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REPORT & PROGRAM SCOPE

2022 Annual Report

The California Department of Food and Agriculture (CDFA) Antimicrobial Use and Stewardship (AUS) program reports annually on the program’s priorities and accomplishments. This AUS 2022 Annual Report focuses on the 2021 - 2022 fiscal year (FY 21 - 22), spanning July 1, 2021 - June 30, 2022. This report continues the practice of informing legislators and stakeholders about the program’s progression in its goal of becoming the leader in innovative approaches to antibiotic resistance and responsible antibiotic use associated with livestock in California.

The Antimicrobial Use & Stewardship Program

Since its inception in 2017, the AUS program has endeavored to support California stakeholders in the shared goal of preserving the efficacy of antibiotic drugs through a multi-faceted antibiotic stewardship and monitoring program to meet the mandates of California’s law, Livestock: Use of Antimicrobial Drugs (Food and Agriculture Code [FAC] Sections 14400 - 14408). The AUS program consists of a team of veterinarians, epidemiologists, and specialists working collaboratively to support its California agricultural stakeholders.
This fiscal year, through collaborations with researchers and laboratories, AUS produced a number of on-farm resources to be used as guidance by veterinarians and livestock producers when making informed decisions on the targeted use of antibiotics. AUS’ outreach with veterinarians and livestock feed distributors was also aided through the creation of tools that facilitate the calculations relevant for veterinary feed directives (VFDs) to improve overall data quality and consolidate resources that are used in creating them. With these new tools, AUS is hopeful that conversations between veterinarians, producers, and livestock feed distributors can be more productive and result in educated decisions.

AUS also expanded its involvement in the national discussion of antibiotics through its invitation to, and participation within, national panels and engagements, thereby contributing AUS’ expertise in antimicrobial stewardship and monitoring during
this fiscal year. Through providing requested public comments on United States Department of Food and Drug Administration (FDA) priorities and participation on well-respected national committees and panels, AUS is proud to continue to be part of the conversation that guides future policies and research to provide science-based answers to the responsible use of antibiotics in both California and the United States.

AUS continues to be proud of its strong collaborations with academic researchers in the field of livestock antibiotic resistance. AUS-funded research is reaching wider audiences through both oral and poster presentations by researchers, as well as in peer-reviewed journals, which expands the impact of this important information. Through current and ongoing projects, outreach, and partnerships with academic researchers, livestock producers, and collaborative agencies, AUS has continued to support animal health and a safe food supply.

The following sections in this report provide a description of the AUS program’s work and accomplishments during FY 21 - 22, including select highlights from various projects.
The AUS program has produced and distributed various materials to assist both producers and veterinarians this fiscal year, including infographic references in disease detection and management protocols to advance antibiotic stewardship, as well as educational materials on the use and development of antibiograms. AUS materials present evidence-based information regarding the current use of antibiotic drugs and how to preserve future antibiotic availability and efficacy. AUS is continually thankful for valuable information received from voluntary contributions and participation by livestock producers, veterinarians, and other stakeholders in AUS data collection, trainings, educational outreach, and engagement efforts.
This guide outlines the basics of diagnosis, treatment, and prevention of pinkeye in cow calf operations.

Infectious bovine keratoconjunctivitis (IBK), commonly known as pinkeye, is the most common ocular disease of cattle. In a survey of California cow-calf operations conducted by the California Department of Food and Agriculture in 2016, IBK was named as the disease that led to the most frequent administration of antimicrobials to cattle in this production system. There are opportunities for veterinarians to promote antimicrobial stewardship through the judicious use of drugs and by employing evidence-based strategies to reduce disease.

**DIAGNOSIS**

Diagnosing IBK early in the course of disease can reduce corneal and ocular damage and may lead to better clinical outcomes for affected cattle.

1. Base your diagnosis on these factors: signalment, environmental factors, clinical signs, laboratory diagnosis.

   - **A. Signalment**
     1. Calves are more frequently affected compared to older cattle.
     2. Lack of eyelid pigmentation (Hereford breed) predisposes cattle to IBK.

   - **B. Environmental factors**
     1. Warm months with increased sunlight favor transmission.
     2. Face flies increase the risk of pinkeye.

---

**Cow Calf Pinkeye: Strategies for Management**

**GENERAL STRATEGY**

Consider the logistics of management and the costs of treating pinkeye before making a strategic plan with your veterinarian for reducing pinkeye in your herd.

**RISK FACTORS**

- Calves are affected more often than older cattle.
- Calves from bull calves are more at risk due to lack of teat cover from their eyes.
- Warm months and increased sunlight favor transmission.
- Face flies increase the risk of pinkeye.

**Conjunctivitis bovina: Estrategias de manejo**

También conocida como queratoconjuntivitis bovina (QCB)

**FACTORES DE RIESGO**

- Calvados son más afectados que los animales más grandes.
- Calvados de los cánidos con teat cover son más a riesgo de QCB.
- Calvados de las vacas de teat cover son más a riesgo de QCB.
- El calor y la luz solar favorecen la transmisión.
- Las moscas aumentan el riesgo de pinkeye.

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Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
Cow Calf Scours: Strategies for Management

Causes
- Neonatal calf diarrhea, also called "calf scours," is a common disease in newborn calves. It is usually caused by
  - Exposure to intestinal pathogens
  - Poor colostrum intake, failure of passive transfer
  - Crowded calving area
  - Oystocia and weak calves

GENERAL STRATEGY

Signs
- Diarrhea
- Blood
- Sunkeneyes, cold legs (signs of dehydration)
- Low appetite
- Lying down, not keeping up with other calves, depression, weakness
- Severe disease can lead to death

Risk Factors
- Difficult calves that require assistance is more common in calves or underconditioned calves.
- Calf scours calves are exposed to food pathogens shed by older calves in mixed-age groups or overcrowded conditions.

Proper immunity from targeted vaccination may greatly increase disease risk.

This guide provides practical approaches for the diagnosis and prevention of neonatal diarrhea in cow calf operations.

Neonatal calf diarrheae, or calf scours, is one of the most common reasons for antimicrobial use in California beef cow-calf operations, according to a 2022 survey by the California Department of Food and Agriculture. Diarrhea is also among the most common causes of death in preweaned beef calves. This guide describes opportunities for veterinarians to promote antimicrobial stewardship through judicious antibiotic use and employment of evidence-based strategies for disease prevention.
Cow Calf Bovine Respiratory Disease (BRD): Strategies for Management

Clinical Signs
- Cough
- Nasal discharge
- Reduced feed intake
- Increased water intake
- Increased rectal temperature

Pathogens
- Type and quantity of pathogens play a role in severity of disease
- SAR, PI-3, BRSV, BVDV, CV, BHV-1, H. somni, T. pyogenes, Pasteurella multocida

HOSTS
- Cows are more vulnerable to BRD after maternal antibodies decline, which varies depending on pathogen type and initial outbreaks; the teenagers (1-3 months of age)
- Male calves (both castrated and non-castrated) are at higher risk
- Calves under stress due to disease outbreaks or environmental factors, early castration is less expensive and reduces risk of disease

DEMOGRAPHIC FACTORS
- Work with your veterinarian to recognize the signs of BRD in your herd and develop a treatment protocol for your farm
- Overdose when treating potential cases can lead to improper treatment

ENVIRONMENTAL RISKS
- Rain stress contributes to disease, and can be avoided by moving cattle early in the day or during cooler seasons
- High dust levels during processing can affect the respiratory tract and immune system, making it harder for the animal to clear infection

Inadequate ventilation reduces immune function and can result in low efficacy or failure of vaccines

Inadequate colostrum intake may lead to poor immunity

Parasitism negatively impacts immunity

In addition to the risk factors above, swarming, commingling, processing, and transportation (shipping) are stressors that commonly influence BRD.

In the field, diagnoses based on clinical signs are most commonly used to come to individual treatment decisions, although the sensitivity and specificity of clinical signs for the diagnosis of BRD in weaned cattle have been estimated to be moderate, at approximately 62%. The clinical signs most frequently used to diagnose a case of BRD are depression, anorexia, respiratory signs, such as tachycardia or nasal discharge, and rectal temperature. Because most of these signs are non-specific (e.g. heat stress can elevate rectal temperature and respiratory rate, GI disease can lead to anorexia and depression), cattle displaying these signs are frequently misdiagnosed as having BRD. Submission of carcasses or tissues to a diagnostic lab to determine the pathogens involved in an outbreak can guide treatments and changes to vaccination protocols. Talk to your diagnostic lab about specific samples to submit; at a minimum, submit lung, heart, liver, kidney, and any tissues with lesions. If encephalitis is suspected as a causative agent, brain may be important to submit as well.

Bovine Respiratory Disease Management in Cow Calf Operations: A Practical Guide for Veterinarians

This guide outlines the scientific evidence for the prevention of bovine respiratory disease with a focus on cow-calf operations.

Bovine respiratory disease (BRD) is a multifactorial disease complex involving interactions between the environment, the host, and pathogens. Environmental risk factors include ambient temperature, humidity, ventilation, dust, Stress, and overfeeding, while host determinants are age, sex, weight, nutrition, breed, genetics, immune status, hydration status, and concurrent disease. Pathogens often associated with BRD include Bovine Herpesvirus-1 (BHV-1, /BR}, Bovine Respiratory Syncytial Virus (BRSV), Parainfluenza Virus 3 (PI-3), Bovine Viral Diarrhea Virus (BVDV), and Bovine Coronavirus, as well as the bacterial species Pasteurella multocida, Mannheimia haemolytica, Haemophilus somni, and Mycoplasma haemofelis. In addition to the risk factors above, swarming, commingling, processing, and transportation (shipping) are stressors that commonly influence BRD.

Environmental factors that can negatively impact immune function include high dust levels, heat stress, and stress due to disease outbreaks or environmental factors. Early castration is less expensive and reduces risk of disease. Dehydration during transport or processing can affect the respiratory tract and immune system, making it harder for the animal to clear infection.

Inadequate ventilation reduces immune function and can result in low efficacy or failure of vaccines.

Inadequate colostrum intake may lead to poor immunity.

Parasitism negatively impacts immunity.

In addition to the risk factors above, swarming, commingling, processing, and transportation (shipping) are stressors that commonly influence BRD.

Enfermedad respiratoria bovina del ternero (ERB): Estrategias de manejo

Diagnóstico

In the field, diagnoses based on clinical signs are most commonly used to come to individual treatment decisions, although the sensitivity and specificity of clinical signs for the diagnosis of BRD in weaned cattle have been estimated to be moderate, at approximately 62%. The clinical signs most frequently used to diagnose a case of BRD are depression, anorexia, respiratory signs, such as tachycardia or nasal discharge, and rectal temperature. Because most of these signs are non-specific (e.g. heat stress can elevate rectal temperature and respiratory rate, GI disease can lead to anorexia and depression), cattle displaying these signs are frequently misdiagnosed as having BRD. Submission of carcasses or tissues to a diagnostic lab to determine the pathogens involved in an outbreak can guide treatments and changes to vaccination protocols. Talk to your diagnostic lab about specific samples to submit; at a minimum, submit lung, heart, liver, kidney, and any tissues with lesions. If encephalitis is suspected as a causative agent, brain may be important to submit as well.

Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
CAHFS ANTIBIOTIC SUSCEPTIBILITY DEVELOPMENT PROCESS

An infographic guide that explains the steps involved in creating Minimum Inhibitory Concentration (MIC) data and how the MIC data is used to develop antibiograms based on the process currently utilized by the California Animal Health and Food Safety Laboratory (CAHFS).

Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
CALIFORNIA LIVESTOCK ANTIBIOGRAMS: A USER GUIDE

A guide to educate veterinary clinicians on the interpretation of antibiograms so they can be effectively used to direct empiric antibiotic selection, improve treatment outcomes, and assess antibiotic resistance prevalence and trends in California.

Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
LIVESTOCK-SPECIFIC ANTIBIOGRAMS DISTRIBUTED TO VETERINARIANS, FY 21 - 22

- Bovine practitioners: 31
- Small ruminant (sheep/goat) practitioners: 25
- Equine practitioners: 19

AUS-funded researchers developed a user-friendly tool to aid in calculating the cost of treating a case of clinical mastitis, which can help farmers make informed decisions regarding treatment protocols, culling strategies, and management practices that may result in financial gains and better animal welfare. Website: https://www.vmtrc.ucdavis.edu/clinical-mastitis-cost

Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
AUS expanded its **Veterinary Feed Directive (VFD) resource library**, compiling **four new resources for veterinarians to ensure VFD accuracy**, as well as find up-to-date information on current requirements for VFDs. AUS also updated its website to create a centralized location for veterinarians, producers, and livestock feed distributors to learn more about VFDs. **Website:** [https://www.cdfa.ca.gov/ahfss/aus/vfdresources/](https://www.cdfa.ca.gov/ahfss/aus/vfdresources/)

**Common VFD Calculations**

1. **Daily drug dose:**
   - For example: 2 mg/kg
   - Formula: \[
   \text{Daily drug dose} = \frac{\text{Drug dose/kg}}{\text{Body weight (kg)}} \times \text{Body weight (kg)}
   \]

2. **Weight of the animal (continuous):**
   - For example: 50 kg
   - Formula: \[
   \text{Weight of the animal} = \text{Weight (kg)}
   \]

3. **Volume of feed administered daily in pounds:**
   - For example: 20 lb
   - Formula: \[
   \text{Volume of feed} = \text{Volume (lb)}
   \]

**Understanding the VFD Form**

1. **Product information:**
   - **Name of product:** A helpful tool for ensuring VFD accuracy
   - **Drug:**
     - **Brand name:**
       - **Trade name:**
     - **Class of animal:**
   - **Drug label:**
     - **Label:**
     - **Packaging:**
     - **Dosage:**
   - **Schedule:**
     - **Schedule:**
     - **VFD accuracy:**
   - **Route:**
   - **Day of the week:**
   - **Type of feed:**
   - **Volume of feed:**
   - **Animal weight:**
   - **Drug concentration:**
   - **Drug form:**

**VFD Online Resources**

- [VFD Online Resources](https://www.cdfa.ca.gov/ahfss/aus/vfdresources/)
- [AVMA Resources](https://www.avma.org)
- [CDFA AUS](https://www.cdfa.ca.gov/ahfss/aus)

**Understanding the VFD Form**

A helpful tool for ensuring VFD accuracy

Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
AUS Outreach & Engagement

- **9** presentations reaching over **355** people
- **191** producers engaged across **11** studies

**Online and In-Person**
Livestock and California Prescription Drug Inspections
Inspections of retailers who sell livestock drugs to ensure compliance with California laws and regulations

**Inspection Services**
VFD Summary Report 2020 - 2021
Summary of veterinary feed directive (VFD) orders in California

- **40** veterinarians received one or more livestock antibiograms

Find AUS publications, as well as scientific research papers resulting from AUS-funded projects, on our [website](https://www.cdfa.ca.gov/ahfss/AUS/Outreach.html)

Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
Animal Management Strategies

What health promotion and infection prevention practices can be used or further developed in California to combat antimicrobial resistance and reduce antibiotic usage?

Through its academic research collaborations, veterinarian input, and voluntary stakeholder participation, AUS is continually keeping abreast of current best management practices to limit antibiotic resistance and promote animal health. Through continued review of the latest research from California, the nation, and world-wide, AUS is able to support stakeholders with the most current and effective information. The following are highlights from AUS’ work in this area during the past fiscal year.

Researchers consulted with dairy stakeholders and, paired with analysis of current quality assurance programs, recommended that additional standard operating procedures and training resources be developed, with particular emphasis on Spanish resources for on-farm decision making and treatment strategies.

Dairy Calves

Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
Infographic resources were generated to assist veterinarians and producers to optimally target infectious bovine keratitis (IBK, pinkeye), scours, and bovine respiratory disease—some of the most common conditions that lead to antibiotic use in cows and calves.

Producers responding to a survey reported decreased or no issues with respiratory, reproductive issues (excluding abortion), diarrhea, and foot rot or scald since the implementation of SB 27. Further, detailed survey results are still under analysis.

Continuing to build on previous progress, this year’s on-farm meetings with farm staff identified recordkeeping and communication gaps between shifts and individual workers. Through regular Community of Practice (CoP) meetings, alternate methods to promote communication have been discussed and implemented on-farm. The farms plan to review these alternate methods regularly to ensure improved animal health management plans that work for each individual farm.

Researchers have compiled a summary of currently available antimicrobial and alternative treatments for common disease pressures encountered on aquaculture facilities. Survey results from interviews with finfish and shellfish producers are being analyzed to produce a report of management and infection prevention practices currently used by producers.

Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
Antibiotic Sales & Use

What antibiotics are sold and how are they used in California?

The sale and use of antibiotics intended for livestock is evolving in California on an annual basis. The cooperative efforts of the Animal Health and Food Safety Services (AHFSS) and Inspection Services (IS) AUS programs provide a closer look at antibiotic sales within California through collection and analysis of veterinary feed directives (VFDs), as well as surveys of producers regarding their on-farm practices. These activities improve the understanding of the use of antibiotic drugs in livestock and guide the development of relevant materials to promote antibiotic stewardship and judicious use practices. Highlights of AUS’ work from the last fiscal year are illustrated in the infographics below.

Indications for Antibiotic Use

As Authorized in Veterinary Feed Directives (VFDs)

- Respiratory Disease (102)
- Gastrointestinal Disease (108)
- Both (303)
- Other (82)

*Number of VFDs collected for calendar year 2021. For more information, see AUS’ VFD Summary Report. Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
In a recent researcher-led study, producers indicated that, given proven efficacy of a replacement treatment of an antibiotic, they were motivated to implement this option on their farm. This indicates future approaches that demonstrate alternative treatment efficacies will be sound investments in providing additional approaches to diseases.

Results from a survey of California aquaculture producers that is underway will provide specific information about antibiotics used by California’s commercial fish producers. Sixteen producers from across the state have provided detailed information about antibiotic usage on their facilities; complete survey data will inform the creation of guidance materials for producers about common health challenges.

AUS staff reviewed and summarized Veterinary Feed Directives (VFDs) to ensure accuracy, created educational materials to facilitate the writing of VFDs, and remain available to veterinarians for outreach and education on filling out VFDs.

Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
Antibiotic Resistance

How are we looking at trends in antibiotic resistance?

In this fiscal year, AUS-funded research evaluated antibiotic resistance trends through multi-year studies and newly commissioned projects. These antibiotic resistance trends are evaluated and analyzed using both on-farm and clinical samples. Multi-year studies allow AUS to follow antibiotic resistance trends from on-farm samples collected from the same operations over time, in order to gain valuable insight into the effects of antibiotic use and other management practices on antibiotic susceptibility. These trends highlight areas where the AUS stewardship team can further identify effective resistance mitigation strategies that may be implemented by California’s livestock producers. The following are highlights from AUS’ work in this area during the past fiscal year. Please refer to the Appendix for additional detail; more information will be provided in separate publications, detailed later in this report.

A total of 219 samples were collected from participating dairy farms to create antibiograms for bovine respiratory disease (BRD) pathogens for each participating farm.

Data analyses are in progress for comparisons of the relative abundance of specific antimicrobial resistance genes that are important in animal and human health among different production systems over time.

A study of backyard poultry showed comparable levels of antibiotic resistance detected across samples from producers that did and did not report using antibiotics. For additional results, please visit: https://ucanr.edu/sites/poultry/Research_748/chickenstudy/.

Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
To date, 294 litter samples have been collected from broiler farms. Isolates of *Salmonella*, *E. Coli*, *Campylobacter* and *Enterococcus* recovered from these samples have been tested for antimicrobial susceptibility. In addition to broilers and turkeys, samples from layer operations have started to be analyzed for resistance patterns in *E. coli* and *Enterococcus*.

Results from a cross sectional study of commercial sheep showed that potentially pathogenic respiratory bacteria recovered from healthy sheep were broadly susceptible to antimicrobials frequently used to treat respiratory disease. Penicillin showed decreased susceptibility among sampled isolates.

AUS funding helped support the California Animal Health & Food Safety (CAHFS) Laboratory to perform 1,650 antimicrobial susceptibility tests for clinical samples submitted from multiple livestock sources.

AUS funding allowed the CAHFS lab to enhance its capabilities to expand genetic sequencing and more rapid assessment of antibiotic residues in milk.

AUS supports federal monitoring programs for antibiotic resistance through CAHFS’ work with USDA.

AUS is continuing to explore methods for analyzing susceptibility data, including statistical models that are capable of estimating temporal trends without requiring the use of breakpoints.

*Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.*
Communication & Engagement

*How are we reaching people and improving our outreach efforts?*

Key components of the AUS program mission include frequent communication with and education of livestock owners, livestock drug retailers, and veterinarians on the requirements of the law, which helps to foster antibiotic stewardship. AUS encourages feedback on the program’s outreach, which it uses to adapt and create resources to reach a wider audience and meet the needs of those we want to engage further in our education efforts. During FY 21 - 22, AUS prepared and presented several infographic resources in both English and Spanish to facilitate getting materials into the hands of those working directly with livestock in California. The following highlights are from AUS’ work in this topic area over the past fiscal year.
Funding opportunities

Veterinary Medical Loan Repayment Program (VMLRP)
CDFA AUS efforts in creating and maintaining a grant opportunity that was awarded to a veterinarian in a designated veterinary shortage area in Modoc County.

Veterinary Services Grant Program (VSGP)
CDFA AUS efforts in creating and maintaining a grant opportunity helped to support a veterinary practice in a designated veterinary shortage area in Siskiyou County.

AUS created continuing education opportunities for veterinarians and producers through webinars focusing on antibiograms and by contributing to the California Temporary Licensing Curriculum classes.

Council of State and Territorial Epidemiologists (CSTE)
Youth in Agriculture

Ongoing efforts in preventing zoonotic disease transmission by promoting and distributing finalized educational packages, which each include an animation, song, and instructor guide for youth (ages 5 - 8 years old), through 4-H clubs, Future Farmers of America (FFA), school districts, and city and county agricultural agencies.

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Collaboration with USDA

CDFA staff collaborated with USDA to complete phone surveys and on-farm visits for the NAHMS Health Management on U.S. Feedlots 2021 study.

As a first-in-nation comprehensive antibiotic stewardship and monitoring program, AUS contributed its expertise by providing public comments to FDA on proposed expansion and clarifications of antibiotic drugs and medicated feed, use of antibiotics in companion animals, and the indexing of drugs in minor species.

AUS has translated many of its outreach resources into Spanish in order to reach a wider audience of California livestock managers and producers.

Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.
AUS-Funded Research Publications & Presentations

*How are our researchers building upon current scientific knowledge and informing the scientific community?*

Part of AUS’ mission is to fund research projects on specific topics curated to reflect the needs of the California livestock sectors, as determined by surveys, outreach efforts, and our mandates. Peer-reviewed journal publications are critical to ensure the materials we produce are thoroughly researched, trusted by animal scientists and livestock veterinarians, and disseminated to the scientific community. AUS is excited to share these publications and poster presentations written by AUS-funded researchers that help inform solutions or future needs, and to share this knowledge with the wider scientific community. Detailed below are the publications and presentations that have been released in the 2021 - 2022 fiscal year. Of note, due to publishing cycles and timing, some of the research detailed in the publications and presentations below may have occurred in prior fiscal years. For more information, please click on the links provided.
https://doi.org/10.3390/ani12030334  
https://www.mdpi.com/2076-2615/12/3/334

*Description:* This scoping review summarizes the English scientific literature on articles about risk factors for the disease as well as ways to prevent bovine respiratory disease (BRD) that are applicable to cow-calf operations. Numerous management and animal factors have been identified as increasing the risk for BRD. Vaccinations, metaphylactic use of antibiotics, and feed supplements are areas of research into the prevention of BRD. Genetics have also been explored to determine the heritability of BRD resistance. While vaccinations and metaphylactic use of antibiotics have been evaluated in multiple systematic reviews and meta-analyses, these types of summaries are missing for commonly studied feed supplements, such as yeast and trace minerals, and the use of nitric oxide releasing substance to prevent BRD.

*Keywords:* bovine respiratory disease, prevention, risk factors, antimicrobial stewardship, shipping fever

https://doi.org/10.1371/journal.pone.0260292

*Description:* This study aimed to provide data from weaned dairy heifers regarding antimicrobial resistance in bovine respiratory isolates and identify relationships between

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*Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.*
respiratory and enteric antimicrobial drug susceptibility. A cross-sectional study was performed between June 2019 and February 2020 on six calf rearing facilities in California. Deep nasopharyngeal and rectal swabs were collected from 341 weaned heifers and submitted for selective bacterial culture and antimicrobial susceptibility testing against 19 antimicrobial drugs. *Mannheimia haemolytica*, *Pasteurella multocida*, and *Histophilus somni* were selectively isolated from respiratory samples; *Escherichia coli* and *Enterococcus spp.* were selectively isolated from rectal swabs. Antimicrobial resistance (AMR), including multidrug resistance, in respiratory isolates appears to be widespread in weaned dairy heifers; enteric bacterial susceptibility appears to have limited direct association with respiratory isolate AMR classification.

**Keywords:** *Mannheimia haemolytica*, *Pasteurella multocida*, *Histophilus somni*, *Escherichia coli*, *Enterococcus*, bovine, cattle, antimicrobial resistance, BRD


**Description:** Antibiotics have been utilized by the beef industry to improve animal health; however, the use of antibiotics may contribute to the development of antimicrobial resistance (AMR) in the bacteria of the production environment. This study characterized the fecal resistome of cattle raised in various grass-fed and grain-fed feeding systems with different management practices related to the use of antibiotics. Grass-fed systems did not receive any antibiotics, while some cattle from other conventional and grain-fed treatment groups received therapeutic antibiotics, and all cattle received monensin in their feedlot rations. The results indicated that conventional livestock feeding systems that utilized antibiotics therapeutically or prophylactically may enrich the diversity of the antibiotic resistance genes in cattle feces.

**Keywords:** antimicrobial resistance, antimicrobial resistance gene, cattle, resistome

**Description:** This study evaluated the effect of swab transport storage media, time, and storage temperature on *Mannheimia haemolytica* and *Pasteurella multocida* yield using an *in-vitro* model simulation. Semi-quantitative (quadrant model) and quantitative culture methods using colony forming units per milliliter were used to recover *M. haemolytica* and *P. multocida*. The results support the value of Aimes culture media and Cary-Blair transport agar for the recovery of *M. haemolytica* and *P. multocida* isolates, especially if the samples were not refrigerated properly. The combination of longer elapsed time and higher temperatures can impair diagnostic accuracy.

**Keywords:** *Mannheimia haemolytica*, *Pasteurella multocida*, transport media


**Description:** Neonatal calf diarrhea (NCD), also known as scours, is an important disease of preweaned calves that affects the production and welfare of beef herds. While hygiene and nutrition are important in reducing the incidence of NCD, vaccination of dams or calves is often employed for the prevention of NCD. This scoping review summarizes the available peer-reviewed scientific English literature on vaccination of dams or calves for the prevention of NCD over the past decades. In the 113 articles included in the review, vaccines tested targeted the pathogens *E. coli* (n = 43), bovine rotavirus (BRV, n = 38), *Salmonella* (n = 29), bovine coronavirus (BCV, n = 14), bovine
viral diarrhea virus (n= 7), and other pathogens (n = 8). Field trials for commercial vaccines have been published for the most important pathogens, and results on efficacy are variable for such vaccines targeting BRV, BCV, and E. coli. Meta-analyses exploring efficacy of these vaccines would be helpful to practitioners and producers. No field studies on commercial products have shown efficacy for Salmonella vaccines, so that a meta-analysis would unlikely come to a different conclusion. Further research is needed on vaccines for protozoal pathogens like Cryptosporidium parvum as well as on the importance of several emerging enteric viruses in calves.

**Keywords:** calf scours, diarrhea, enteritis, vaccine

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https://doi.org/10.3389/fvets.2022.771841 

**Description:** Many antimicrobial resistance studies in both human and veterinary medicine use traditional statistical methods that consider one bacteria and one antibiotic match at a time. A more robust analysis of antimicrobial resistance patterns in groups of animals is needed to improve on traditional methods examining antibiotic resistance profiles, or the associations between the patterns of resistance or reduced susceptibility for all isolates in an investigation. The use of Bayesian network analysis can identify associations between distributions; this investigation seeks to add to the growing body of antimicrobial resistance pattern research by using Bayesian networks to identify relationships between susceptibility patterns in Escherichia coli isolates obtained from weaned dairy heifers in California.

**Keywords:** bovine, Bayesian Network Analysis, minimum inhibitory concentration, antibiotics, antimicrobial resistance

**Description:** The goal of this study was to determine the association between quarter-level automatic milking systems and cow-level data and intramammary infection at dry-off. Data from automatic milking systems may help farmers to identify cows with intramammary infection at dry-off when individual somatic cell count is not routinely evaluated. Data from 186 cows milked in automatic milking system units from two dairies in California was obtained from August to December 2021.

**Keywords:** automatic milking systems, intramammary infections, dry-off


**Description:** Results from a survey developed and administrated by California State University, Chico, in collaboration with CDFA AUS and industry partners, to evaluate current sheep industry health management practices and antibiotic use in the California sheep industry.

**Keywords:** antibiotic use, sheep, health management, California, vaccine
Looking Ahead

What’s next?

AUS has accomplished much in FY 21 - 22 and is looking forward to continuing this success in FY 22 - 23. Several ongoing projects will have valuable results to report in the next few years. AUS continues to partner with researchers, producers, veterinarians, and other stakeholders to learn more about livestock-associated antibiotic resistance and to continue the promotion of animal and public health in California. The following highlights describe a selection of upcoming AUS projects anticipated for the next fiscal year.

**Extended Colostrum Feeding to Calves**
Quantify and determine the effect of extended colostrum feeding (up to 14 days after birth) on disease incidence, performance, and carcass characteristics during the production cycle of dairy calves raised for beef.

**VFD Collection**
Continued collection, reporting, and analysis of VFD orders.

**Antibiograms**
Continue to provide educational materials and to expand database of clinical isolates to help veterinarians apply best practices in targeting antibiotic use and to assess antibiotic resistance trends.

**VFD Outreach to Veterinarians**
Continue to provide educational outreach to veterinarians in California who may request further training and share strategies to help veterinarians incorporate best practices and improve VFD accuracy.

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*Above is a selection of highlights from the work AUS completed over FY 21 - 22; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 21 - 22.*
GETTING INVOLVED & ACKNOWLEDGEMENTS

How to Get Involved

Participation in AUS surveys and studies is voluntary! Your participation in our efforts to gather information is essential to the program’s success and ensures that the program’s work reflects what is currently happening with California livestock. If you receive a survey or an invitation to participate in one of our on-farm studies, please consider participating! Your participation provides valuable information that the program incorporates into publications and recommendations, impacting animal agriculture in California. Antibiotic resistance is a concern for both human and animal health. By working together, we can find ways to minimize the risk and preserve the effectiveness of antibiotics for the future.

For more information AUS program or to download our educational materials, please visit https://www.cdfa.ca.gov/AHFSS/aus/

• If you have feedback or would like to keep in touch, contact us: cdfa_aus@cdfa.ca.gov
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This past fiscal year was successful thanks to the dedication and support of many individuals and organizations. The AUS program would like to thank everyone who contributes to our progress. Our advisory boards and stakeholders play a key role in providing guidance and support at all stages of our research, outreach, and education efforts. Veterinarians, livestock owners, and other stakeholders are crucial to our success as they continue to participate in our studies and promote our outreach materials. We would also like to extend our gratitude to all the researchers who share their expertise with us and work each day to help us accomplish our goals.
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APPENDIX

The following pages represent high-level summaries of a selection of the studies and projects supported by AUS during FY 21 - 22. These include information regarding the purpose, design, impact, and progress for each project. Summary findings are described where appropriate, dependent upon project progress. These summary documents are meant to provide detailed background information and progress updates for AUS’ varied efforts and do not represent final reports or results for the studies included.
I. Analyzing Trends in Antimicrobial Susceptibility Data

*Investigating alternative methods for regression analysis for MIC data of bacterial bovine respiratory disease pathogens*

**Questions:** What statistical methods can effectively analyze trends in minimum inhibitory concentration (MIC) values without requiring dichotomization of the data? How do these methods compare to and complement conventional methods of regression analysis?

**Significance to CA:** The ability to analyze trends in antimicrobial susceptibility testing results, i.e., MIC values, is essential in efforts to monitor changes in antimicrobial resistance (AMR) over time. Current methods for analyzing this data commonly rely on clinical breakpoints to interpret MIC values. Since breakpoints are not always available in veterinary medicine and are also subject to change, it is crucial to identify alternative methods for analyzing trends in MIC data.

**Research Team:** This project involves collaboration between multiple subject matter experts at University of California, Davis, with research expertise in veterinary epidemiology, antimicrobial resistance, antimicrobial susceptibility testing, and related coding, modelling, and regression methods.

**Summary:** To monitor and detect AMR across bacterial samples, antimicrobial susceptibility testing is performed; one standard method for this testing produces a measure of susceptibility called an MIC. A dataset containing MIC results is typically analyzed by using clinical breakpoints to dichotomize the MIC values into “susceptible” and “resistant” categories and then applying a logistic regression. In veterinary medicine, particularly among livestock animals, there are not always established clinical breakpoints to serve as interpretive criteria for this dichotomization. Additionally, reducing quantitative MIC measurements to a binary variable (two categories) disregards much of the information available in an MIC dataset. Thus, it is critical to investigate new analysis methods that do not rely on clinical breakpoints and to also take advantage of the quantitative nature of MIC data. This project aims to evaluate the utility of accelerated failure time (AFT) regression models and a more flexible model under development to fill this need. Bovine respiratory disease (BRD) represents one of the largest threats to the health of feedlot cattle and pre-weaned dairy cattle. This project will apply the best-performing candidate models to a dataset of MIC values from bacterial pathogens commonly associated with BRD.

**Study Progress:** Approximately 800 BRD isolates have been selected from banked isolates (2010 - 2021) at the CAHFS Laboratory System for inclusion in the study analysis. Coding for simulating MIC datasets for AFT model fitting and model development is also underway.

**How This Helps AUS:** Monitoring AMR in bacteria associated with California’s livestock is a core component of the AUS program’s mandate. This work will investigate alternate methods for analyzing AMR data that address gaps in conventional approaches, can be applied moving forward for consistent analysis of trends over time, and may be able to more effectively identify emerging resistance.

**Next Steps:** Antimicrobial susceptibility testing will be performed on the bacterial isolates identified for this project to generate a dataset of BRD MICs. Coding and simulations will continue to develop an algorithm and package for fitting the models and analysis of data. Best-performing AFT regression models will be applied to the BRD dataset and compared with conventional logistic regression analysis.
II. Preweaned Dairy Calf Health Management in California

Assess management practices, antibiotic resistance, and bacteria counts of colostrum and milk

Questions: Are there differences in preweaned calf management between calves raised on conventional and organic dairies? What is the final disposition of bull and heifer calves that receive antibiotics on organic dairies? What is the antimicrobial sensitivity profile of pathogenic bacteria found in colostrum and milk fed to preweaned calves on conventional and organic dairies that relate to antimicrobial drug use in California?

Significance to CA: Currently, national surveys of dairy cattle producers have shown that treatment of mastitis in lactating and dry cows, as well as diarrhea and respiratory diseases in calves, are the most common reported uses of antimicrobial drugs. Within California, conventional dairies have reported that treating calves is the most frequent indication for antimicrobial use. Few studies have reported on antimicrobial drug use, alternatives to antimicrobials that are used, or the fate of preweaned heifer and bull calves that receive antimicrobial treatment on organic dairies. Therefore, preweaned calves represent a target population for investigations to understand how management practices may impact antimicrobial use and resistance. Representative studies of California farms describing preweaned dairy calf management practices, including both heifer and bull calves in both conventional and organic dairies, are limited. In addition, little has been published about management practices on organic dairies in California or elsewhere. This proposed study will focus on both conventional and organic dairies to fill the knowledge gap on potential preweaning management factors associated with antimicrobial drugs (AMD) use or alternatives to AMDs.

Research Team: University of California, Davis researchers and University of California Cooperative Extension specialists with extensive experience with calf health, dairy cattle, management practices, and antibiotic resistance.

Summary: This study has two objectives. The first objective is to collect data on preweaned dairy calf health management practices on conventional and organic dairies through surveys, calf health records, and collection of biological samples. The second objective will compare the management practices between conventional and organic dairies in California to investigate potential associations with calf health outcomes, antimicrobial drug use, and phenotypic antimicrobial resistance in waste milk and colostrum.

Study Progress: The research team is working with University of California Cooperative Extension Specialists to identify farms for participation. Researchers are also developing survey tools to collect accurate information from participating farms. Trainings are under development to standardize sample collection across sites.

How This Helps AUS: The data from this study will serve as a baseline for potential interventional approaches to improve antimicrobial use and stewardship for heifers and bull calves in the future. Results from this study are expected to generate recommendations for improving calf health, reducing antimicrobial drug use and resistance, and fostering antimicrobial stewardship.

Next Steps: Surveys and sample collection are scheduled to begin in 2023 on participating farms. The researchers will develop data collection tools to be used on farms. Survey results will be combined with laboratory results from participating farms to investigate the association between management factors and antimicrobial resistance in waste milk and colostrum. Results from evaluations will be summarized to inform potential interventions on conventional and organic farms that could impact the levels of antimicrobial resistance in waste milk and colostrum samples fed to calves raised in California under different management practices.