glass vial bioassays to determine chemical resistance of permethrin resistant and susceptible horn fly (Diptera: Muscidae) populations

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Keywords: chemical resistance, horn fly

Introduction

Horn flies continue to be one of the most economically damaging pests affecting grazing cattle in the United States, it is estimated the annual economic losses attributed to uncontrolled horn fly populations is around 1.75 billion dollars (Swiger et al., 2016). Therefore, control of this pest is encouraged in rangeland operations. The biological niche that horn flies reside in often negate the use of non-chemical options to control this pest. Multiple insecticide specific control options are available. However, pyrethroids and organophosphates are commonly relied upon (Oyarzun et al., 2008). The overuse of these compounds to control horn fly populations inevitably leads to chemical resistance. Current methodologies used to identify horn fly insecticide resistance are generally reactive confirmations following product failure and/or loss of efficacy. Developing a more proactive approach for identifying insecticide resistance in horn fly field populations could help maximize control efforts. Therefore, the objective of the current study is to compare common insecticidal assessment assays using different delivery methods across and within permethrin resistant (PR) and susceptible (SS) horn fly strains exposed to various pyrethroid and organophosphate compounds.

Materials and Methods

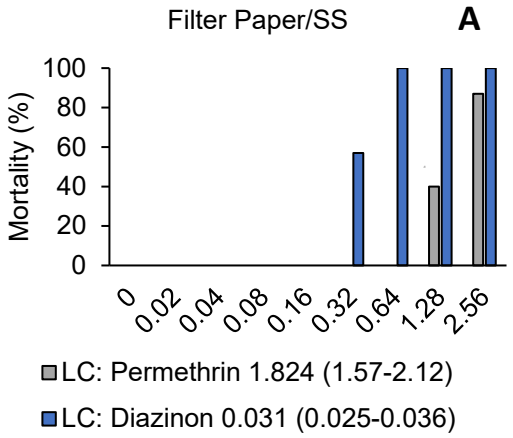
Horn flies were acquired from the New Mexico State University Veterinarian Entomology Research Laboratory (VERL) in Las Cruces, New Mexico. Flies were anesthetized using methods as describe by Smythe et al. 2016. Adult flies were immobilized in a walk-in freezer ~ 4°C counted into groups of 10 females prior to being placed into screen-topped holding containers for recovery. Flies were allowed one blood meal prior to initiation of the assays.

The study utilized two strains of horn flies: susceptible and permethrin resistance horn flies. Two active ingredients were evaluated: permethrin and diazinon. Each active ingredient was evaluated across 9 serial dilutions for each delivery type. Starting concentrations were determined using preliminary data to identify effective ranges. The study evaluated two delivery systems: filter paper and glass. A total of 1080 female horn flies from each strain were separated into groups of 10. Filter papers were treated with 1 mL of acetone containing desired concentrations of either permethrin or abamectin. The glass vial bioassays also received 1mL of solution distributed evenly across the surface of the vial. Following treatment, 10 female flies were added to each assay container and evaluated for mortality. Mortality counts were made at the 2, 4, 6, and 8 h marks. Mortality was determined by visually by

summating the number of ataxic flies. Data were analyzed using PROC PROBIT procedure of SAS 9.4. Lethal estimates at the 8 h mark were established and reported. Susceptibility ratios were calculated by dividing filter paper lethal concentration (LC_{50}) by the LC_{50} of the glass for each strain and active ingredient.

Results

Susceptible horn flies were 91 fold more sensitive to permethrin delivered in glass in comparison to filter papers (Figure 1-A). Moreover, PR flies were 1,415.27 more susceptible when permethrin was delivered in glass (Figure 1-B). Similarly, susceptible flies were 19.75 times more vulnerable to diazinon when exposed in glass than in filter paper (Figure 1-C). Finally, PR flies were 369.23 more susceptible when utilizing glass as the delivery method (Figure 1-D).



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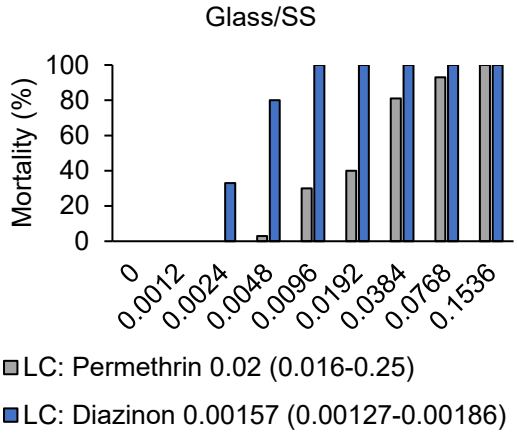

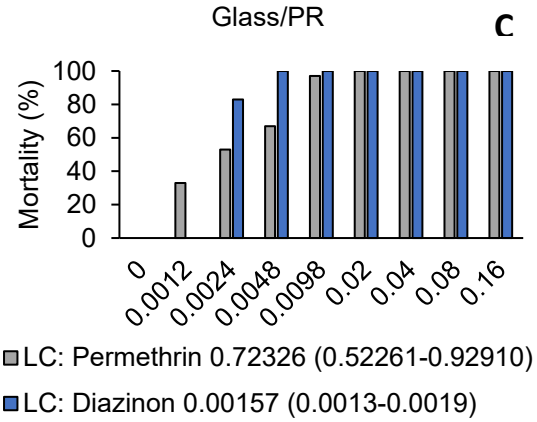

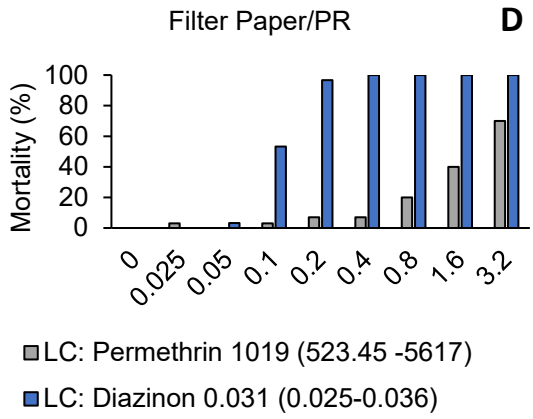

Figures 1 A - D. Figure 1-A. Mortality percentage of susceptible horn flies exposed to permethrin and diazinon using filter papers. Figure 1-B. Mortality percentage of susceptible horn flies exposed to permethrin and diazinon using glass vials. Figure 1-C. Mortality percentage of permethrin resistant horn flies exposed to permethrin and diazinon using filter papers. Figure 1-D. Mortality percentage of permethrin resistant horn flies exposed to

permethrin and diazinon using filter papers. All horizontal axis are presented at $\mu g/cm^2$.

Conclusions

Preliminary results indicate that both permethrin resistant and susceptible horn fly strains respond differently when the compounds are delivered on either glass or filter paper substrates. There are also different responses to each chemical. These results highlight the importance of selecting an appropriate substrate delivery method when establishing baseline susceptibility of horn fly field populations. Future work will attempt to develop more efficient and accessible ways for producers to determine resistance before allocating money in a control option.

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New Mexico Livestock Producers' Interest in a State Meat Inspection Program and Direct Marketing to Consumers[1]

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Keywords:
meat, inspection, direct marketing, consumers, producers, beef

Introduction:

U. S. per capita meat availability (consumption) has steadily grown over time and more recently from 57.1 lbs./year (retail wt.) in 2018 to 57.9 lbs./year in 2019. Such growth offers evidence for beef producers to increase production (USDA, 2021). New Mexico had 1.45 million head of cattle with a total of $1.5 billion dollars in inventory value in 2019 (NMDA, 2019) giving New Mexico producers a chance to expand markets.

The onset of COVID-19 had major impacts on U. S. supply chains, including those for red meats leading consumers to consider assessing more local meat sources; however, currently, any New Mexico livestock producers wishing to direct market red meat are limited to choosing among six federally inspected slaughter facilities in the State.

Pre-COVID-19 research by Parker-Sedillo et al.(2020) examined the cost of implementing and operating a state meat inspection program, as well as processor and consumer preferences regarding such a state meat inspection program. However, the study did not include the perspectives and interest levels of livestock producers.

This research fills a gap in the analysis of the State's meat supply chain by assessing the livestock producers' interest in a state managed meat inspection program and in marketing directly to consumers.

Objectives:

The three primary goals of the study were to:

- Determine New Mexico livestock producers' level of interest in establishing a state meat inspection program.
- Establish the level of New Mexico producer interest in direct marketing of meat to consumers; and
- To better understand the issues current New Mexico livestock producers view as important for meat supply chains.

Methods:

An online survey was approved by the NMSU IRB (#20203) and was emailed to 14,000 registered brand owners in New Mexico. A total of 344 provided online responses. The data was analyzed using SPSS version 25 to estimate a binary probit model and examine possible multicollinearity

[1] This research was funded by the State of New Mexico and reported in Mr. Dillen Martinez's graduate thesis in the Spring of 2021: Martinez, D., Robinson, C., and Miller, F. (2021). New Mexico Livestock Producers' Interest in New Market Access to Final Consumers. M.S. Thesis, New Mexico State University, Las Cruces.

issues. The chi-square test was used to better understand the relationship between livestock producers and their level of support for a state meat inspection service and overall interest to market direct to consumers. The equation estimated was defined as

$$Interest\ to\ Direct\ Market\ Access\ to\ Consumer = a + b_1(Herd\ size) + b_2(Currently\ Sell\ Direct) + b_3(Support) + b_4(Familiarity) + b_5(Current\ Sector) + b_6(Years\ in\ Production) + b_7(Education)$$

Variable definitions:
Herd size refers to the number of head of cattle; *Currently Sell Direct* refers to NM producers responses to a question if they were currently selling direct to consumers; *Support* refers to the response to a question concerning producers' level of support for a state meat inspection program; *Familiarity* refers to producers' response for their familiarity of the previous NM meat inspection program; *Current Sector* represents the responses indicating what sector of the supply chain the producers were currently selling into; *Years in Production* represents how long the producer has been participating in the beef industry; and *Education* represents the respondents' level of education.

Results and Discussion:
The data focused on New Mexico beef producers and their support for a state meat inspection program as well as their interest in marketing directly to consumers. Table 1 reports the final output from the model. The variables found significant to producer interest in a state meat inspection service were current sector of sale: marketing or production (p=0.023), currently selling direct to consumers: yes or no (p=0.00), interest in expanding: yes or no (p=0.042), and education: 4 year degree or better and 2 year degree of less (p=0.066).

Table 1. Output for Interest to Direct Market Access to Consumer

Variables	Description	Coefficient	Mean	SD (σ)	Sig (α)
Herd Size	0=0-100 1=101-500 2=501-1000 3=1001-5000 4= 5000+	0.089	0.60	0.908	0.295
Direct to Consumers	1= Yes, 0= No	-1.435	0.71	0.454	0.000***
NMMIP Support	1= Yes, 0= No	-0.020	0.49	0.501	0.898
NMMIP Familiarity	1= Yes, 0= No	0.100	0.57	0.496	0.532
Interest in Expanding	1= Yes, 0= No	0.347	0.44	0.497	0.042**
Current Sector	1=Marketing 0=Production	-0.449	0.20	0.401	0.023**
Years in Production	# of years producing cattle	-0.004	34.40	37.690	0.227
Education	1= 4 year degree + 0= 2 years degree -	-0.282	0.57	0.496	0.066*

*, **, and *** indicate statistical significance at $p \leq$ 0.01, 0.05, and 0.10 levels.
Dependent Variable: Interest To Direct Market Access to Consumer
Model: (Intercept), Herd Size, Selling to Consumers, NMMIP Support, NMMIP Familiarity, Expanding Interest, Current Sector, Years in Production, Education

Multicollinearity and Chi-Square
Multicollinearity diagnostic tests are designed to detect issues with collinearity between the variables. The test determined there was no collinearity between each of the variables in the model. Each variable was evaluated using the Chi-square test to show dependence among the variables in the model. Only two variables were identified to exhibit significant

dependence: the interest to sell to consumers (χ^2= 67.05) and the current sector the producers are selling to (χ^2 = 15.14).

Summary and New Mexico Impact:
Producers are split in their level of support for a state meat inspection service with the majority supporting (μ=0.57). The data suggest livestock producers indicated an interest to expand their production capacity but to not expand into direct-to-consumer marketing.

Producers already selling their product direct to consumers are interested in expanding into additional consumer markets, but producers working only in production are strictly interested in expanding production opportunities, not increasing market access direct to consumers.

Implications:
New Mexico livestock producers, specifically beef producers are supportive of a state meat inspection program. This support would provide many producers with new opportunities to explore marketing directly to consumers but there is little evidence from the producers to indicate they are interested in that activity.

Those producers who are strictly production-oriented but support the idea of a state meat inspection service may be more interested in the potential for marketing additional live animals within the state to those who are currently participating in the direct-to-consumer markets. However, these individuals are not interested in establishing their own beef supply chain for marketing direct-to-consumers.

Those individuals currently marketing direct to consumers are less likely to support a state meat inspection program. These individuals are already operating within the current regulatory environment and have established a beef supply chain for their customers. The reinstatement of a state meat inspection service would bring new competition into the marketplace.

University Approvals:
Survey instrument was approved by NMSU's Internal Review Board #20203.

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Seasonal yield and animal preference for irrigated winter cereal forages under continuous stocking in a semiarid, subtropical region[2]

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Keywords: Grazing preference, Oat, Rye, Triticale, Wheat, Winter pastures

Introduction

Winter annual cereal forages, such as oat, rye, triticale, and wheat, perform well in semiarid, subtropical regions, like New Mexico, where they form a significant component for backgrounding of stocker cattle from autumn through spring (Rao, et al., 2000; Lauriault & Kirksey, 2004; Marsalis et al., 2008). Little information is available comparing the seasonal productivity of winter cereal forages under grazing, particularly in New Mexico. Such information would assist stocker operations in deciding which species to use for winter pasture. Hence, the objective of this research was to compare seasonal productivity and animal preference of winter cereals in New Mexico.

Method(s)

Oat, rye, triticale, and beardless wheat were sown late August in two consecutive years, in 2.4-ac plots within two pastures at the New Mexico State University Rex E. Kirksey Agricultural Science Center at Tucumcari, NM. Two permanent exclosures were erected in each plot prior to the initiation of grazing.

Thirty recently weaned, predominantly British x continental mixed-breed steers, divided into groups of equal weight, were turned in to graze the pastures from mid-November through mid-April each year. Within each year, forage samples were collected monthly from within and near each exclosure to estimate accumulated and available forage yield. To evaluate grazing preference, steer head counts by plot were made twice daily to determine which cereals were being grazed by steers.

Forage yield and grazing preference data were subjected to statistical analysis to test the main effects of year, date, and cereal and all possible interactions. Least significant differences (LSD) were used to show where differences occurred among means.

Results

[2]The study was funded by state and federal funds appropriated to the Agricultural Experiment Station at New Mexico State University.

All animal handling and experimental procedures were in accordance with guidelines set by the New Mexico State University Institutional Animal Care and Use Committee.

Date and year x date interactions were significant for all variables. The year x date interaction for accumulated yield was caused by a greater increase in yield from November to December in Year 1 than in Year 2. The year x cereal interaction for accumulated yield occurred as a difference in magnitude across years among cereals (2.59 vs. 1.36; 2.75 vs. 1.74; 1.97 vs. 0.51; and 1.98 vs. 1.21 t/ac for oat, rye, triticale, and wheat yields in Year 1 vs. Year 2, respectively, LSD = 0.29). Greater precipitation during August and September of Year 1 than in Year 2 was the likely cause. Lauriault and Kirksey (2004) reported that irrigation to promote germination and again in mid-October increased forage yield in the spring of cereals in less than optimum precipitation years; but even then, yields would not equal those of irrigated cereals with more optimum precipitation (Marsalis et al., 2008). For the date x cereal interaction for accumulated yield, oat and rye outyielded triticale every month while wheat was usually intermediate, being not different from any other cereal until March when oat and rye were greater and different from each other.

Cereal species and all interactions including species were significant for the animal preference. With unlimited available forage in Year 1, animals selectively grazed oat until it became limited and then they grazed rye more heavily, but also keeping oat grazed down, all the while avoiding the wheat and triticale when possible. Availability remained limited throughout Year 2, with no difference among oat, rye, and wheat, and triticale having less availability than rye on every date, except in February, leading cattle to spend more time on the rye and keep the oat and wheat grazed down. Previous research at this and another location in New Mexico indicates that oat, triticale, and wheat are later-maturing than rye, and if allowed to grow later into the spring, overall forage yield would be triticale = wheat > oat = rye, on average and depending on growing conditions (Lauriault & Kirksey, 2004; Marsalis et al., 2020).

Despite the interactions for grazing preference, the main effect of cereal was significant for grazing preference such that oat > wheat = rye > triticale (29, 22, 21, and 14%, respectively; LSD = 5).

Summary

Little difference existed among cereals in the autumn and winter growth periods under this limited irrigated system; however, rye had accumulation greater forage by early April than the other cereals and oat was greater than triticale with wheat being intermediate. Growing cattle preferred oat followed by rye and wheat and, then, triticale.

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Purpose of the New Mexico youth beef feeder contest in youth development

Halee Prather, Dr. Frannie Miller, Dr. Craig Gifford, Dr. Marcy Ward

Introduction

One of the objectives of the 4-H Market and Breeding Beef project is to teach responsibility through properly caring for an animal (Metzger et al. 2010). In a survey of Texas parents about the life skills gained by participating in the traditional 4-H Beef Project, knowledge of the livestock industry was rated by 38% of the parents as an important life lesson (Boleman et al. 2004). Youth involved in 4-H livestock projects were shown to have higher retention rates (Baney and Jones, 2013). However, the traditional beef project is one of the most expensive livestock projects; Nash and Eborn (2012) estimated the net profit as -$2,002. With this in mind, a new livestock project will be available this year. The objective of the New Mexico Youth Beef Feeder contest is to teach youth about commercial beef production. Youth will learn how to raise beef from start to finish, while also developing leadership skills and advocating for the beef industry. The contest is designed to align with the New Mexico beef industry, with a focus on how producers manage the economic choices of beef production. Educational seminars and materials are being provided in cooperation with New Mexico State University on topics such as financing, record keeping, animal nutrition, animal health, carcass evaluation, and marketing.

Objectives

The primary goal of the Youth Beef Feeder contest is to enhance the educational value of the traditional 4-H and FFA beef projects by providing an affordable option that rewards production merit and carcass value of the market animal, along with accurate and complete record keeping, industry knowledge, and public engagement by the participant. This commercial beef project places an emphasis on the economic strategies to feed and develop livestock for markets, with a focus on feed costs, average daily gains, feed conversions, and management strategies. The contest also includes leadership and public engagement opportunities such as a speech, informational poster, and promotional video.

Approach

The contest is divided into two different phases. During the first phase, youth will be responsible for backgrounding their calf. In the second phase, youth will transport their calf to the NMSU Agricultural Science Center in Tucumcari and track their individual calf's performance from home using Growsafe technology. Estimated cost of participation is $2,500.00. The ballpark estimate during the backgrounding phase is $300 from purchase to feedlot for a total ration that targets two pounds per day. Participants will enter a contract with the feedlot for a flat fee of $200.00 per month. If feed costs exceed the $200.00 per month, participants will be billed accordingly. If the total cost is less than the monthly fee, corrections will be made on the closing statement.

Participants are also responsible for the processing fee.

Upon completion of phase two, the steers are being transported to the USDA processing facility in Las Vegas, NM. The cattle will be harvested and carcass data will be collected. The product is returned to participants. Participants can choose to use the meat for their own personal consumption or market the meat to make a profit. The product will have the USDA labeling.

This statewide program has gained substantial interest from numerous organizations, producers, and youth. This year, 20 youth are participating from 12 different counties. The support and promotion from various entities has been encouraging. So far, funding for $6,500 in scholarship money and a trip to the NCBA Convention for high point individuals has been provided.

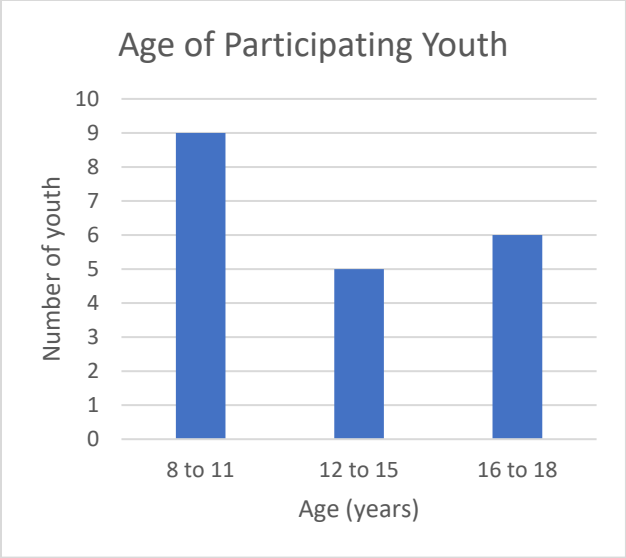
Expected Outcomes

The contest is expected to increase industry knowledge in 4-H and FFA youth. Youth will develop skills relating to record keeping, financing beef production, providing the proper nutrition to feeder calves, and agricultural advocacy. Youth will be participating in the stocker and feedlot phases of commercial beef production which rely heavily on low cost of gain. Youth will be able to identify and explain key components of the beef industry and utilize the skills learned.

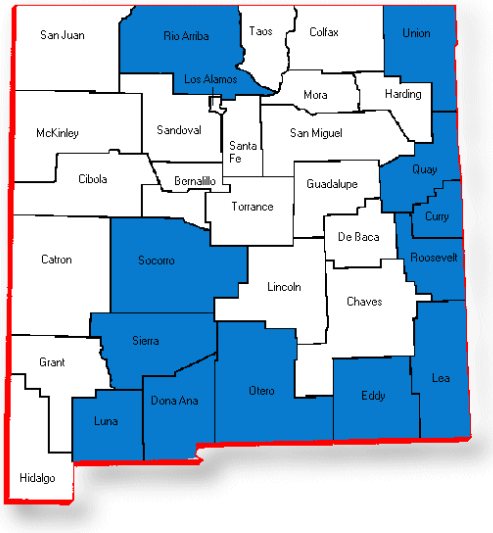
The contest provides industry support by providing animal performance and carcass data to participating New Mexico producers inform breeding programs. The data can be used to help EPDs (Expected Progeny Differences). The carcass data is a tool that producers can use to develop livestock with the desirable traits that the market demands.

Impact

The impact of the contest will be measured pedagogically through tests, a survey, and evaluation of record books. Pre and post tests will be conducted to measure participants' growth in knowledge before and after educational seminars. Additionally, a survey will be conducted for parents to identify the life skills they are wanting their child to gain from 4-H and FFA projects and assess how effective this contest is at developing some of the identified life skills. Lastly, the requirement of a detailed record book will allow for an assessment of the expense involved in this alternative format and a comparison of what the economic savings are.



Counties with Participating Youth



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Permits Required for Mobile Slaughter

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Keywords:
Meat processing permit, mobile slaughter permit, on-site slaughter, New Mexico permits

Introduction:
Meat processing centers across the U.S. are experiencing extremely high volumes of livestock to be processed for consumption. According to the National Agriculture Services Statistics (NASS), “Over 95 percent of the total U.S. slaughter for most species is under federal inspection” (NASS-USDA, 2020). While there are 800 federally inspected slaughtering facilities across the United States, there are only 8 within the state of New Mexico. This market limitation has forced New Mexico livestock producers to send their livestock out of state to be processed for potential resale. Because of this, people have started to look for slaughtering alternatives to the traditional slaughter facility. This brings in the idea of the mobile slaughter unit (MSU) which travels to and from a farm/ranch and slaughters livestock on-site. From here, the MSU operator will transfer the recently slaughtered carcasses to a brick and mortar facility to be aged and cut/wrapped, completing the slaughtering process. A brick and mortar processing facility is a traditional, stationary meat processing operation. The MSU is unable to carry out the complete functions (aging and cut/wrapping of the slaughtered meat) in which a brick and mortar processing facility can. The concept of the MSU is to be as beneficial to producers as possible while providing a humane slaughtering process to the livestock. Research shows humane slaughtering can provide higher quality meat (Friedrich et al., 2015).

Through this research, inquirers will be given the opportunity to learn about all permits required to operate a mobile slaughter unit within the state of New Mexico. The three most well-known types of meat inspection will be covered throughout this paper.

Materials and Methods:
In the United States there are three different types of meat inspection that processors must operate under, all are in some way governed by the USDA. The main three types of meat processing are: USDA/Federal Inspection, State Inspection, and Custom Exemption.

Required under the Federal Meat Inspection Act (FMIA), any meat that is sold commercially must be inspected by the USDA Food Safety and Inspection Service (FSIS) in order to ensure the meat is “safe, wholesome, and properly labeled” (USDA-FSIS, 2015). During the

entirety of the slaughtering process, FSIS must have an inspector present. This requires the MSU operator to pay a fee to have the inspector onsite during all slaughters. These federally inspected facilities are required to have written Standard Operating Procedures for Sanitation (SSOP) as well as written Hazard Analysis and Critical Control Point (HACCP) plans. Additionally, a HACCP coordinator must also be employed through the MSU's operation under Federal inspection. Federal inspection is offered in all states including New Mexico.

State meat facilities are required to function under Federal inspection unless they operate under a State Meat and Poultry Inspection program (MPI). State MPI programs are offered in 27 states but not in New Mexico (USDA-FSIS, 2015). State MPI programs are primarily imposed to inspect meat for resale within a state, meat processed through State MPI programs cannot be sold interstate and must ensure the facility "meets or exceeds the USDA requirements". This leaves New Mexico unable to sell meat that is not Federally inspected due to the absence of a State MPI program.

Lastly, there is Custom Exemption operations. Custom-exempt facilities perform slaughtering services intended only for the owner of the livestock. Any and all meat processed through these facilities is not allowed to be resold after processing. These facilities are exempt from FMIA which does not require them to be inspected daily or by carcass. Although, they are required to be registered under the USDA and are subject to some review intermittently in order to ensure that the facilities are operating in a safe, clean, and wholesome manner while also producing quality slaughtering services.

Touched on previously, New Mexico does not have a State MPI program which only allows for Federal inspection as well as Custom Exemption for meat processing. In the coming sections, required operating permits to run a slaughtering facility, specifically a Mobile Slaughter Unit, under New Mexico law will be covered.

Results and Discussion:

Under the USDA Mobile Slaughter Unit Compliance Guide, there are seven listed steps to follow in order to obtain Federal meat and poultry inspection.

The following information can be found on the USDA-FSIS website under 'Mobile Slaughter Unit Compliance Guide', https://www.fsis.usda.gov/guidelines/2010-0001. The steps to operate a MSU under Federal inspection are as follows:

1. File an Application for Inspection
    a. Contact your district office (DO) and they will provide you with the "Application for Inspection".
2. Facilities Must Meet Regulatory Performance Standards
3. Obtain Approved Labels or Brands
4. Obtain Approved Water Source Letter
    a. Water sources must comply with the National Primary Drinking water regulations
5. Obtain Approved Sewage System Letter
    a. A letter of approval from a local health authority must be provided
6. Provide a Written Standard Operating Procedure for Sanitation
7. Provide a Written Hazard Analysis Assessment and HACCP Plan

State of New Mexico

In order to operate a MSU within New Mexico, there are a few more regulations that are set into place to enforce safe slaughter.

- A Commercial Driver's License must be obtained since the unit will be transporting hazardous materials, i.e. animal offal. MSU operators can apprehend this certification through most Motor Vehicle Departments or through the state's Department of Transportation.
- A hauling permit is required by the Environmental Department to haul hazardous waste accumulated through slaughtering. This is required when hauling hazardous waste to and from slaughter site and composting areas.
- MSU operators must also write up Disposal Plan for Specified Risk Material such as Bovine Spongiform Encephalopathy, otherwise known as "mad cow disease", which can be found within the central nervous system of cattle. Ways to dispose of SRM safely include rendering, incineration, burial on-farm or at an authorized landfill/composting center.

Summary and Discussion:

When deciding to operate a mobile slaughter unit, many factors must be discussed. Operating permits are a necessity for MSU's but the first step to starting a mobile slaughter unit is to determine the type of inspection that you are willing to operate under. This can be influenced by the state you live in as well as the costs associated with each type of inspection. A mobile slaughter unit within New Mexico would be required to obtain at least a custom exemption certification for meat inspection along with several different permits.

Discussed previously, New Mexican operators must obtain a Commercial Driver's License (CDL) through the NM Department of Transportation or a NM Motor Vehicle Department. A CDL is required by the State of New Mexico due to the MSU hauling hazardous material such as animal waste and offal.

With the MSU hauling hazardous material, a Hazardous Waste permit must be obtained through the NM Environmental Department for the transportation of the animal waste/offal from the kill site to the compost/rendering facility. Along with this, a compost/landfill agreement must also be made in order to ensure that there is a set disposal location, aside from the potential disposal area at the kill-site, aka farm or ranch.

Mobile slaughter within the state of New Mexico has immense potential but can be heavily regulated. By following the MSU Guidelines above, determining the type of inspection desired, as well as obtaining the required permits, mobile slaughter unit operations in New Mexico can be started.

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Taking care of cows by taking care of people, understanding the dairy labor conundrum

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Take home messages

- The U.S. dairy workforce is evolving rapidly: multicultural, multilinguistic, with ergonomic challenges more than ever before.
- Dairy managers typically are promoted because they excel at managing cows: learning people managing skills is the challenge.
- Successful dairy operations seem to be those that have successfully navigated the workforce development and training conundrum.

Introduction

As the dairy landscape continues to evolve through consolidation and dairy expansion, we are witnessing a rapid evolving dairy workforce landscape. Labor continues to be the number one challenge on dairies, specifically human resource development. Where dairy owners and managers historically were challenged with training and educating a largely foreign-born workforce originating primarily from Mexico, with the sharp increase in number of workers from Central America, we have now added another layer of challenges to the mix. Many producers may not even realize the extent to which this is occurring on their farms and what the implications of that change are for workforce training and development, but also in terms of workplace safety. The goal of this article is to shine some light on these developments and provide producers with information on how to continue to focus on getting the best from their employees.

Labor: The number one challenge on dairies

The number of books written on (effective) workforce development is simply staggering, however by just adding the word “dairy” in the search engine, that number dwindles down to exactly zero. There are few available resources for dairy workforce development. But ask any given dairy producer about their number one challenge outside of the “non-controllables” such as feed- and milk prices, the unanimous response is labor, and more specifically managing or developing that resource. This is no different outside of dairying: hiring, training, and developing the right employees for any business is generally considered one of the toughest challenges.

Focus: Taking care of people taking care of cows

When evaluating the success of dairy operations in today’s paper-thin economic environment, it appears that dairy operations that are successful in getting the best from their employees and therefore their cows, seem to do well.

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Since there are no good metrics or benchmarks to compare the level of success in “motivating people to do the right thing” or “giving 100% every time, all the time”, I can’t support that statement with any numbers. However, as I speak about this subject with producers all over the country, I do seem to receive overwhelming agreement for this subjective measure. And it makes sense: taking care of people taking care of cows should be the primary focus of management. So why is this so difficult, and what do we need to do to become proficient in that department? This is not an indictment of managers, but a simple realization that managing people is simply much more difficult than managing cows!

Developing people managers: It’s not the dairy manager’s fault

Dairy managers were and continue to be first and foremost successful cow managers, oftentimes promoted from within because they excelled at the technical part of their jobs: taking care of cows. The question that needs to be asked is: Will a good milker, breeder, feeder, or outside worker make a good people manager? Many new managers have failed at managing people, became frustrated, and left the organization to go back to what they were good at: Taking care of cows. Many growing dairy operations have been unable to continue to grow because they were unable to find or develop good middle managers from within.

Again, this is not to be critical of managers, because is not anybody’s mistake or fault. Where did dairy managers go to learn how to manage people? Most dairy owners and managers learned how to manage cows in technical programs, schools, or college and through practical experience. On the other hand, how many dairy owners or managers went to school to specifically take classes on managing people? Or alternatively, how many producers were in a position to bring in outside HR managers, people with little dairy knowledge, simply to help develop a workforce training program? Except for learning as we go and trial and error, few current owners and managers obtained any formal education on managing people. Recognizing this is step one in becoming better, it is not your dairy manager’s fault.

Does my personality get in the way?

Secondly, if we were to conduct a Meyers-Briggs personality test amongst dairy owners and managers to see what the predominant personal strengths are, it is likely that few will fit the preferred manager profile, with a delegating, motivating, coaching-minded CEO personality. Many working in agriculture possess personality traits that allow them to be strong individuals, “the doers”, flexible with common sense, based on experience, without a lot of patience for nonsense, and if it takes any more than 30 seconds to explain something, they likely will take over and do it themselves.

That’s two strikes: One, people management was learned by experience, and two, personality interferes. The younger generation entering the dairy business is somewhat different. This group of young managers is generally much better at working with people because they grew up around the dairy, working with and learning from workers from many different backgrounds, learning the customs, the language, and the culture, and are

typically much more comfortable in a leadership role managing people on the dairy.

Recognizing your real workforce

There is a third strike: Understanding your audience or in this case your workforce. Our dairy workforce is primarily foreign born, speaks a different first language, is culturally different, and generally has limited agricultural and animal handling experience when starting to work on a dairy. Even though this is nothing new, these facts are oftentimes cited as the primary barriers for effective workforce development and training. Recent data from our dairy safety and animal handling trainings throughout the US shows some fascinating trends.

Traditionally, the majority of the foreign-born dairy workers, (>90%), originated from Mexico and identified culturally as Hispanic. This is changing fast. Data collected during trainings indicate that in the Southwest up to 45% of the workers on dairies and an even higher percentage on calf raising facilities, originate from Central America (Guatemala, Honduras, El Salvador) and identifies as indigenous or of Mayan descent. Instead of understanding the complexities of managing two different cultures and languages on the dairy, producers are now trying to work with three cultures, three languages and three statures.

Workers from Central American countries may or may not speak Spanish depending on where they came from and if they received any schooling. Many Central American workers originating from the countryside with limited or no schooling, typically speak one the many different Mayan languages, of which K'iche is the most prominent, and usually know very limited or no Spanish. They identify culturally as from Mayan descent, a culture that is very different from the familiar Hispanic culture of workers originating from the northern parts of Mexico. In addition, the stature of workers from Mayan descent is typically significantly smaller than that of Hispanic or Anglo descent. These workers therefore may have more difficulty as milkers reaching the udder or the control panel in the parlor, or as breeders inseminating cows, tasks easier performed by taller workers. Another potential challenge is that milkers with shorter statures must reach higher for a prolonged period and as a result may fatigue sooner, a potential safety concern. Research is under way in that area to determine to what extend that affects performance.

What does this mean for my dairy?

Owners and managers are usually very aware of the challenges presented by managing employees from different cultures and languages. However, this just became infinitely more complicated by adding a third language, a third culture, and a third stature to the mix. The real questions are how do these workers relate to the other cultures? Are there cultural issues between workers from the Hispanic and the Mayan cultures? Are we aware of those issues or is that an invisible piece of the iceberg? Does this explain some of the workforce issues that seem difficult to address? Where can one find information to learn about or address these issues?

How well can workers perform their jobs if training is only provided in Spanish or English and there is limited recognition

for the differences between Hispanic and indigenous cultures? For one, until recently, most Mayan cultures did not have a written language. Do the employees even read? What does that mean in terms of understanding or comprehension when we provide written SOPs or other documents in Spanish? Or any written material for that matter? What about the real effectiveness of training if all trainings are in Spanish, but there is a large percentage of non-Spanish speaking employees? Who is doing the translating to the Central American workers and what do they truly comprehend? What else is being overlooked in this complicated picture?

This is what is meant by knowing your audience. Do we really know and understand non-English speaking dairy employees and how to adequately communicate with them? Can the dairy manager really get the best from their employees if they do not know how to validate their employees' values? It is commonly accepted that the best work comes from workers who feel validated and respected by their superiors. By workers that receive appropriate feedback on their performance and are encouraged or coached in the process to become better at what it is they do. Are dairy managers doing that effectively not realizing or understanding the mixed bag of issues they are dealing with?

Characteristics of profitable dairies

As a final, likely rhetorical, is the difference between the "top 25% dairies" in comparison to the other 75% of dairies solely based on differences in cow genetics or feed quality and other cow related metrics? Or is the difference between profitable and not-so profitable operations based on how owners and managers are successful in adequately developing their workforce, evaluating performance, providing timely feedback, and setting the bar higher for improvement while recognizing and validating the unique blend of cultural differences and backgrounds that exists in their workforce?

Certainly, the consequences of the U.S. failed immigration system are not helpful in giving managers a fair opportunity to fully endorse and implement a solid workforce development program. But, despite the failed system, there are many things that can be done, beginning by recognizing differences, identifying cultural, linguistic, or even ergonomic bottle necks; learning more about the uniqueness of our workforce; and by validating people for who they are and the value they bring to the workplace. This means for most manager personalities getting out of one's comfort zone. It will likely bring many challenges associated with these differences to the service and can make us uneasy about how to handle them (remember it is easier to manage cows…). But without attempting this, there is no other way than to continue to do "business as usual", with predictable outcomes considering undeniable industry trends.

You are not alone: Resources

Many producers, owners, and managers, for reasons described above find it extremely challenging to develop a successful and effective worker training and evaluation program. It is easier to tell Jose to make sure that Juan knows what to do, without teaching Juan the why. These challenges are recognized by industry leadership and the NMPF FARM Program has developed and collected a series of resources and tools to be utilized on the

dairy farm. Many of the resources have been translated in Spanish but also into K'iche, and they are all available for use or download from the NMPF FARM Program website. Many Extension programs in New Mexico and elsewhere, including NMSU's Dairy Extension Program, have developed additional resources pertinent to their regional or state situations. A simple internet search will get you there.

Effects of antibiotic class, treatment frequency, and metaphylaxis management on performance in yearling bulls.

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Abstract

Comingling young cattle in confinement can increase cases of respiratory disease. Data from 763 yearling bulls comingled from 21 ranches were evaluated for morbidity rate, treatment response, and respiratory disease effects on performance. Performance parameters included gain (ADG), intake (DMI), feed conversion (FE), and residual feed intake (RFI). Nutrition and health management at the test station were the same each year. Metaphylaxis management varied among producers, however there was no correlation between unilateral antibiotic treatment and morbidity rate. Treatment protocol had a significant impact on how often bulls required a 2nd or 3rd treatment. The long acting macrolide broad spectrum antibiotics(M) had lower retreatment rates than the florfenicol (F) products included in the protocol ($P<0.001$). Gain (ADG) and DMI were lower in morbid bulls that were treated at least once, compared to healthy bulls, regardless of the treatment protocol ($P<0.05$). Year and ownership had the greatest impact on morbidity rates in yearling bulls ($P<.001$). Key Words: bulls, morbidity, performance.

Introduction

In 2015, the Tucumcari Bull Test station transitioned to a comingling pen system to improve mobility and provide more square footage per animal. Comingling cattle from different locations can result in increased respiratory disease and morbidity and decreased performance in feedlot cattle. Metaphalaxis is a management tool to prevent illness in newly comingled cattle; where all cattle are administered a long acting antibiotic. This study reviewed five years of health and performance data collected during the Tucumcari Bull Test, located in Tucumcari, New Mexico. The effects of treatment frequency, antibiotic class, and metaphylaxis management on overall health, growth, and efficiency in yearling bulls were evaluated.

Materials and Methods

From 2015 to 2020, 763 yearling bulls from 21 ranches were performance tested at the Tucumcari Bull Test station. All cattle were required to have two doses of five way modified live viral and eight way clostridial vaccines. Bulls were weaned for 30 to 45 days, and all had a negative BVD-PI test. Five owners utilized metaphylaxis management prior to delivery each year under evaluation. Feed and performance data was collected over 120 days. Gain (ADG), dry matter intake (DMI), feed conversion (FE), and residual feed intake (RFI) were the standard measures of performance.

Bulls were monitored twice daily for health. The DART method (depression, appetite, respiratory distress, and temperature) was utilized for determining sickness. When a bull demonstrated signs of illness, the animal was pulled from the pen and evaluated for sickness. If symptoms were minor (body temp103-104°F), cattle were given a long acting macrolide broad spectrum antibiotic (M). If symptoms were

severe (body temperature of >104°F), they were treated with a combination of a florfenicol antibiotic and flunixin meglumine anti-inflammatory (F) to quickly reduce fever. If symptoms returned in an animal, it was treated according to the protocol. Need for re-`1 treatment most commonly occurred approximately 30 days post first treatment.

Results and Discussion

Impacts of treatment frequency on performance are illustrated in (Table 1.). Of the 763 bulls evaluated, 174 were treated at least once, 44 twice, and 18 required three treatments.

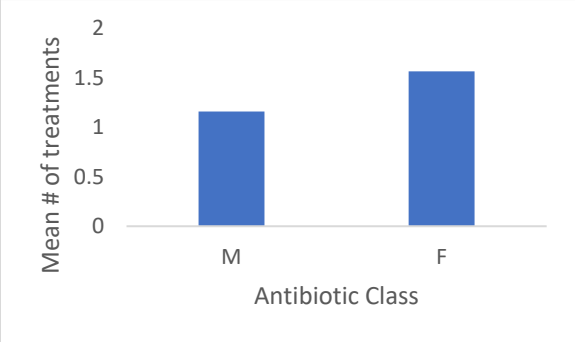
Table 1. Performance of yearling bulls treated 0, 1, 2, and 3 times for sickness.

	0	1	2	3	P VALUE
ADG	3.72[a]	3.50[b]	3.56[ab]	3.16[b]	0.001
DMI	22.3[a]	21.4[b]	21.73[ab]	20.8[b]	0.043
FE	6.26	6.31	6.33	7.11	0.15
RFI	0.06	0.78	0.81	0.79	0.55

[a,b] Significance between treatment level (P<0.05) Treatment frequency had the greatest impact on gain and intake. Feed conversion (FE) and RFI had higher variability across treatment frequencies, so were not influenced by morbidity.

Figure 1. demonstrates the bulls' response to either M or F antibiotic class of treatments. When bulls were given M antibiotic on their first treatment, there was a significant reduction in need for a second treatment (P<.0012). There was no correlation (r=-0.047), however, between metaphylaxis management by owner and morbidity rates.

Figure 1. Number of treatments required for morbid cattle based on antibiotic class given on the first treatment.



[a,b] Significance between antibiotic class (P<0.001) The greatest contributions towards morbidity rates were year (P<0.001) and owner (P<0.001). 2020 had the lowest morbidity rate compared to the previous four years (P<0.02). Though owner overall was significant, individual owners had varying years of health issues in their cattle. Breed of cattle had no influence on morbidity rate. The results of this study agree with previous treatment assessments in feedlot cattle (Skogerboe et al.,2005).

Conclusion

Morbidity negatively effects performance in yearling bulls. Metaphylaxis did not improve overall morbidity rates. Results from this study will help improve treatment management to reduce respiratory diseases at the Tucumcari Bull Test.

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New Mexico Calf Management and Marketing Survey

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Introduction

New Mexico is largely a cow/calf production state, with beef cattle and calves being the second most important cash commodity in the state (USDA, 2019). However, production practices vary widely across the state. A survey was conducted to identify common calf management and marketing methods for producers in the state.

Materials and Methods

A total of 1000 hard copy survey were mailed to New Mexico producers, with an online version being available on the NM Beef Website. Responses were managed in a Microsoft Excel spreadsheet (Microsoft, Redmond, WA) and summary statistics were analyzed in SAS 9.4 (SAS Inst. Inc., Cary, NC, USA). There was an average response rate of 15% (n=154). The following proceedings summarizes information provided by respondents.

Producer Demographics

Producers who participated in the survey represented 4,404,040 acres of private owned, private leased and leased public rangeland in New Mexico. Average producer age was 57 years' old with average experience of 24 years. Table 1 summarizes average operation characteristics of respondents.

Table 1. NM Producer Demographics

Question Topic	Mean	No. of Responses	SEM
Operation size, head of cow/calf	288	155	38.0
Weaning weight, lbs.	556	153	7.4
Weaning rate, %	91	135	0.8
Calf Death loss, %	2	151	0.2

Calf Management

Producers were asked to indicate the primary reason for calf death loss on their operation. Most producers (34%) indicated that predation contributes greatest to calf death loss, while 27% of producers indicate unknown factors contributing the most to death loss and 20% indicated that illness is the cause of calf death loss. The remaining 19% indicated either weather, dystocia, or plant toxicities as being factors that contribute to calf death **(Table 2).** Table 2 summarizes management methods surrounding calf health and vaccination.

Table 2. Calf Death Loss and Vaccination

Question Topic	Frequency, %	No. of Responses	SE of %
Primary reason for calf death loss, %		129	
Predation	34	44	4.2
Unknown	27	35	3.9

Illness	20	26	3.5
Weather	8	10	2.4
Dystocia	7	9	2.3
Plant toxicity	4	5	1.7
Calf Vaccination, %		157	
Yes	98	154	1.1
No	2	3	1.1
Assistance for developing vaccination program, %		145	
Veterinarian	43	62	4.1
Personal research	20	29	3.3
Extension Service	6	8	2.0
Neighbor/Family	2	3	1.2
Industry/Vaccine sales	2	3	1.2
Combination, Veterinarian, and personal research	12	18	2.7
Combination, Extension service and veterinarian	9	13	2.4
Combination, multiple methods	5	7	1.8
Other methods	1	2	1.0
Experience respiratory disease problems in calves, %		153	
Yes	28	43	3.6
Unknown	10	16	2.5
No	61	94	4.0

Vaccination

Figure 1 represents the use and timing of administration of clostridial (black leg), Modified live viral respiratory, killed-viral respiratory and Mannheimia haemolytica vaccinations. Clostridial and modified live viral respiratory vaccine were most widely used amongst producers. Clostridial blackleg is primarily administered at branding with a booster provided at weaning. Modified-live viral respiratory vaccine is administered at branding and weaning (**Figure 1).**

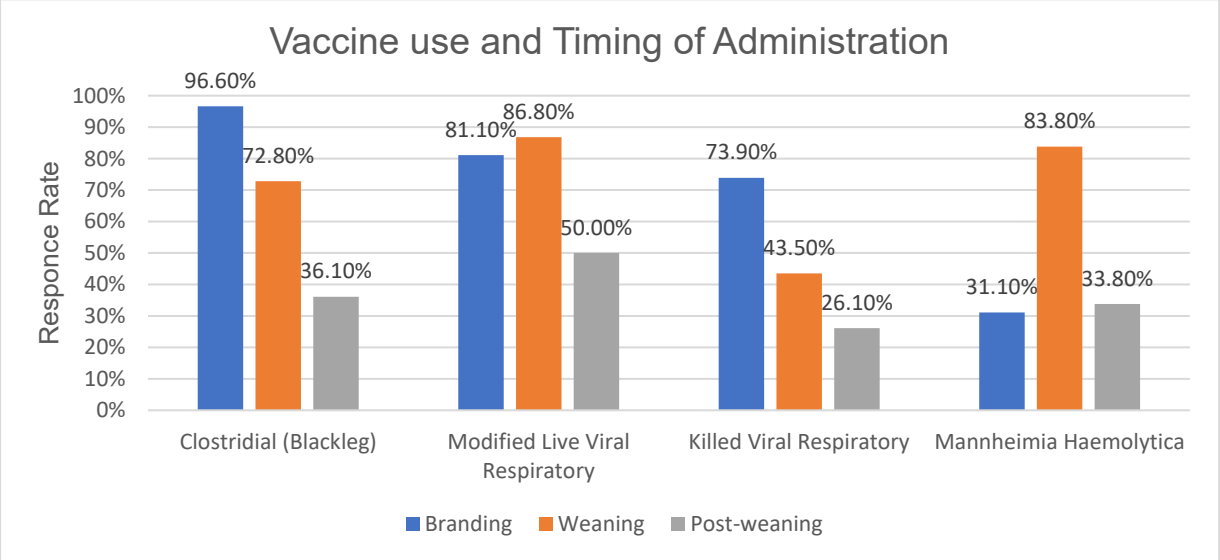

Figure 1. Vaccination methods for New Mexico Producers

Weaning and Marketing

Producers were asked to describe their weaning management. Most producers (70%) report weaning their calves prior to marketing, while 22% occasionally wean their calves and the remaining 8% do not **(Table 3.)** Although responses varied, most respondents (63%) indicated they wean between 45 and 60 days prior to marketing, with 22% indicating they wean fewer than 45 days prior to market and 16% reported they wean more than 60 days before marketing.

Producers were further asked to indicate how they market their calves. Marketing methods varied amongst respondents, but the majority (35%) report the local sale barn as being their only avenue for marketing calves. Twenty-three percent of respondents indicated utilizing on-ranch cattle buyers or video marketing and the local sale barn, direct to feedlot, or video marketing. A portion of producers (16%) indicated utilizing a combination of multiple methods and 9% report using other methods.

Table 3. Calf management and marketing

Question Topic	Frequency, %	No. of Responses	SE of %
Wean prior to marketing, %		156	
Yes	70	109	3.7
Sometimes	22	35	3.4
No	8	12	2.1
Days wean prior to marketing, %		80	
Less than 45 days	21	17	4.6
Between 45-60 days	63	50	5.4
Over 60 days	16	13	4.2
Marketing methods		150	
Local sale barn	35	53	3.9
Utilize on-ranch cattle buyer	16	24	3.0
Direct to feedlot	6	9	1.9
Video	5	8	1.8
Combination, local sale barn and on-ranch cattle buyer	7	11	2.1
Combination, local sale barn and video	5	7	1.7
Combination multiple methods	16	24	3.0
Other methods	9	14	2.4

Summary and New Mexico Impact

Results demonstrate that most New Mexico producers vaccinate their calves and most commonly administer either a clostridial (blackleg) or modified live viral respiratory vaccine at branding and weaning. Producers commonly wean their calves 45-60 days prior to marking and most prefer to utilize the local sale barn for calf marketing. These data identify calf management methods for producers in the state and can be used to direct future industry or educational trainings. In addition, these data provide New Mexico producers with benchmarks allowing producers to compare their operation to regional averages.

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Complement system activity in feedlot heifer calves affected by BRD

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Introduction

Bovine respiratory disease (BRD) remains the largest factor negatively affecting the U.S. beef industry. Advancements in vaccines and antimicrobial agents have helped producers but have not significantly reduced the incidence of morbidity and mortality of calves caused by BRD. Additionally, NM producers still report problems with BRD after weaning and at arrival to feedlots.

The two branches of the immune system are known as adaptive and innate. Vaccines rely on adaptive immunity, where the body recognizes a pathogen after re-infection (Gaspers et al., 2016). Innate immunity is the first line of defense. The complement system is one component of innate immunity. It is composed of many proteins that are activated at first signs of a pathogen. The complement proteins work to ultimately destroy pathogens and prevent infection.

The degree of infection by BRD in calves entering the feedlot varies. This variation leads to some animals significantly being affected by BRD while others are not (Snowder et al., 2006). The components in the calf serum which may provide protection against a severe case of BRD are unknown.

Therefore, the current experiment evaluated the calf serum for candidate proteins. A test was then used to determine the relative amount of candidate proteins in animals that were severely affected by BRD and those without any signs of infection.

Key words: cattle, complement system, respiratory disease, toxicity

Materials and Methods

Serum was collected from heifer calves (n=89; BW +/- 483 lbs.) at processing upon entering the feedlot.

Heifer calves were retrospectively assigned to groups consisting of those never needing treatment for BRD and remaining alive throughout the feeding period (NT; n=80) or calves that died within 1 wk of arrival (D; n=9). Calf serum collected at initial processing was tested using a CH50 assay.

Serum from protective and non-protective calves was analyzed by LC-MS/MS using a label-free data-dependent "shotgun" mass spectrometry approach. Comparisons of candidate proteins were evaluated to determine those that were upregulated.

Briefly, to perform a CH50 assay, serum was added to tubes with a 50% serial dilution from 1:4 to 1:64. Guinea pig red blood cells sensitized with antibodies were added to each tube. Tubes were incubated for 30 min at 37℃ to allow for cell lysis to occur. After incubation, absorbance of the supernatant was determined. Serum that was more diluted but was able to lyse 50% of the cells would be considered to have an increased CH50 value.

Results and Discussion

Comparisons between calves that were considered protective (P) versus non-protective (NP) calves against BRD, demonstrated upregulated proteins in P calves were complement system and associated proteins (Figure 1.).

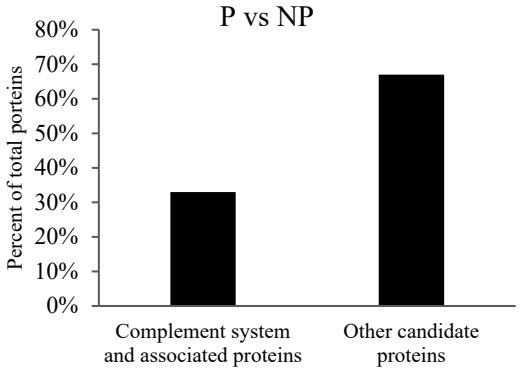

Figure 1. Serum from protective and non-protective calves was analyzed to determine candidate proteins leading to protection. A majority of total candidate proteins upregulated in protective calves were complement system and associated proteins.

Calves that entered the feedlot and who never received treatment for BRD and remained alive throughout the feeding period had a significantly (P < 0.05) higher CH50 value compared to those that died within 1 wk of arrival (Figure 2).

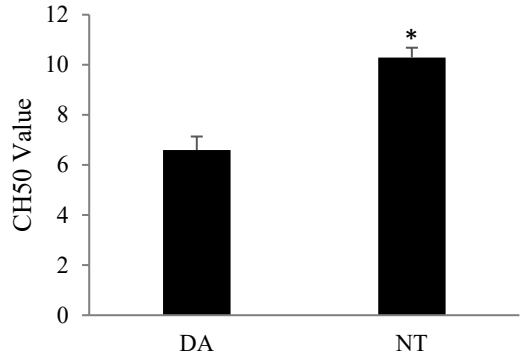

Figure 2. Serum from calves that died from BRD one week after feedlot arrival had reduced (P < 0.05) complement system activation compared to calves never treated for BRD and remained alive.

Heifers who died within the first week at feedlot arrival had reduced (P < 0.05) CH50 values compared to calves never needing treatment for BRD and remaining alive. Of note, the serum used to test the complement system of calves was collected at arrival prior to any clinical symptoms. The CH50 assay is a screening test for complement system proteins, which indicated by our results appear to be increased in calves never needing treatment for BRD. Increasing or administering complement proteins in calves may provide an additional tool to combat BRD or evaluation of complement system activity may provide insight into calves predisposed to severe cases of respiratory disease. Future studies will continue investigating complement system proteins and their mechanistic role in cases of BRD.

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Testing of a LoRa-WAN digital ranching system on desert rangelands: some practical experiences

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Key words: precision livestock farming, precision grazing, digital agriculture, beef cattle, GPS-tracking, rain gauge sensor, water level sensor

Introduction

Precision livestock farming (PLF) is an emerging agricultural strategy that incorporates sensors and data analytics to inform management decisions (Neethirajan, 2017; Tedeschi et al., 2021). Though common in household and more intensive livestock and crop production systems, Internet of Things (IoT) tools are in earliest stages of development for extensive beef and sheep production systems on arid rangeland primarily due to limited infrastructure and lack of Wi-Fi, cellular (e.g. 3 and 4G), or satellite network access. Yet Long Range Wide Area Networks (Lora-WAN) could offer a high efficiency and low-cost solution to this hindrance as they promise near-real time long-range coverage (e.g. > 6 mi), a strong signal, long battery life, and customizable data collection units (e.g. widgets or sensors), compared to other conventional network types (Bocquier et al., 2014). Precision livestock technologies could provide New Mexican livestock producers novel tools for real-time monitoring of animal location and activity, asset tracking, and infrastructure monitoring in the face of a dwindling workforce and harsher climate (Spiegal et al., 2020).

This study aimed to test a PLF LoRa-WAN-based monitoring system across four pastures (12,000 ac) of Chihuahuan Desert rangeland. We report the installation protocol, maintenance, and practical applications associated with the system.

Materials and Methods

This PLF system consisted of a single Kerlink® LoRa-WAN iStation gateway, a remote 100-watt solar panel system (consisting of Renogy® components), a pair of Ubiquity® NanoBeam M2 airMAX Bridge Wi-Fi backhaul extenders, 43 LoRa WAN-enabled Abeeway® Industrial trackers, one Decentlab® tipping bucket rain gauge, and one Decentlab® water level sensor.

In this system, small packets of data can be transmitted from sensors to the LoRa WAN gateway on to the network server via one or more of a variety of backhaul systems including Wi-Fi, Ethernet, and 3G or 4G cellular GSM. The system we tested utilized a Wi-Fi backhaul, though it had GSM backhaul capability as well. Data transmission from the network server to the cloud or application endpoint was achieved via a secure payload transmission control protocol and coupled internet protocol (TCP/IP) or secure sockets layer (SSL; Figure 1). Flow of data was bidirectional

such that sensor configuration could be modified using the applications server (a user-friendly internet dashboard) and transmitted via the cloud and network server back to the sensors to configure data acquisition frequency and precision.

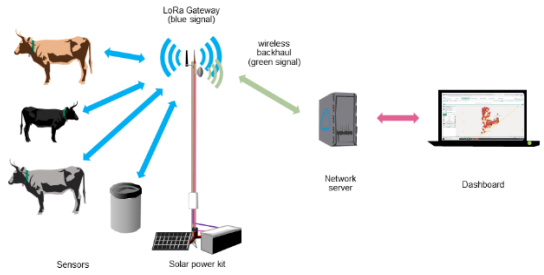

Figure 1. Dataflow between LoRa-enabled sensors, network gateway and antenna (tower with solar power kit), network server, and dashboard. Collars on cows represent LoRaWAN-enabled industrial tracking sensors used to monitor animal location in close-to-real time. Gray bucket represents a LoRaWAN-enabled tipping bucket rain gauge. The network server was a desktop computer connected to the internet via broadband. Cloud computing was used for data storage. The solar panel kit powered the gateway and Wi-Fi backhaul that transmitted LoRa data packets to and from the hard-wired internet connection at the ranch house. The applications dashboard is shown on a laptop computer with red points illustrating near real time cow location. Blue bi-directional arrows represent LoRa WAN signal, whereas a green bi-directional line represents Wi-Fi backhaul and a pink bi-directional line represents the TCP/IP SSL secure transmission of sensor payloads.

Industrial trackers equipped with global positioning system (GPS) were placed on custom collars on 43 rangeland beef cows and geo-positioning data was collected at 15-minute intervals for approximately 3 months from March 9 – June 9, 2020. The user dashboard was equipped for remote visualization of animal location, and offered several additional geo-positioning settings (e.g. time difference of arrival, Wi-Fi sniffing, and low power GPS) aimed at conserving battery life. The tipping bucket rain gauge and water level sensor settings were edited and visualized on a separate Decentlab® dashboard. All animal handling protocols were approved by the New Mexico State University IACUC.

Results and Discussion

The 100 watt solar and battery power system appeared adequate for the LoRa-WAN gateway and Wi-Fi backhaul, though there was only intermittent inoperability of the system as a whole, which may have been related to power, Wi-Fi backhaul, or other untraceable issues (e.g. weather and plant interference). The battery power of the industrial trackers was less than expected and dropped from 100 to ~35% over the three-month trial. The GPS data packets were recovered at 0 – 1.3 hour intervals and 46 ± 4% of GPS data packets were received on average, though for some weeks and pastures this data acquisition exceed 80% of expected GPS fixes. Power and Wi-Fi backhaul issues may have played a role in acquisition rates, in addition to upload channel and signal spreading factor settings, which were set to transmit over only one of six available channels. Battery life and data collection rates of precipitation events and trough water level were more consistent and reliable across the testing period (albeit these also timed out when the Wi-Fi system went down).

The system cost per cow is projected to range from ~$50 – 90 dollars per year depending on the level of features added. This system required new equipment and associated infrastructure, including cow trackers and other sensors, custom collars, Wi-Fi backhauling system, solar power and battery kit, and an annual subscription for licenses and use of dashboards. Current tests are being conducted to determine the reliability of utilizing 3 or 4G cellular

backhaul as an additional data communication system, though this could add an additional data plan cost component.

Figure 2. Example of Abeeway® Device Analyzer dashboard and map viewfinder 'tab'.

Overall, the system, in its current state, provided several unique management tools. The rancher using the system quickly became accustomed to checking the online dashboard in the morning before heading out to visually inspect the animals. This resulted in less time invested in finding and tracking of animal locations and frequently grazed areas. In some instances, the system helped identify when cows had crossed a fenced boundary and ranch employees were able to quickly find and re-pen escaped cattle that were being tracked in near-real time. The rancher also became acquainted with cattle watering-bouts by watching daily return intervals on the dashboard, which resulted in reliable predictions of times when animals would be in watering corrals and could be gathered for evaluation.

The rancher checked the water level sensor daily to ensure animals in the pasture had access to fresh water. This process alone has merit for greatly reducing personnel and fuel costs associated with water monitoring, especially in hot summer months, in addition to enhancing peace of mind (Elias et al., 2020).

Data mining and calculation of animal behavior variables like minimum daily area explored also suggest promising application to identify and develop alerts to inform ranchers of potential problems with individuals or cohorts of cattle. Cows apparently reduced daily area explored around days of calving, so real-time monitoring of this and other variables could eventually be incorporated into this and similar systems to provide real-time signals of cow welfare to producers (Figure 3).

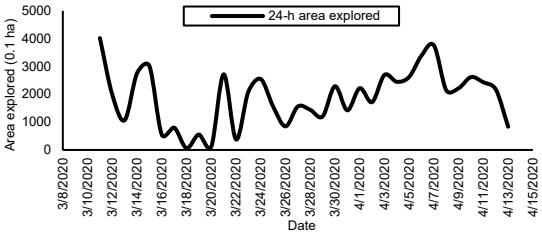

Figure 3. Example of GPS-derived behavioral metric and its relationship to parturition date. In this example, the cow gave birth on March 20, 2020 which coincided with daily area exploration nadir (0.1 ha).

Summary and New Mexico Impact

This case study revealed that mounting a real-time Lora-WAN system for PLF is possible on desert rangeland and could offer producers a user-friendly tool for close-to-real-time monitoring of animal location, activity patterns, as well as precipitation and trough water levels.

Acknowledgements

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