ANNUAL REPORT 2022

AUS ANTIMICROBIAL USE AND STEWARDSHIP

cdfa

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Suggested citation:
California Department of Food and Agriculture. Antimicrobial Use and Stewardship Program Annual Report 2022. Sacramento, California, 2022.

To access this report online: https://www.cdfa.ca.gov/ahfss/AUS/

TABLE OF CONTENTS

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REPORT & PROGRAM SCOPE

2022 Annual Report

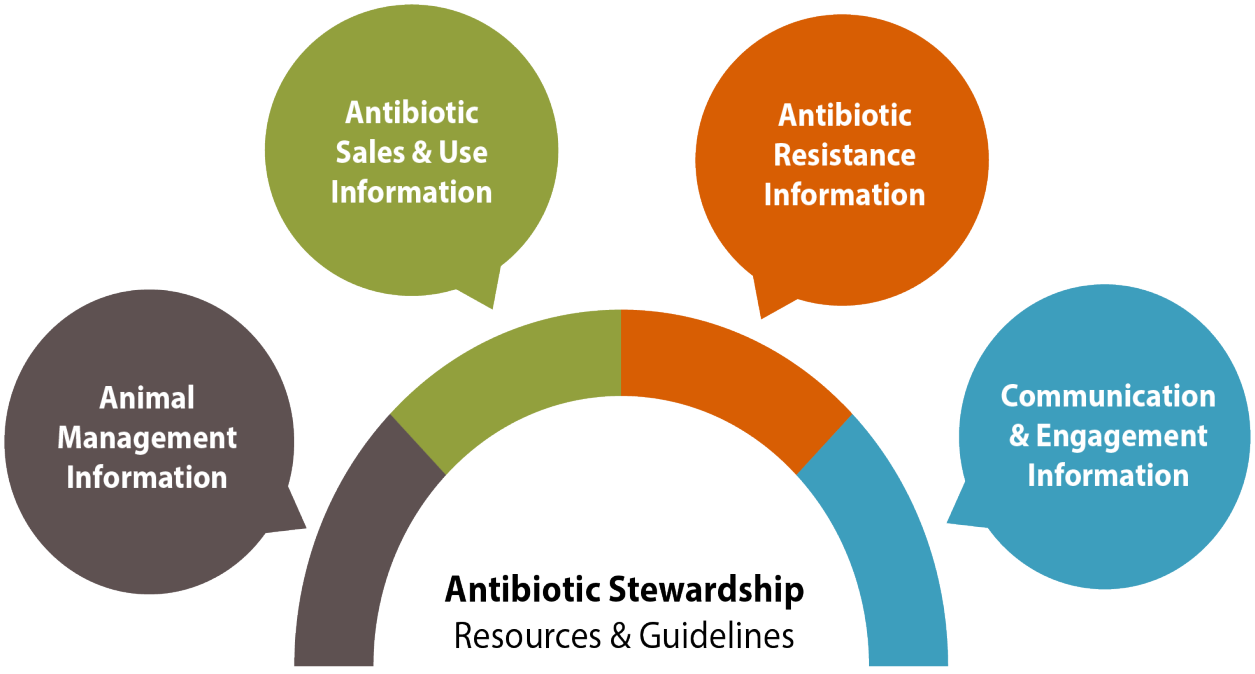
The California Department of Food and Agriculture (CDFA) Antimicrobial Use and Stewardship (AUS) program reports annually on the program's priorities and accomplishments. This AUS 2022 Annual Report focuses on the 2021 - 2022 fiscal year (FY 21 - 22), spanning July 1, 2021 - June 30, 2022. This report 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.

PROGRAM HIGHLIGHTS

Program Products

What materials and information have we produced?

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.

COW CALF DISEASE MANAGEMENT RESOURCES

Infographic aids to provide direction for producers and veterinarians to assist with the detection, prevention and management for each of the top three diseases that can lead to antibiotic use in cow calf operations.

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Pinkeye Management in Cow Calf Operations: A Practical Guide for Veterinarians

Based on results of the scoping review: Dr. Gaby Maier; Sheedy et al. 10.1016/j.animal.2021.10024

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. [1] 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** [2]
   - A. **Signalment**
     - i. Calves are more frequently affected compared to older cattle [3-5]
     - ii. Lack of eyelid pigmentation (Hereford breed) predisposes cattle to IBK [6, 7]
   - B. **Environmental factors**
     - Warm months with increased sunlight and prevalence of face flies increases the risk of transmission

Cow Calf Pinkeye: Strategies for Management

References: Sheedy et al. 10.1016/j.animal.2021.10024

Also known as bovine keratoconjunctivitis (IBK)

Signs:
- Tearing
- Closed or squinted eye
- Reddening of the white part of the eye
- Eye ulcers

Possible consequences:
- Slower rate of weight gain due to pain
- Production loss
- Cost of treatment

GENERAL STRATEGY

Consider the logistics of management and the **costs** of treating pinkeye (expense, labor) while making a strategic **plan with your veterinarian** for reducing pinkeye in your herd

RISK FACTORS

Age	Calves are affected more often than older cattle
Breed	Hereford cattle are more at risk due to lack of pigment around their eyes
Season	Warm months and increased sunlight favor infection
Flies	Face flies increase the risk of pinkeye

Conjuntivitis bovina: Estrategias de manejo

Referencias: Sheedy et al. 10.1016/j.animal.2021.10024

También conocida como queratoconjuntivitis bovina (QIB)

Signos:
- Lagrimeo
- Ojo cerrado o entrecerrado
- Enrojecimiento de la parte blanca del ojo
- Úlceras oculares

Posibles consecuencias:
- Menor tasa de aumento de peso debido al dolor
- Pérdida de producción
- Costo del tratamiento

ESTRATEGIA GENERAL

Considere la logística del manejo y los **costos** del tratamiento de la conjuntivitis (gastos, mano de obra) mientras elabora un plan estratégico **con su veterinario** para reducir la conjuntivitis en su rebaño

FACTORES DE RIESGO

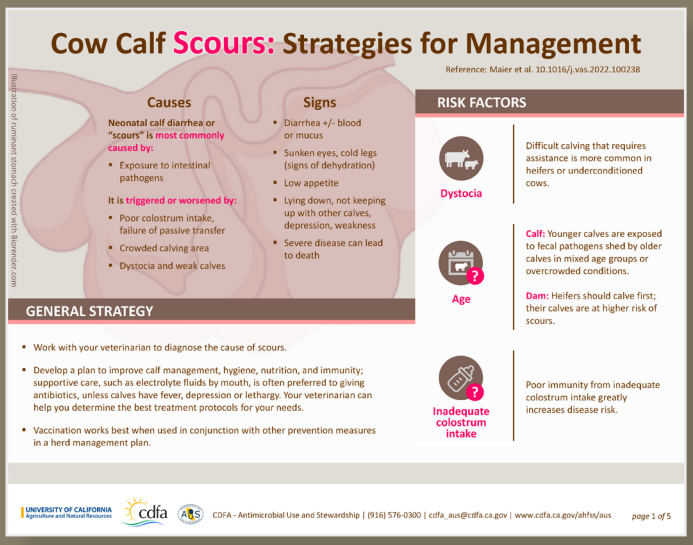
Edad	Los terneros se ven afectados con más frecuencia que el ganado mayor
Raza	El ganado Hereford corre más riesgo debido a la falta de pigmento alrededor de los ojos
Temporada	Los meses cálidos y el aumento de la luz solar favorecen las infecciones
Moscas	Las moscas de la cara aumentan el riesgo de padecer conjuntivitis

PINKEYE

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 DISEASE MANAGEMENT RESOURCES

SCOURS



Cow Calf Scours: Strategies for Management

Reference: Maier et al. 10.1016/j.vas.2022.100238

Causes

Neonatal calf diarrhea or "scours" is most commonly caused by:

- Exposure to intestinal pathogens

It is triggered or worsened by:

- Poor colostrum intake, failure of passive transfer
- Crowded calving area
- Dystocia and weak calves

Signs

- Diarrhea +/- blood or mucus
- Sunken eyes, 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

Dystocia

Difficult calving that requires assistance is more common in heifers or underconditioned cows.

Age

Calf: Younger calves are exposed to fecal pathogens shed by older calves in mixed age groups or overcrowded conditions.

Dam: Heifers should calve first; their calves are at higher risk of scours.

Inadequate colostrum intake

Poor immunity from inadequate colostrum intake greatly increases disease risk.

GENERAL STRATEGY

- Work with your veterinarian to diagnose the cause of scours.
- Develop a plan to improve calf management, hygiene, nutrition, and immunity; supportive care, such as electrolyte fluids by mouth, is often preferred to giving antibiotics, unless calves have fever, depression or lethargy. Your veterinarian can help you determine the best treatment protocols for your needs.
- Vaccination works best when used in conjunction with other prevention measures in a herd management plan.

Diarrea neonatal de los terneros: Estrategias de manejo

Referencia: Maier et al. 10.1016/j.vas.2022.100238

Causas

La diarrea neonatal de los terneros o "scours" es más comúnmente causada por:

- Exposición a patógenos intestinales

Se desencadena o empeora por:

- Ingesta deficiente de calostro, fallo en la transferencia pasiva
- Zona de partos lleno
- Distocia y terneros débiles

Signos

- Diarrea +/- sangre o mucosidad
- Ojos hundidos, piernas frías (signos de deshidratación)
- Poco apetito
- Acostarse, no mantenerse al día con otros terneros, depresión, debilidad
- Las enfermedades graves pueden provocar la muerte

FACTORES DE RIESGO

Distocia

Los partos difíciles que requieren asistencia son más comunes en las novillas o en las vacas de baja condición.

Edad

Ternero: Los terneros más jóvenes están expuestos a los patógenos fecales que desprenden los terneros de más edad en grupos de edad mixtos o en condiciones de hacinamiento.

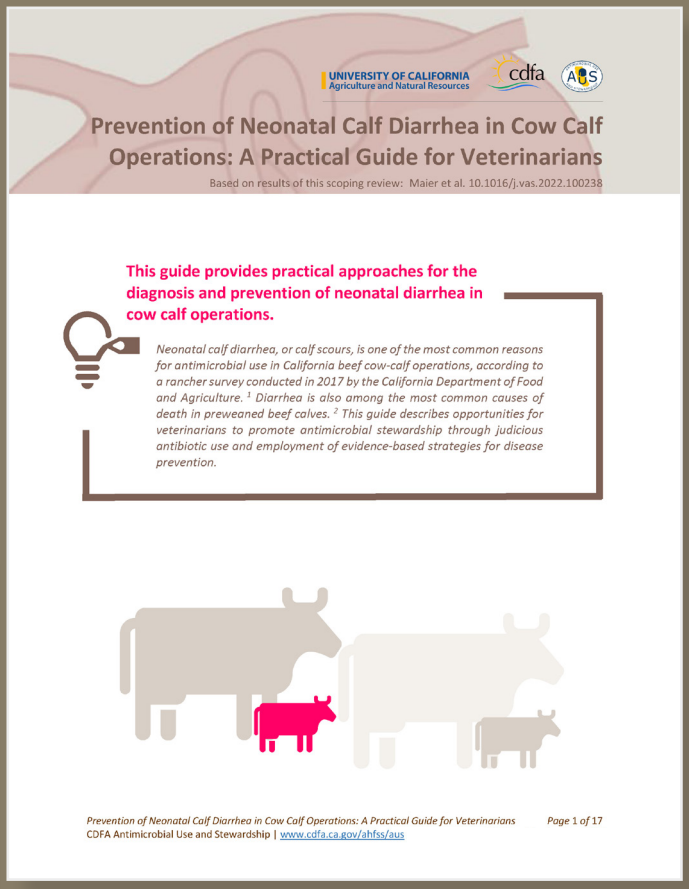
Presa: Las novillas deben parir primero; sus terneros tienen mayor riesgo de sufrir diarrea.

Inadecuada ingesta de calostro

Una inmunidad deficiente debida a una ingesta inadecuada de calostro aumenta en gran medida el riesgo de enfermedad.

ESTRATEGIA GENERAL

- Trabaje con su veterinario para diagnosticar la causa de la diarrea.
- Desarrolle un plan para mejorar el manejo, la higiene, la nutrición y la inmunidad de los terneros; los cuidados de apoyo, como los líquidos electrolíticos por vía oral, suelen ser preferibles a la administración de antibióticos, a menos que los terneros tengan fiebre, depresión o letargo. Su veterinario puede ayudarle a determinar los mejores protocolos de tratamiento para sus necesidades.
- La vacunación funciona mejor cuando se utiliza junto con otras medidas de prevención en un plan de manejo del hato.



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Prevention of Neonatal Calf Diarrhea in Cow Calf Operations: A Practical Guide for Veterinarians

Based on results of this scoping review: Maier et al. 10.1016/j.vas.2022.100238

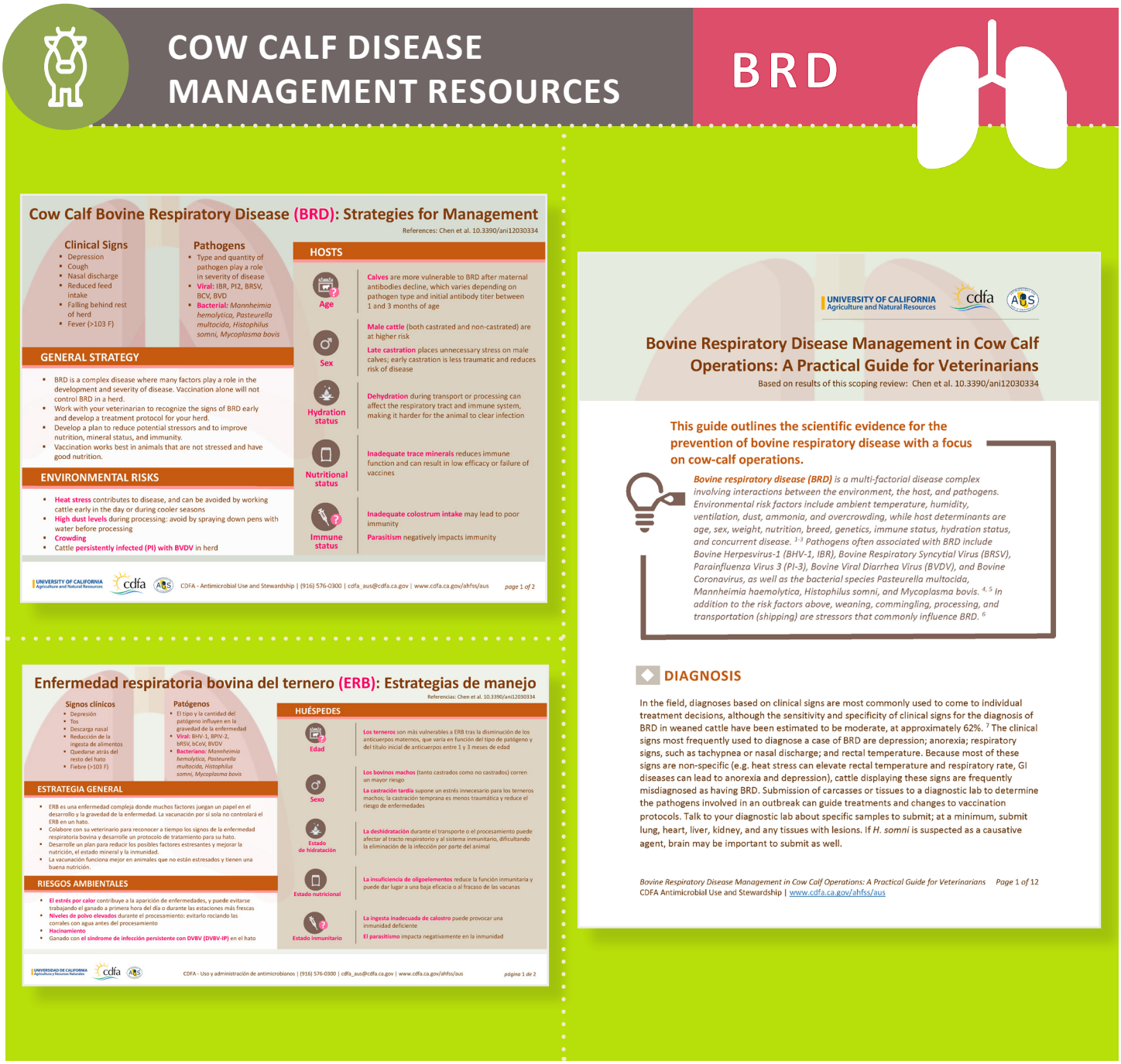
This guide provides practical approaches for the diagnosis and prevention of neonatal diarrhea in cow calf operations.

Neonatal calf diarrhea, or calf scours, is one of the most common reasons for antimicrobial use in California beef cow-calf operations, according to a rancher survey conducted in 2017 by the California Department of Food and Agriculture.[1] Diarrhea is also among the most common causes of death in preweaned beef calves.[2] This guide describes opportunities for veterinarians to promote antimicrobial stewardship through judicious antibiotic use and employment of evidence-based strategies for disease prevention.

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 DISEASE MANAGEMENT RESOURCES

BRD



Cow Calf Bovine Respiratory Disease (BRD): Strategies for Management

References: Chen et al. 10.3390/ani12030334

Clinical Signs
- Depression
- Cough
- Nasal discharge
- Reduced feed intake
- Falling behind rest of herd
- Fever (>103 F)

Pathogens
- Type and quantity of pathogen play a role in severity of disease
- **Viral:** IBR, PI2, BRSV, BCV, BVD
- **Bacterial:** *Mannheimia hemolytica, Pasteurella multocida, Histophilus somni, Mycoplasma bovis*

GENERAL STRATEGY
- BRD is a complex disease where many factors play a role in the development and severity of disease. Vaccination alone will not control BRD in a herd.
- Work with your veterinarian to recognize the signs of BRD early and develop a treatment protocol for your herd.
- Develop a plan to reduce potential stressors and to improve nutrition, mineral status, and immunity.
- Vaccination works best in animals that are not stressed and have good nutrition.

ENVIRONMENTAL RISKS
- **Heat stress** contributes to disease, and can be avoided by working cattle early in the day or during cooler seasons
- **High dust levels** during processing: avoid by spraying down pens with water before processing
- **Crowding**
- Cattle **persistently infected (PI) with BVDV** in herd

HOSTS

Age — **Calves** are more vulnerable to BRD after maternal antibodies decline, which varies depending on pathogen type and initial antibody titer between 1 and 3 months of age

Sex — **Male cattle** (both castrated and non-castrated) are at higher risk. **Late castration** places unnecessary stress on male calves; early castration is less traumatic and reduces risk of disease

Hydration status — **Dehydration** during transport or processing can affect the respiratory tract and immune system, making it harder for the animal to clear infection

Nutritional status — **Inadequate trace minerals** reduces immune function and can result in low efficacy or failure of vaccines

Immune status — **Inadequate colostrum intake** may lead to poor immunity. **Parasitism** negatively impacts immunity

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

Referencias: Chen et al. 10.3390/ani12030334

Signos clínicos
- Depresión
- Tos
- Descarga nasal
- Reducción de la ingesta de alimentos
- Quedarse atrás del resto del hato
- Fiebre (>103 F)

Patógenos
- El tipo y la cantidad del patógeno influyen en la gravedad de la enfermedad
- **Viral:** BHV-1, BPIV-2, bRSV, bCoV, BVDV
- **Bacteriano:** *Mannheimia hemolytica, Pasteurella multocida, Histophilus somni, Mycoplasma bovis*

ESTRATEGIA GENERAL
- ERB es una enfermedad compleja donde muchos factores juegan un papel en el desarrollo y la gravedad de la enfermedad. La vacunación por sí sola no controlará el ERB en un hato.
- Colabore con su veterinario para reconocer a tiempo los signos de la enfermedad respiratoria bovina y desarrolle un protocolo de tratamiento para su hato.
- Desarrolle un plan para reducir los posibles factores estresantes y mejorar la nutrición, el estado mineral y la inmunidad.
- La vacunación funciona mejor en animales que no están estresados y tienen una buena nutrición.

RIESGOS AMBIENTALES
- **El estrés por calor** contribuye a la aparición de enfermedades, y puede evitarse trabajando el ganado a primera hora del día o durante las estaciones más frescas
- **Niveles de polvo elevados** durante el procesamiento: evitarlo rociando las corrales con agua antes del procesamiento
- **Hacinamiento**
- Ganado con **el síndrome de infección persistente con DVBV (DVBV-IP)** en el hato

HUÉSPEDES

Edad — **Los terneros** son más vulnerables a ERB tras la disminución de los anticuerpos maternos, que varía en función del tipo de patógeno y del título inicial de anticuerpos entre 1 y 3 meses de edad

Sexo — **Los bovinos machos** (tanto castrados como no castrados) corren un mayor riesgo. **La castración tardía** supone un estrés innecesario para los terneros machos; la castración temprana es menos traumática y reduce el riesgo de enfermedades

Estado de hidratación — **La deshidratación** durante el transporte o el procesamiento puede afectar al tracto respiratorio y al sistema inmunitario, dificultando la eliminación de la infección por parte del animal

Estado nutricional — **La insuficiencia de oligoelementos** reduce la función inmunitaria y puede dar lugar a una baja eficacia o al fracaso de las vacunas

Estado inmunitario — **La ingesta inadecuada de calostro** puede provocar una inmunidad deficiente. **El parasitismo** impacta negativamente en la inmunidad

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

UNIVERSITY OF CALIFORNIA Agriculture and Natural Resources · cdfa · AUS

Based on results of this scoping review: Chen et al. 10.3390/ani12030334

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 multi-factorial disease complex involving interactions between the environment, the host, and pathogens. Environmental risk factors include ambient temperature, humidity, ventilation, dust, ammonia, and overcrowding, while host determinants are age, sex, weight, nutrition, breed, genetics, immune status, hydration status, and concurrent disease.* [1-3] *Pathogens often associated with BRD include Bovine Herpesvirus-1 (BHV-1, IBR), 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, Histophilus somni, and Mycoplasma bovis.* [4, 5] *In addition to the risk factors above, weaning, commingling, processing, and transportation (shipping) are stressors that commonly influence BRD.* [6]

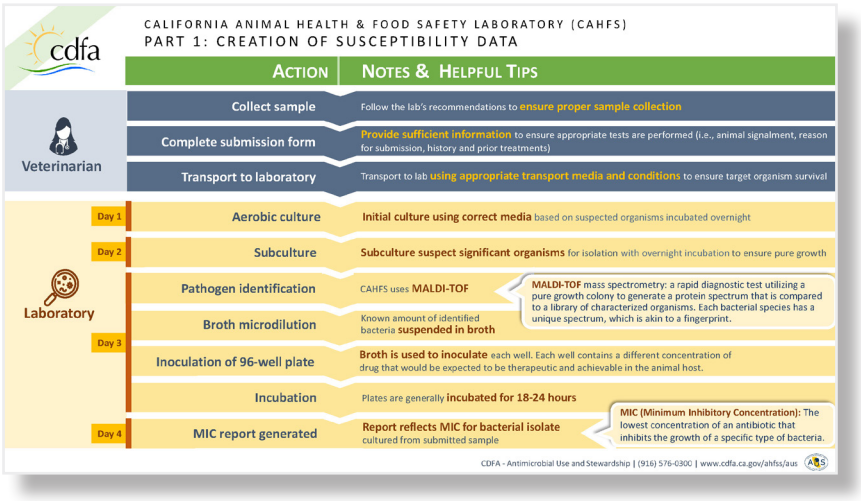
DIAGNOSIS

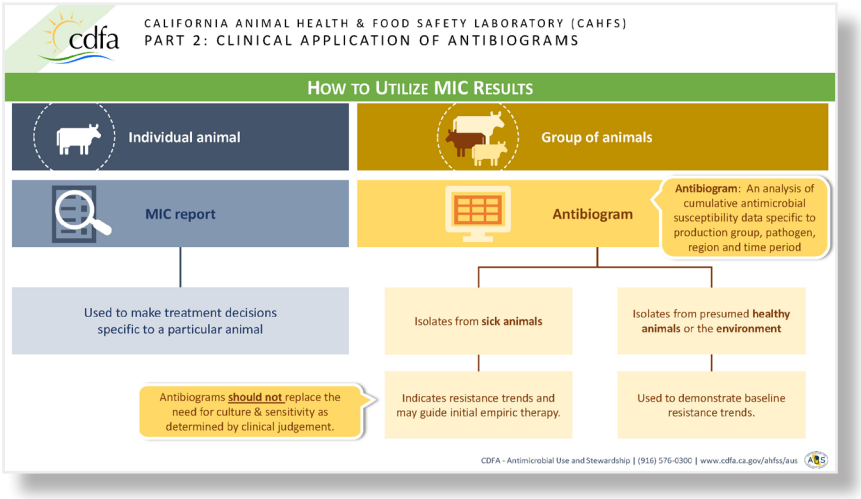
In the field, diagnoses based on clinical signs are most commonly used to come to individual treatment decisions, although the sensitivity and specificity of clinical signs for the diagnosis of BRD in weaned cattle have been estimated to be moderate, at approximately 62%. [7] The clinical signs most frequently used to diagnose a case of BRD are depression; anorexia; respiratory signs, such as tachypnea 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 diseases 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 *H. somni* 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 ANTIBIOGRAM 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).





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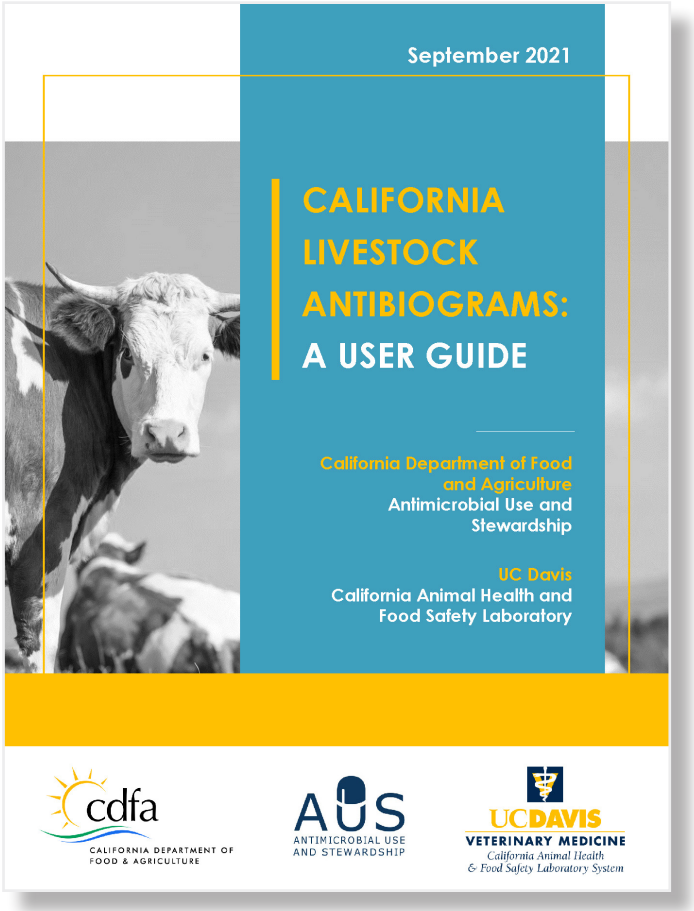
CALIFORNIA LIVESTOCK ANTIBIOGRAMS: A USER GUIDE



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.

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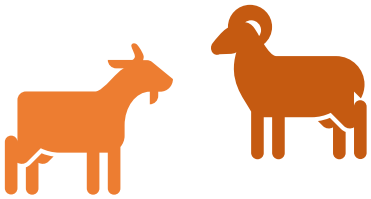
LIVESTOCK-SPECIFIC ANTIBIOGRAMS DISTRIBUTED TO VETERINARIANS, FY 21 - 22

Bovine practitioners

31

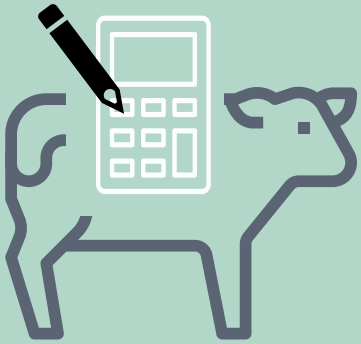


Small ruminant (sheep/goat) practitioners

25

Equine practitioners

19

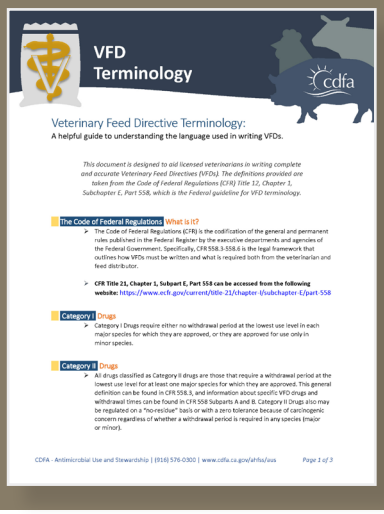


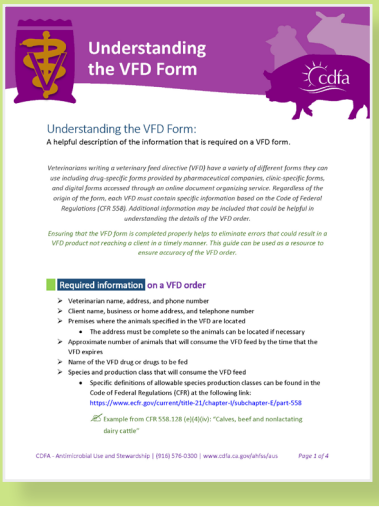
AUS-funded researchers developed a **user-friendly tool** to **aid in calculating the cost of treating a case of clinical mastitis,** which can help farmers make informed decisions regarding treatment protocols, culling strategies, and management practices that may result in financial gains and better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

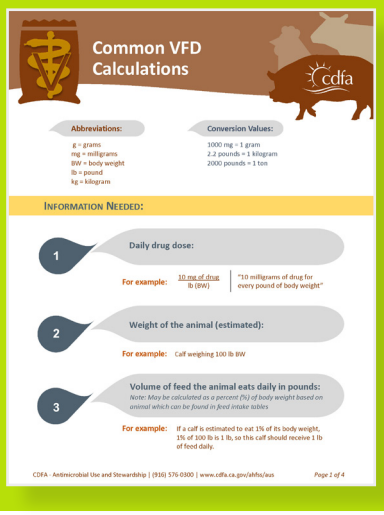
Website: https://www.vmtrc.ucdavis.edu/clinical-mastitis-cost

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 distributers to learn more about VFDs. Website: https://www.cdfa.ca.gov/ahfss/aus/vfdresources/







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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

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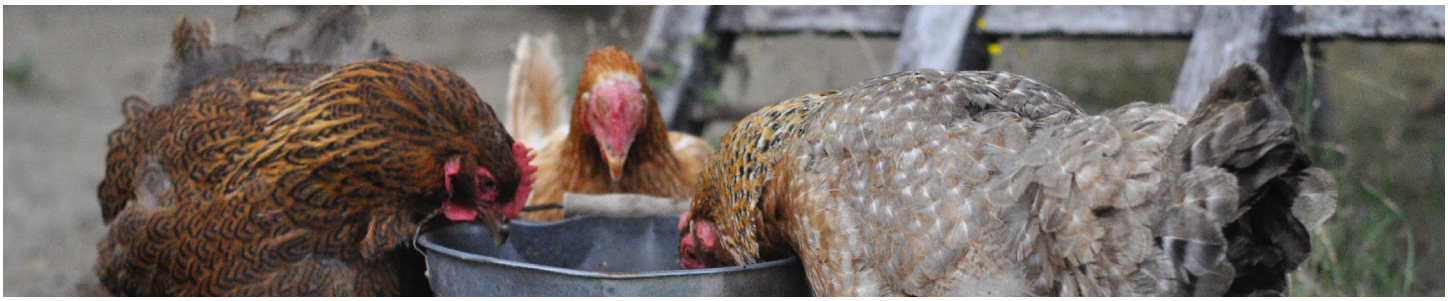

Animal Management Strategies

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.

Dairy Calves

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.

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.

Beef Cattle

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.

Commercial Sheep

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.

Community of Practice

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.

Aquaculture

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.*

Commercial Sheep

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.

Aquaculture

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.

VFD Outreach

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.

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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.

Dairy Cows

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

Beef Cattle

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.

Backyard Poultry

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/.

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Commercial Poultry

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*.

Commercial Sheep

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.

CAHFS Testing

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.

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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.

AUS continued its **national engagement** through placement on USDA NIFA's Veterinary Medicine Loan Repayment Plan national review panel.

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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.

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Chen, S.-Y.; Negri Bernardino, P.; Fausak, E.; Van Noord, M.; Maier, G. (2022) Scoping Review on Risk Factors and Methods for the Prevention of Bovine Respiratory Disease Applicable to Cow-Calf Operations. Animals, 12, 334.
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

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Depenbrock S, Aly S, Wenz J, Williams D, ElAshmawy W, Clothier K, et al. (2021) In-vitro antibiotic resistance phenotypes of respiratory and enteric bacterial isolates from weaned dairy heifers in California. PLoS ONE 16(11): e0260292.
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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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

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Feng, Y., Yang, L., Klopatek, S., Oltjen, J., Yang., X. (2022, June). The fecal resistome of beef cattle from conventional grain-fed and grass-fed systems in the western United States. Poster presentation at the 75th Reciprocal Meat Conference hosted by American Meat Science Association. Des Moines, IA.

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

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Garzon, A., Hoyos-Jaramillo, A., Hustad, S., Byrne, B.A., Fritz, H.M., and Pereira, R. (2022, June). Evaluating factors affecting recovery of *Mannheimia haemolytica* and *Pasteurella multocida*. Oral presentation at the 2022 American Dairy Science Association Meeting. Kansas City, MO.

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

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Maier, G, Breitenbuecher J, Gomez JP, Samah F, Fausak E, Van Noord M (2022). Vaccination for the Prevention of Neonatal Calf Diarrhea in Cow-Calf Operations: A Scoping Review. Veterinary and Animal Science, Volume 15: 100238, ISSN 2451-943X, https://doi.org/10.1016/j.vas.2022.100238.
https://www.sciencedirect.com/science/article/pii/S2451943X22000096

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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Morgan, B L, Depenbrock, S, Martinez-Lopez, B. Identifying Associations in Minimum Inhibitory Concentration Values of *Escherichia coli* Samples Obtained from Weaned Dairy Heifers in California using Bayesian Network Analysis. (2022) Frontiers in Veterinary Science, Vol. 9, ISSN: 2297-1769.
https://doi.org/10.3389/fvets.2022.771841
https://www.frontiersin.org/articles/10.3389/fvets.2022.771841/full

Descrip ion: 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

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Ongom, J., Okello, E., McFarlan, K., and Ferreira, F. (2022, June). Association between milking and cow parameters and intramammary infections at dry-off in automatic milking systems. Oral presentation at the 2022 American Dairy Science Association Annual Meeting, Kansas City, MO.

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

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Phillips, C.R., Cardin, J. L., Lopez, E., Silva, M., Lorenz, C., Busch, R., Patton, W., Macon, D., VanLangingham, M., Pettey, L. A. and Issacs, K., (2021, August). California Sheep Producer Survey Results on Health Management and Antibiotic Use. Presented at the 2021 California Wool Growers Association meeting.

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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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

Acknowledgements

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.

Special Thanks

AUS would like to give special thanks to the following individuals who contributed to this annual report:

Dr. Sharif Aly	*University of California, Davis*
Dr. Rosie Busch	*University of California, Davis*
Dr. Pedro Carvalho	*University of California, Davis*
Dr. Munashe Chigerwe	*University of California, Davis*
Dr. Sarah Depenbrock	*University of California, Davis*
Dr. Fernanda Ferreira	*formerly with University of California, Davis*
Dr. Heather Fritz	*California Animal Health and Food Safety Laboratory System*
Dr. Jackson Gross	*University of California, Davis*
Dr. Meera Heller	*University of California, Davis*
Dr. Ashley Hill	*California Animal Health and Food Safety Laboratory System*
Dr. Todd Kelman	*University of California, Davis*
Dr. Terry Lehenbauer	*University of California, Davis*
Dr. Gaby Maier	*University of California, Davis*
Alec Michael, Ph.D. candidate	*University of California, Davis*
Brittany Morgan, Ph.D. candidate	*University of California, Davis*
Dr. Emmanuel Okello	*University of California, Davis*
Dr. James Oltjen	*University of California, Davis*
Dr. Richard Pereira	*University of California, Davis*
Dr. Celina Phillips	*California State University, Chico*
Dr. Maurice Pitesky	*University of California, Davis*
Dr. Noelia Silva del Rio	*University of California, Davis*
Dr. Randall Singer	*University of Minnesota*
Dr. Martin Smith	*University of California, Davis*
Alex Wright, Ph.D. student	*University of California, Davis*
Dr. Xiang (Crystal) Yang	*University of California, Davis*
Project Staff	*NAHMS Health Management on U.S. Feedlots 2021 study*

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.