Antimicrobial Use and Stewardship

AUS

ANNUAL REPORT 2025

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California Department of Food and Agriculture - Antimicrobial Use and Stewardship

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Thank You

AUS would like to thank the **California Legislature** for the foresight to create our first-in-nation program and to protect the efficacy of antimicrobial drugs. Our progress and success is a direct outcome from the trust and support from our leaders, lawmakers, and stakeholders.

Thank you to **livestock producers and veterinarians** who participate in our studies voluntarily and assist with our monitoring and stewardship efforts that contribute to the success of our program.

&

AUS would like to express its gratitude to **Dr. Annette Jones** for her incredible leadership and mentorship since the inception of the AUS program. It has been an honor to work under her trusted guidance, empowering AUS to have many early successes and establish itself as a one-of-a-kind leader in the AMR landscape. We appreciate her deep dedication to California's livestock, agricultural stakeholders, and scientific discovery. We wish her well in her much-deserved retirement.

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AUS
ANTIMICROBIAL USE AND STEWARDSHIP

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A REPORT & PROGRAM SCOPE

2025 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 2025 Annual Report focuses on the 2024-2025 fiscal year (FY 24-25), spanning July 1, 2024 - June 30, 2025. This report continues the practice of informing legislators and stakeholders about the program's leadership 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 its 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 Agricultural Code [FAC] Sections 14400-14408). The AUS program consists of a team of veterinarians, epidemiologists, and specialists working collaboratively to support California's agricultural stakeholders.

Like the experience of many stakeholders, FY 24-25 brought several unexpected changes and challenges for livestock producers, AUS, and the State of California. Response to the influenza A H5N1 virus infections in poultry (causing highly pathogenic avian influenza, HPAI) and in dairy cows

brought together a united front, including staff from both CDFA and USDA, to tackle the highly infectious disease head-on. With the combined expertise of varied emergency personnel, veterinarians, and epidemiologists, the dynamic situation continues to be handled in a targeted and swift manner. AUS staff have assisted with epidemiology, biosecurity, environmental sampling, and real-time mapping of the outbreak, as well as research coordination of USDA-funded, H5N1-specific projects. AUS is fortunate to have staff with the expertise and experience needed to manage and support this innovative research that will yield California-specific results while contributing to the wider scientific understanding of this disease and its spread. To learn more about these unique efforts this FY, please see the “Special Section—H5N1 Research Projects” included at the end of this year’s Annual Report.

While continuing its involvement on several key national committees and panels, AUS has also spent significant time working on the needs of California’s rural communities that have veterinary shortages with its support of national programs such as the Veterinary Medical Loan Repayment Program (VMLRP) and the Veterinary Services Grant Program (VSGP). Although changes in the federal funding landscape resulted in these national programs being placed on hold in February 2025, AUS continues to respond to and support stakeholders in rural communities that seek help with their veterinary shortages.

In addition to fulfilling programmatic objectives while assisting with the H5N1 outbreak, AUS is proud of its contributions over the past fiscal year to support California's animal and public health. Through current and ongoing projects, outreach, and partnerships with academic researchers, livestock producers, and collaborating agencies, AUS has continued to support animal health and food safety and security in California.

The following sections in this report provide a description of the AUS program’s work and accomplishments during FY 24-25, including select highlights from various projects.

B PROGRAM HIGHLIGHTS

Program Products

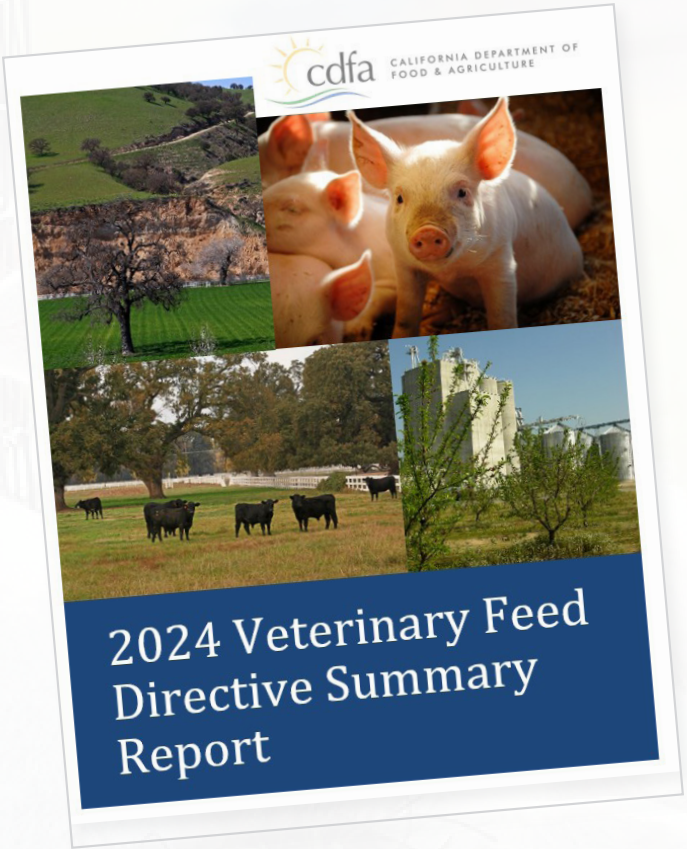
What materials and information have been produced?

The AUS program has produced and distributed various materials and educational resources to advance antibiotic stewardship. 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 from livestock producers, veterinarians, and other stakeholders through data collection, training, educational outreach, and engagement efforts.

AUS' VFD Summary Report Issued by Inspection Services

Summary of veterinary feed directive (VFD) orders in California.

https://www.cdfa.ca.gov/is/ffldrs/pdfs/vfd_summary_report_2024.pdf



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Collaboration with CDFA's Meat, Poultry and Egg Safety Branch

In collaboration with CDFA's Meat, Poultry and Egg Safety (MPES) Branch, AUS has produced a 1-page flyer for licensed industry livestock and poultry meat inspectors, to educate them on the differences between **antibiotic resistance** versus **antibiotic residues** and the importance of **responsible antibiotic use** and **food safety.** This flyer was distributed and is available online in English, Spanish, and two-sided English-Spanish.

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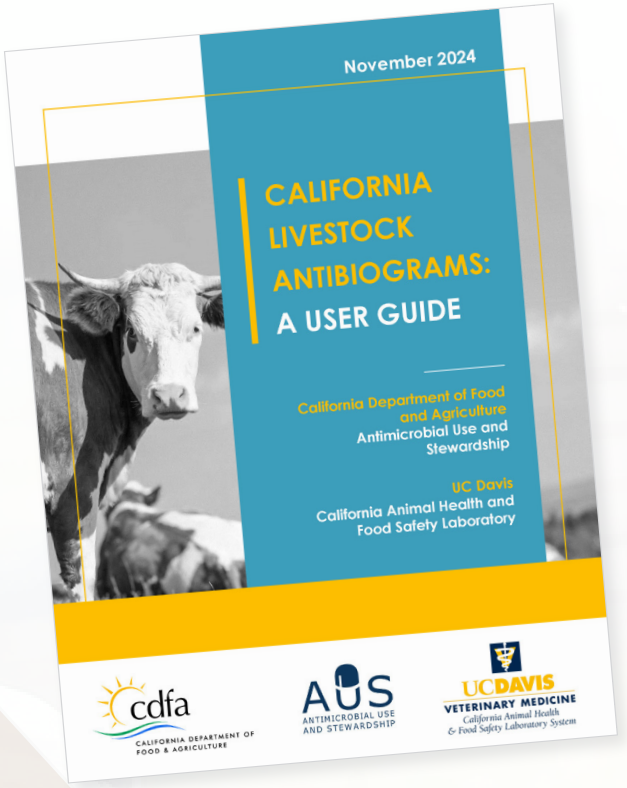

Updated Guidance for Antibiogram Use and Telemedicine

Ongoing guidance to veterinarians regarding the use of, and decision-making for, antibiograms in clinical situations. Existing materials were amended to include clarifying guidance on the changing landscape of veterinary telemedicine in California.

https://www.cdfa.ca.gov/AHFSS/AUS/docs/AntibiogramUserGuide.pdf

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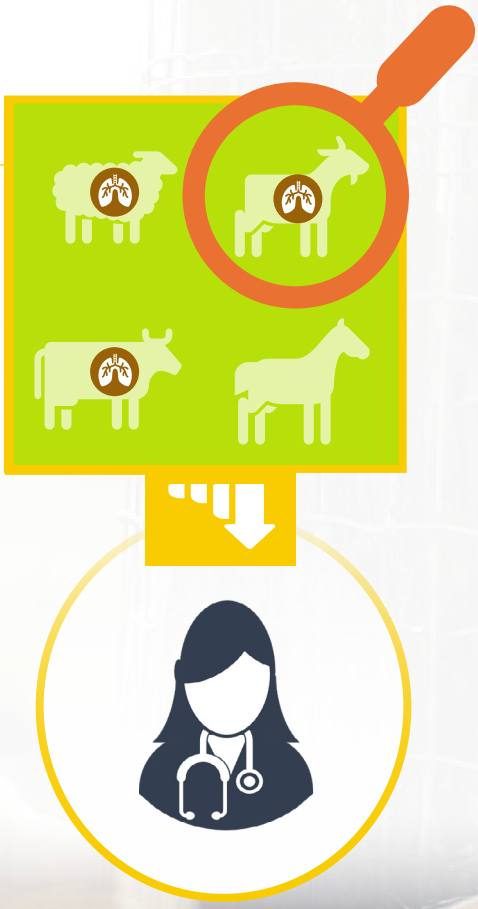
Antibiograms

Two sets of **antibiograms** were released to **57** **veterinarians** this fiscal year and included sheep respiratory, goat respiratory, cattle respiratory, and equine isolates.



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Ongoing Educational Resources

Ongoing resources and **customized materials** are available to all California veterinarians regarding veterinary feed directives (VFDs) and livestock-specific antibiograms.

AUS staff provide multiple opportunities for **veterinary continuing education credits** through presentations at various conferences and universities.

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AUS Outreach & Participation

Ongoing Guidance for VFDs

One-on-one guidance for California veterinarians regarding veterinary feed directive (VFD) changes and updates by FDA. Visit AUS' web page: https://www.cdfa.ca.gov/ahfss/aus/vfdresources/

Farms Engaged

156 farms participated in

13 active studies in FY 24-25

Presentations (in-person & virtual)

500 attendees

CDFA's Livestock Veterinary Feed Directive Training

AUS' Inspection Services Division, in conjunction with the Food Animal Residue Avoidance Databank (FARAD) and UC Davis, developed an on-line training program that covers the regulatory landscape of using antibiotics in food animals, VFD regulations, calculations, and a walk through on how to write a VFD. This course is intended for California feed distributors, as well as other relevant participants.
To register: https://ce.vetmed.ucdavis.edu/symposia-article/cdfa-livestock-veterinary-feed-directive

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 optimize antibiotic usage?

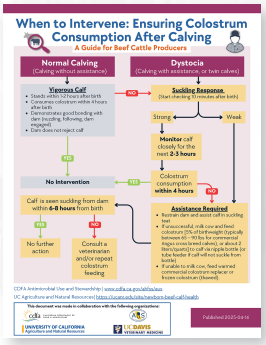
Through its academic research collaborations, veterinarian input, and voluntary stakeholder participation, AUS continues to keep abreast of current best management practices to limit antibiotic resistance and promote animal health. AUS supports stakeholders with the most current and effective scientific information with an ongoing review of the latest California, national, and world-wide research. The following are highlights from AUS' work in this area from the past fiscal year.

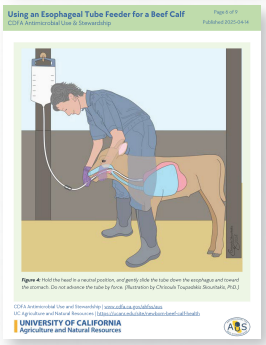
Aquaculture

As the leading state for sturgeon production for both meat and caviar, the California-based study uses ten tanks, each stocked with 50 sturgeon, to evaluate how different dietary protein sources affect the physiological health of farmed fish. The experimental diets are formulated to have identical nutrient profiles but differ in their primary protein ingredients, including fish-based, plant-based, and poultry-based alternatives. These diets are being compared to a commercial control containing a proprietary blend of protein sources commonly used by sturgeon producers. This work supports the development of more sustainable sturgeon diets by reducing reliance on traditional fishmeal and fish oil while ensuring that diet selection is based not only on growth and meat quality but also on comprehensive fish health metrics important for survival, welfare, and disease management on farms. Sample collection is currently underway to assess the effects of these diets on physiological condition and product quality.

Beef Calves

Step-by-step guides have been finalized and provided for public use to aid in identification and implementation of appropriate interventions to ensure adequate colostrum intake by beef calves on ranches. Detailed guidance includes information on record keeping, navel infections, castration, vaccination, nutritional requirements, and safe esophageal feeding tube placement. These resources can be found at: *https://ucanr.edu/site/newborn-beef-calf-health*





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Communities of Practice

After the pilot testing of a Communities of Practice (CoP) program at five different farm settings, the lessons learned were used to create a 10-part video series that describe strategies and takeaways for the development of future CoPs. This video series is publicly available both in California and nationally to livestock producers and Cooperative Extension professionals. The aim is to help future groups who hope to implement practical, farm-level change in their herds or flocks.

Video 1: Project Abstract	**Video 2:** Organizational Structure & Management	**Video 3:** Project Overview	**Video 4:** A Reform Model of Professional Development
Video 5: Overview and Findings, **Case 1:** *Dairy Cattle Operation*	Click on each individual box to view the video		**Video 6:** Overview and Findings, **Case 2:** *Dairy Cattle Operation*
Video 7: Overview and Findings, **Case 3:** *Dairy Cattle Operation* Expected Reduction in Somatic Cell Count	**Video 8:** Overview and Findings, **Case 4:** *Sheep Operation*	**Video 9:** Overview and Findings, **Case 5:** *Sheep Operation*	**Video 10:** Project Summary

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Dairy Calves

Results are being analyzed from a study that included 26 conventional and 12 organic dairies across the state. Participating dairies received results regarding colostrum quality and transfer of passive immunity to assess their calf management practices in real-time. These results also help direct the CDFA AUS team towards useful interventions to optimize disease prevention strategies.

Dairy Cows

A six-part, interactive, online training series on the judicious use of antimicrobials for new and existing dairy farmworkers has been created in both English and Spanish. The first publicly available webinars for both veterinarians and producers will be presented in Fall 2025, which will be followed by a website where the public can access the training series on an ongoing basis.

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Antibiotic Sales & Use

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

The sale and use of antibiotics intended for livestock evolves on an annual basis and reflects changes in disease threats, as well as in management practices, both in California and in states where California products are sold. With 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 the 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.

Indications for Antibiotic Use

As Authorized in VFDs

- Respiratory Disease (193)
- Gastrointestinal Disease (127)
- Either / Both (257)
- Other (23)

**Number of VFDs collected for calendar year 2024. For more information, see AUS' VFD Summary Report.*

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Commercial Sheep

For the 2024 National Animal Health Monitoring System (NAHMS) Sheep study, CDFA and USDA staff visited numerous operations throughout the state to collect survey and biologic information, with the intention to yield California-specific results.

Dairy Calves

Based on a study of 26 conventional dairies across the state, most antimicrobials were used for the treatment of diarrhea and respiratory disease prior to weaning. Over 60% of the dairies surveyed indicated interest in obtaining information on relevant antibiotic resistance patterns, antibiotic usage guidelines, and best management practices developed by CDFA AUS.

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Antibiotic Resistance

How are we looking at trends in antibiotic resistance?

This fiscal year, AUS-funded research evaluated antibiotic resistance trends through multi-year studies and newly commissioned projects. These antibiotic resistance trends were explored and analyzed from samples collected on-farm, as well as from clinical samples submitted by research partners. Multi-year studies allow AUS to follow antibiotic resistance trends from on-farm samples collected at the same operations over time to gain valuable insight into the effects of antibiotic use and other management practices on antibiotic susceptibility. These trends pinpoint areas where the AUS Stewardship team can further identify effective strategies that may be implemented by California's livestock producers and veterinarians to help mitigate the development and spread of antibiotic resistance, as well as highlight where existing stewardship efforts prove effective. The following are highlights from AUS' work in this area during the past fiscal year.

Aquaculture

As described earlier, a study investigating the overall effects of dietary protein sources on antimicrobial susceptibility in the sturgeon microbiome is focusing on three potentially pathogenic bacteria: *Aeromonas*, *Vibrio*, and *Streptococcus*. Fecal samples were collected from a representative population of fish before starting the experimental diets, which differ in their protein sources. These baseline samples will be compared with those obtained after the fish have been fed the diets for approximately 16 weeks.

Beef-on-Dairy

Pre- and post-weaning phases have been concluded in a study which enrolled 252 beef-on-dairy calves to evaluate the effects of extended colostrum feeding during the production cycle. A total of 743 presumptive *E. coli* isolates from fecal samples have been collected for future analysis. Blood samples were collected and analyzed for total serum protein. The feedlot phase has started for all enrolled calves and ongoing sampling will occur at regular intervals.

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CAHFS Testing

AUS funding helped support the California Animal Health & Food Safety (CAHFS) Laboratory to perform 829 antimicrobial susceptibility tests for clinical samples submitted from multiple livestock sources.

AUS bolsters federal monitoring programs for antibiotic resistance through CAHFS' work with USDA, which contributes to publicly available antibiotic resistance data in specialized dashboards.

Commercial Poultry

Litter material was collected from 19 broiler farms during this period. In addition, *Salmonella* isolates were received from an additional 130 broiler farms. No antibiotics were used on these broiler farms. The litter samples that were collected from participating broiler farms in California were cultured for *E. coli*, *Enterococcus, Salmonella,* and *Campylobacter*. Isolates of *E. coli* and *Enterococcus* were recovered from all litter samples, with all bacterial isolates tested for antimicrobial susceptibility. One isolate of *Campylobacter* was also recovered. The main serotypes of *Salmonella* recovered during this period were *S.* Kentucky, *S.* Enteritidis, *S.* Alachua, and *S.* Infantis. *Enterococcus* isolates that have been tested for antimicrobial susceptibility showed no resistance against the antimicrobials ampicillin, avilamycin, linezolid, and vancomycin; resistance was detected to the antimicrobials erythromycin and tetracycline. For the *E. coli* isolates, no resistance was detected against the antimicrobials cefoxitin, ceftriaxone, and ciprofloxacin; resistance was detected to the antimicrobials ampicillin and tetracycline.

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Dairy Cows

Few target bacteria (*Staphylococcus*, *Mycoplasma*, and *E. coli*) were isolated in colostrum from conventional and organic dairies across the state. Susceptibility from these isolates and other pathogens is currently being analyzed.

From a separate study, a series of papers were published evaluating a framework for the creation of herd-level antibiograms tailored for dairy cattle. Significant findings related to factors that affect both pathogen recovery and susceptibility results include:

Age, season, and farm were identified as significant factors associated with the recovery of *P. multocida* and *M. haemolytica* in bovine respiratory disease (BRD) clinical cases. Across seasons, cows had lower odds of being culture-positive for *P. multocida* compared to calves during the spring and summer, and heifers in the fall and winter. For *M. haemolytica*, calves in the spring and summer showed some of the lowest odds of being culture-positive, while heifers in the fall and winter exhibited some of the highest odds, other than the significant effect of farm.

A significant difference in the odds of nonsusceptibility among BRD bacteria to multiple antimicrobials due to age and farm, but not season, was observed, highlighting the need to consider these factors when creating antibiogram reports. The farm effect was significantly associated with *P. multocida* nonsusceptibility to all antimicrobials but penicillin, suggesting individual farm management practices may heavily affect profiles of nonsusceptible BRD bacteria.

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Swine

An in vitro study evaluated how heavy metal overexposure affects the antibiotic susceptibility of Enterotoxigenic *Escherichia coli* (ETEC). A total of 172 antimicrobial resistance genes (ARGs) were identified, with 109 linked to resistance to multiple drug classes, including glycopeptides, tetracyclines, and aminoglycosides. Zinc oxide treatment resulted in fewer ARGs, but the relative abundance of these genes was higher, indicating selective enrichment of resistant populations. These findings align with previous studies showing zinc oxide's impact on microbial resistance profiles. Iron and copper treatments increased ETEC susceptibility to bactericidal antibiotics like gentamicin, kanamycin, and ampicillin, especially with copper. However, zinc treatment did not affect ETEC's response to these antibiotics. For bacteriostatic antibiotics, all three metals enhanced resistance to erythromycin and tetracycline, with varied responses to chloramphenicol based on the metal type.

Previous studies indicated that dietary supplementation with short chain fatty acids (SCFA) derivatives can enhance intestinal development, enrich beneficial microbiomes, reduce inflammation from post-weaning ETEC infection, and improve overall health and growth in newly weaned pigs. This project focused on the effects of water application of these SCFA derivatives on performance, diarrhea, and other health parameters in weaned pigs. Serum and cecal digesta metabolites were analyzed from newly weaned pigs experimentally infected with F18 *E. coli*. Bacterial DNA was also isolated from ileal digesta, cecal digesta, and feces for rRNA sequencing. It was found that application of monobutyrin or monovalarin to water altered serum and colon digesta metabolites in patterns similar to those observed with carbadox.

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Communication & Engagement

How are we reaching people and improving our outreach efforts?

Key components of the AUS program mission include education and continuous communication with livestock owners, livestock drug retailers, and veterinarians on the requirements of the law, and 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, as well as meet the evolving needs of those it seeks to engage further in its education efforts. During FY 24-25, AUS prepared and presented several infographic resources in both English and Spanish to facilitate the distribution of 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.

Food Animal Veterinary Shortages

Veterinary Medical Loan Repayment Program

In Fall 2024, California successfully nominated the maximum of eight county veterinary shortage designations. An applicant was awarded for the combined Tehama, Glenn, and Colusa Counties veterinary shortage designation. No veterinarian applications were accepted in Spring 2025, as USDA NIFA's Request for Applications had been paused and placed under review in January 2025.

In September 2025, USDA NIFA notified stakeholders that the program will resume in the upcoming 2026 federal fiscal year. AUS continues to keep stakeholders informed through a dedicated webpage for this valuable veterinary incentive program: https://www.cdfa.ca.gov/AHFSS/AUS/CAVetNeeds.html.

The AUS Stewardship team continues to be a resource for veterinary students exploring careers in food animal or mixed animal practice, facilitating mentorship connections with interested private practicing veterinarians across the state. These opportunities provide a critical link to communities experiencing high veterinary service needs through shadowing and formal clinical experiences at existing large animal veterinary practices. This enables current veterinary students to experience what the day-to-day might look like for a clinician. CDFA AUS continues to **connect** interested **veterinary students** with **practicing veterinarians** in **veterinary shortage areas.**

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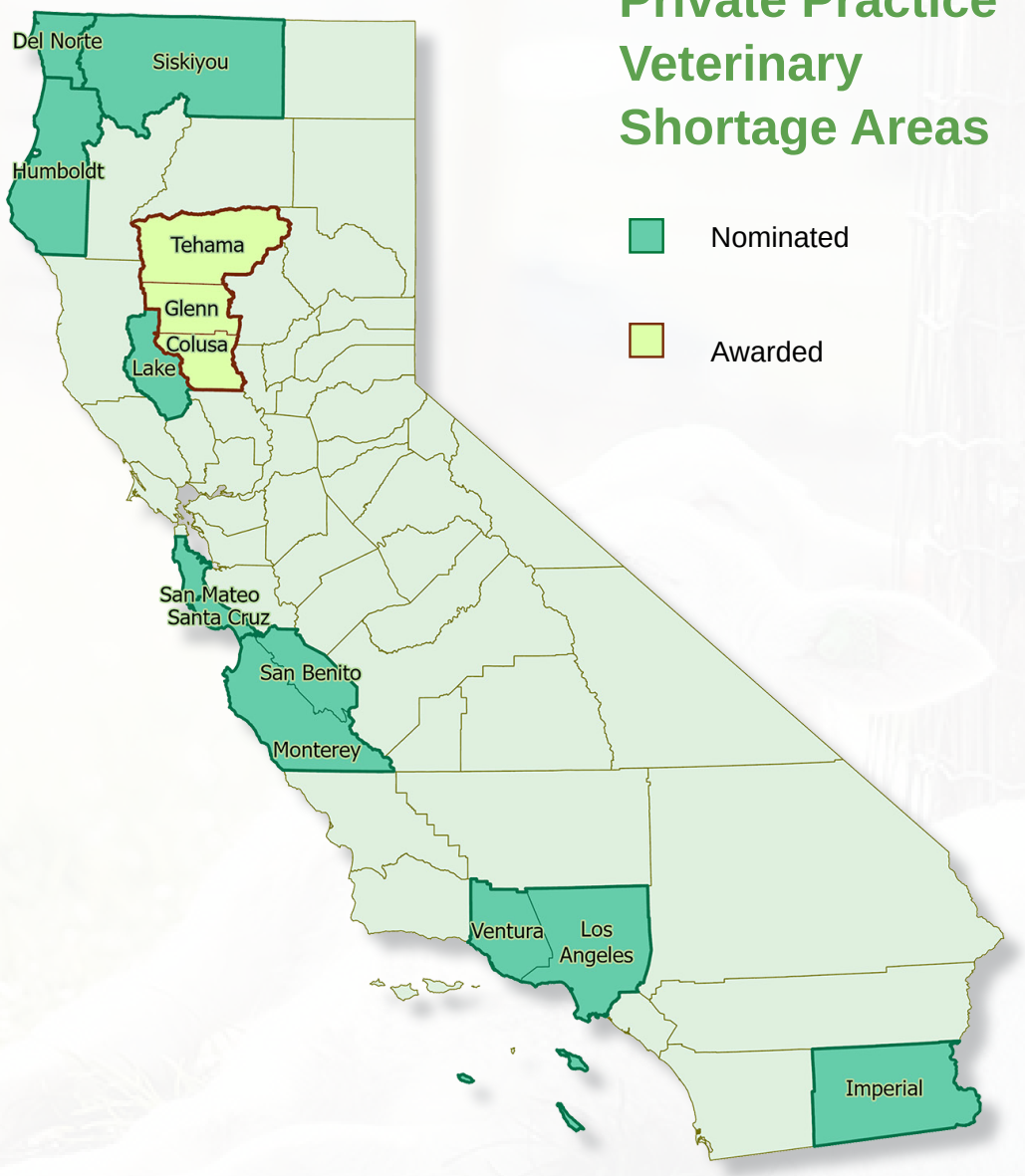
Private Practice Veterinary Shortage Areas



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Training Collaboration

MPES Presentation to Train Livestock and Poultry Meat Inspectors

In **collaboration** with CDFA's Meat, Poultry and Egg Safety (MPES) Branch, a novel training module was created with a focus on distinguishing between antibiotic resistance versus antibiotic residues. Combining subject-matter expertise, regulatory insight, and field experience across both branches, the training presentation and materials were incorporated into MPES' annual maintenance training to equip licensed industry inspectors with a clear and practical understanding to address misconceptions, promote responsible antibiotic use, and strengthen food safety compliance.

National Engagement

AUS staff continued **national engagement** on antimicrobial resistance and worked to alleviate the veterinary shortages in rural areas through positions on various committees and review panels, while providing experience, science-based analysis, and recommendations to government agencies.

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AUS-Funded Research Publications & Presentations

How are our researchers building on current scientific knowledge?

Part of AUS' mission is to fund research projects on specific topics that have been curated to reflect the needs of California's livestock sectors, as determined by surveys, outreach efforts, and program mandates. Peer-reviewed journal publications are critical to ensure the materials AUS produces 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 by AUS-funded researchers to 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 2024-2025 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.

Busch, R. **Addressing on-farm antimicrobial drug use practices through a community of practice-based approach – A case study.** (2024, October). Presentation at the 20th Annual Applied Animal and Public Health Research and Extension Symposium hosted by the American Association of Extension Veterinarians in Nashville, TN.

Keywords: antimicrobial stewardship, change management, communities of practice, employee engagement, professional development

Description: Decision-making by farm employees is often influenced by previous experience, risk aversion, and costs, sometimes resulting in a disconnect between the expectations of a prescribing veterinarian and the actions of the end users. Innovative approaches that seek to understand and acknowledge individuals' values, social trust, and personal experience are needed to effectively empower decision makers on farm.

Chigerwe, M. **Colostrum Impacts in Organic Dairies.** (2024, November). Presented at the Western Organic Dairy Producers Conference and Trade Show in Reno, NV.

Keywords: antimicrobial stewardship, calf health, colostrum, dairy, organic

Description: The aims of this study were to evaluate the impact of colostrum and milk management factors and their association with preweaning calf health and antimicrobial/probiotic/prebiotic use in organic dairies in California. Twelve farms were enrolled. Data collected included colostrum management, milk/milk replacer management, record-keeping practices, morbidity and mortality, calf rearing practices, antibiotic and probiotic use, and determination of treatment protocols. Identified areas for improvement include heat treatment of colostrum, colostrum storage, timing of colostrum feeding, testing for passive transfer, and maintenance of accurate records.

Keywords:
antimicrobial resistance, bovine respiratory disease, BRD, dairy cattle, whole genome sequencing, WGS

Garzon, A., Miramontes, C., Weimer, B.C., Profeta, R., Hoyos-Jaramillo, A., Fritz, H.M., and Pereira, R.V. (2025) **Comparison of virulence and resistance genes in *Mannheimia haemolytica* and *Pasteurella multocida* from dairy cattle with and without bovine respiratory disease.** *Microbiol Spectr* 13:e01200-25. https://doi.org/10.1128/spectrum.01200-25

Description: *Mannheimia haemolytica* and *Pasteurella multocida* are two of the main bacterial pathogens associated with bovine respiratory disease (BRD). The objectives of this project were to (i) characterize virulence factor (VF) and antimicrobial resistance (AMR) genes in *M. haemolytica* and *P. multocida* isolates from dairy cattle of different ages with and without BRD using whole genome sequencing (WGS); (ii) evaluate associations between microbial genetic elements and animal disease status; and (iii) assess the accuracy of genome-based predictions for the antimicrobial resistance phenotype. Using a case-control study, AMR and VF genes were characterized from 149 *P. multocida* and 68 *M. haemolytica* isolates from preweaned calves, weaned heifers, and cows with and without BRD. The large genetic diversity observed in both bacterial species prevented the identification of unique genetic markers associated with disease status or age group. AMR genes (22 genes) from 12 antimicrobial classes were identified in *P. multocida* isolates, while 11 AMR genes for seven antimicrobial classes were identified in *M. haemolytica* isolates. Additionally, 28 and 15 virulence genes were identified in *P. multocida* and *M. haemolytica*, respectively. The ability of WGS-based predictions to predict phenotypic antimicrobial resistance showed variable accuracy across different antimicrobials, achieving moderate levels of agreement overall. Findings from this project demonstrate that identifying genomic markers based on gene presence/absence lacks discriminatory power within this population for identifying unique genotypes associated with disease status in these genomically diverse organisms.

Keywords:
antimicrobial resistance, antimicrobial susceptibility, *Mannheimia haemolytica,* ovine respiratory disease, *Pasteurella multocida,* sheep

Jackson, W., Tucker, J., Fritz, H., Bross, C., Adams, J., Silva, M., Lorenz, C., and Marshall, E. (2024) **Antimicrobial susceptibility profiles among commensal *Mannheimia haemolytica* and *Pasteurella multocida* isolated from apparently healthy sheep processed in California: Results from a cross-sectional pilot study.** *Preventive Veterinary Medicine,* Volume 233, 106360, ISSN 0167-5877.
https://doi.org/10.1016/j.prevetmed.2024.106360

Description: To gather information on the susceptibility of bacteria commonly associated with ovine respiratory disease (ORD), the upper respiratory tract (URT) from 620 apparently healthy sheep carcasses was sampled at slaughter in California. Sheep sampled in the study were selected based on origin prior to processing (out-of-state or California) and marketing status (antibiotic-free or conventional management), two factors hypothesized to influence antimicrobial susceptibility profiles. The recovery rate among sampled carcasses was 46.8% (290/620) for *M. haemolytica* and 15.8% (98/620) for *P. multocida.* Very low to no antimicrobial resistance was observed across both bacterial species tested, demonstrating that *M. haemolytica* and *P. multocida* in this apparently healthy sheep population remain broadly susceptible to the antimicrobials licensed for the treatment of ORD. In addition, antimicrobial susceptibility did not differ based on origin or marketing status, as defined for this study. Sampling at slaughter provides an opportunity to collect baseline information about antimicrobial susceptibility of the commensal flora of the sheep URT that can give rise to ORD, but may not be generalizable to sheep with clinical respiratory disease or to sheep reared by non-commercial producers.

Karle, B. **Impacts of colostrum management on calf health and growth during the preweaning period.** (2024, November). Presentation at the Golden State Dairy Management Conference in Modesto, CA.

Keywords:
antimicrobial stewardship, calf health, colostrum, dairy

Description: The aims of this study were to evaluate the impact of colostrum and milk management factors and their association with preweaning calf health and antimicrobial use in conventional and organic dairies in California. Data collected included colostrum management, milk/milk replacer management, record-keeping practices, morbidity and mortality, calf rearing practices, antibiotic and probiotic use, and determination of treatment protocols. Twenty-six conventional and 12 organic dairies were enrolled in the study.

Liu, Y. **Boosting robustness in pigs through nutrition and feed management.** (2024, September). Presentation at California Swine Day hosted by University of California, Davis in Davis, CA.

Keywords:
antimicrobial stewardship, diet, *E. coli,* gut microbiome, swine

Description: The gastrointestinal (GI) tract undergoes rapid and vulnerable development during the weaning period, making piglets susceptible to stress-induced dysfunctions, reduced appetite, and pathogenic infections—particularly from enterotoxigenic *Escherichia coli* (ETEC) bearing F4 and F18 fimbriae. The presentation underscores the economic and health impacts of post-weaning diarrhea, including decreased feed efficiency and increased mortality, which often lead to antibiotic use and contribute to antimicrobial resistance (AMR). To address these issues, an evaluation of a range of nutritional interventions aimed at supporting gut integrity, microbial balance, and immune function. These include the use of functional amino acids (e.g., glutamate and aspartate), monoglycerides of short-chain fatty acids, and probiotic strains such as *Bacillus subtilis,* known for its spore-forming stability and performance-enhancing effects. The presentation also highlights the PIG-PARADIGM project—an interdisciplinary, international initiative funded by the Novo Nordisk Foundation—that seeks to reduce antibiotic use and curb AMR by disentangling the interactions between pig diet, the host, and the gut microbiome.

AUS has leveraged the opportunities with UC Davis' CLEAR Center to be involved with the PIG-PARADIGM project to further support the judicious use of antimicrobials.

For more information, visit:
https://projects.au.dk/pig-paradigm

https://clear.ucdavis.edu/news/uc-davis-yanhong-liu-shores-pig-paradigm-study

Monteiro, H.F., Jaramillo, A.H., Garzon, A., Fritz, H.M., Miramontes, C.C., Matos, I.M., Lehenbauer, T.W., Aly, S., Lima, F.S., and Pereira, R.V. **Development of an antibiogram report for bovine respiratory disease: Factors affecting culture-positivity, antimicrobial susceptibility, and multi-drug resistance of 2 pathogens in California dairies.** (2025, June). Presentation at the American Dairy Science Association Annual Meeting in Louisville, KY.

Monteiro, H.F., Jaramillo, A.H., Garzon, A., Fritz, H.M., Miramontes, C.C., Matos, I.M., Lehenbauer, T.W., Aly, S., Lima, F.S., and Pereira, R.V. (2025) **Antibiogram use on dairy cattle for bovine respiratory disease: A repeated cross-sectional study evaluating antimicrobial susceptibility of *Pasteurella multocida* and *Mannheimia haemolytica*.** *Journal of Dairy Science,* Volume 108, Issue 7, P7401-7414.
https://doi.org/10.3168/jds.2025-26441

Keywords:
antibiogram, antimicrobial resistance, antimicrobial stewardship, bovine respiratory disease, BRD, clinical epidemiology

Description: In human medicine, cumulative antimicrobial susceptibility testing (CAST) is used to generate antibiograms that support empirical decision-making for antimicrobial treatment. The goal of this study was to evaluate a CAST framework for bovine respiratory disease (BRD) in dairy cattle and factors of relevance when analyzing and reporting antibiogram data for on-farm treatment decisions. From three dairy farms in California, calves, heifers, and cows were sampled using deep nasopharyngeal swabs for culture and

antimicrobial susceptibility testing for *Pasteurella multocida* and *Mannheimia haemolytica*. Overall, *P. multocida* isolates were mostly nonsusceptible to tetracycline (74%) and spectinomycin (46%), whereas *M. haemolytica* isolates were frequently nonsusceptible to penicillin (43%) and tetracycline (34%). For *P. multocida,* isolates nonsusceptible to tetracycline and spectinomycin were affected by age group, with calves showing greater odds of nonsusceptibility to antimicrobials. The farm effect was significantly associated with *P. multocida* nonsusceptible to all antimicrobials but penicillin, suggesting individual farm management practices may heavily affect profiles of nonsusceptible BRD bacteria. Similarly, nonsusceptible *M. haemolytica* was consistently associated with farm for macrolides and tetracyclines and with age, with heifers showing the greatest odds of being nonsusceptible when compared with cows. Season did not affect the nonsusceptibility of either pathogen, suggesting that either California seasonal patterns or other factors, such as farm practices and animal management, play a more prominent role in the change of susceptibility profile. Overall, these findings highlight the potential effects of farm and age when interpreting data from CAST reports for BRD, where these and other factors should be considered when analyzing and presenting antibiogram reports.

Keywords:
antibiogram, antimicrobial resistance, antimicrobial stewardship, bovine respiratory disease, BRD, clinical epidemiology

Monteiro, H.F., Jaramillo, A.H., Garzon, A., Fritz, H.M., Miramontes, C.C., Matos, I.M., Lehenbauer, T.W., Aly, S., Lima, F.S., and Pereira, R.V. (2025) **Antibiogram use on dairy cattle for bovine respiratory disease: Factors associated with bacterial pathogen identi ication and prediction of bacterial recovery using machine learning.** *Journal of Dairy Science,* Volume 108, Issue 6, P6284-6296.
https://doi.org/10.3168/jds.2024-26205

Description: Limited information is available on factors associated with herd-level bacterial pathogen recovery for bovine respiratory disease (BRD) clinical cases, which are important data to help identify strategies to support the successful collection of a minimum number of each organism over time to generate cumulative antibiogram susceptibility testing reports. Our objective was to evaluate factors associated with the recovery of common pathobionts (*Pasteurella multocida* and *Mannheimia haemolytica*) in BRD clinical cases from preweaning calves, heifers, and cows at three California dairy farms over two years. For our study, samples were collected from a total of 301 BRD clinical cases: 146 samples with a culture-positive for *P. multocida,* 63 samples with a culture-positive for *M. haemolytica,* and three samples with a culture-positive for *Histophilus somni.* For factors associated with the culture-positive of *P. multocida* in BRD clinical cases, an interaction between age and season was identified, where cows had overall lower odds of being culture-positive independently of the season when compared with calves in the spring and summer and heifers in the fall and winter. For factors associated with the culture-positive of *M. haemolytica* in BRD clinical cases, an interaction was also observed between age and season, but the farm further played a role in the odds of being culture-positive, with one farm having considerably greater odds than the remaining ones. Overall, correctly identifying factors that may be associated with the prevalence of BRD pathogens and, therefore, recovery of these pathogens is critical for the development of antibiogram programs for evaluation of the antimicrobial susceptibility of BRD pathogens.

Monteiro, H.F., Jaramillo, A.H., Garzon, A., Fritz, H.M., Miramontes, C.C., Matos, I.M., Lehenbauer, T.W., Aly, S., Lima, F.S., and Pereira, R.V. (2025). **Antibiogram use on dairy cattle for bovine respiratory disease: Multidrug resistance in *Pasteurella multocida* and *Mannheimia haemolytica* in California dairies.** *Journal of Dairy Science,* Volume 108, Issue 9, P10060-10072.
https://doi.org/10.3168/jds.2025-26708

Keywords: antibiogram, antibiotic, antimicrobial stewardship, bovine respiratory disease, BRD, clinical epidemiology, multidrug resistance, MDR

Description: Although antibiograms have emerged as a tool to support empirical decision making for disease treatment, the prevalence of multidrug-resistant (MDR) isolates on a farm can have a negative effect on the selection of the best antibiotic treatment using antibiogram data. This study aimed to characterize the MDR profile of *Pasteurella multocida* and *Mannheimia haemolytica* isolates from the deep nasopharyngeal swabs of calves, heifers, and cows diagnosed with bovine respiratory disease (BRD) over two years. For this purpose, three large dairy farms in California were sampled and a total of 146 *P. multocida* and 53 *M. haemolytica* isolates were tested for antimicrobial susceptibility. Our results showed that, overall, a small fraction of the animals in the study had MDR *P. multocida* (15%) and *M. haemolytica* (17%). The prevalence of MDR *P. multocida* isolates was comparable between calves (14%), heifers (19%), and cows (12%), whereas MDR *M. haemolytica* was most prevalent in heifers (40%) followed by calves (4%). No MDR *M. haemolytica* was detected in the isolates from cows. Farm effect had the most significant association with MDR BRD pathogens, with one farm accounting for 94% of all MDR isolates of the study, while season had a minor association with MDR. The most common antimicrobial resistance drug classes across MDR pathogens were macrolides, phenicols, quinolones, and tetracyclines. Prevalence of resistant isolates to tetracyclines represented the greatest disparity between the two BRD pathogens

evaluated, with *P. multocida* isolates having a higher percentage of resistance (71.8%) when compared with *M. haemolytica* (22.2%). In conclusion, there was a low prevalence of MDR in both *P. multocida* and *M. haemolytica* in the study, but farm management and the age of the animals increased the odds of MDR prevalence. These factors should be considered when generating antibiogram reports for BRD treatment to account for the potential prevalence of MDR isolates.

Pereira, R. **Improving cow's health management on the dairy: New tools for on-farm training of farmworkers.** (2024, November 18). Presentation at the Golden State Dairy Management Conference in Modesto, CA.

Pereira, R. **Improving cow's health management on the dairy: New tools for on-farm training of farmworkers.** **(**2025, February 12). Presentation at the Golden State Dairy Management Conference at the World Ag Expo in Tulare, CA.

Keywords: antimicrobial stewardship, on-farm training, dairy, farmworker

Description: This presentation summarized the findings from research conducted related to an antimicrobial stewardship dairy program that evaluated an on-farm training program for farmworkers. This presentation also introduced the upcoming online training program to be offered at no cost for dairy farm workers, being offered in English and Spanish.

Wright, A., Moody, C., and Gross, J. (2025) **Composition of California's aquaculture industry and surveying its disease challenges and management strategies.** *Aquaculture Reports,* Volume 42, 102799, ISSN 2325-5134.
https://doi.org/10.1016/j.aqrep.2025.102799

Keywords: aquaculture survey, disease management, antimicrobials, extension

Description: California (CA) aquaculture is best characterized by its diversity of production systems, cultured species, and final products. The industry comprises four major sectors (i.e., finfish, shellfish, macroalgae, and natural resource agency), which raise aquatic organisms for a variety of purposes, such as sustenance, conservation, recreation, and scientific research. In terms of commercial production value, California aquaculture contributes roughly 6% to the total value of the U.S. aquaculture industry. The predominant forms of commercial aquaculture in CA are the production of finfish and shellfish for human consumption, which contribute 40.2% and 30.0%, respectively, to the total production value of the industry. Other forms of commercial aquaculture in CA include the production of sportfish species for recreational fishing, and other seafood products like caviar and macroalgae. Natural resource agencies, such as the California Department of Fish and Wildlife (CDFW), are also significant aquaculture producers that raise salmonids for conservation and recreation purposes. The diversity within CA aquaculture requires an equally diverse set of disease management strategies that address the specific needs of each sector. A recent survey on aquatic animal health indicates that California finfish and shellfish facility managers are aware of disease challenges and use a preventative approach to reduce the likelihood of disease outbreaks. Our survey results suggest that when disease is detected, non-prescription antimicrobial products (i.e., hydrogen peroxide) are used most frequently for disease treatment (71% commercial, 17% commercial shellfish, 86% CDFW), while prescription antibiotics are only utilized following veterinary review and approval (18% commercial finfish, 0% commercial shellfish, 71% CDFW). Biosecurity and disease-response protocols are also important components of disease management, and their standardization across each sector will enhance the disease prevention capabilities of the aquaculture industry.

Looking Ahead

What's next?

AUS has accomplished much in FY 24-25 and is looking forward to continuing this success in FY 25-26. Several ongoing projects will have valuable results to report in the next 1-2 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.

ANTIBIOGRAMS

Provide educational materials and continue to expand database of clinical isolates to help veterinarians apply best practices in targeting antibiotic use and to assess antibiotic resistance trends

California-licensed veterinarians have access to livestock-specific antibiograms by responding to this survey: http://tinyurl.com/AntibiogramSignup

EDUCATIONAL VIDEOS

Distribution of interactive, educational resource packages targeted at youth to encourage and enhance knowledge of scientific concepts of how to stay healthy when working with livestock

Above is a selection of highlights from the work AUS completed over FY 24-25; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 24-25.

NATIONAL ANTIMICROBIAL RESISTANCE MONITORING SYSTEM (NARMS) DATA

Publication of *Campylobacter*, *Enterococcus*, *E. coli*, and *Salmonella* reports for California-specific NARMS data

VFD COLLECTION

Continue collection, reporting, and analysis of VFD orders

VFD OUTREACH TO VETERINARIANS

Continue to provide educational outreach to veterinarians in California that have written incomplete or incorrect VFDs with deficiencies and share strategies to help veterinarians incorporate best practices and improve VFD accuracy

Above is a selection of highlights from the work AUS completed over FY 24-25; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 24-25.

C 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 California agriculture. 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 on the 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 stakeholders, including veterinarians, livestock owners, academics, and others, play a key role in providing guidance and support at all stages of our research, outreach, and education efforts. They 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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AUS would like to give special thanks to the following individuals who contributed to this Annual Report:

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Dr. Rosie Busch	*University of California, Davis – Cooperative Extension*
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Project Staff	*California Department of Food and Agriculture – Meat, Poultry and Egg Safety Branch*
Project Staff	*NAHMS Sheep 2024 study*

D

SPECIAL SECTION— H5N1 RESEARCH PROJECTS

In response to the growing impact of avian influenza (HPAI, H5N1) in California, CDFA partnered with USDA and research collaborators from multiple institutions in an effort led by AUS to gain more insight into disease transmission, detection, impact, and management. Studying an outbreak in real time provides an opportunity to gain important insights for the future. The following pages represent a selection of high-level summaries of the studies and projects in dairy cattle managed by AUS and funded by a cooperative agreement between CDFA and USDA. These descriptors include information regarding the purpose, design, impact, and progress for each project. Summary findings are described where appropriate, dependent upon project progress.

I. Early Detection and Longitudinal Sampling

Principal Investigators
Dr. Jason Lombard, Colorado State University
Dr. Blaine Melody, Lander Veterinary Clinic, Inc.

Collect a battery of samples and other data throughout all phases of disease to help determine routes of intra-herd and inter-herd transmission and the impacts on immunity and environment

Project Objective

This study provides detection and monitoring of the virus at the operation- and cow-levels. By collecting samples from cattle and their surrounding environment during the four phases of infection (incubation, prodromal, illness, and convalesce), the routes and duration of H5N1 viral shedding, serological response, and potential modes of transmission will be better understood. Evaluation of in-depth records of sampled individuals will explore intra-herd disease impacts of H5N1. It is expected that these sampling components will significantly enhance our understanding of this disease by monitoring temporal changes in the immunological response, viral load at the operation level, transmission dynamics, and duration of shedding. Analyses of these outcomes will further increase understanding of herd transmission risks and correlation to immunity. This project will also provide stakeholders crucial information regarding individual cow health and production impacts of H5N1 throughout all phases of infection, as well as environmental locations that may harbor virus.

Progress

Details can be found in the following publication and additional publications forthcoming:

Lombard, J., Stenkamp-Strahm, C., McCluskey, B., and Melody, B. **Evidence of Viremia in Dairy Cows Naturally Infected with Influenza A Virus, California, USA.** *Emerg Infect Dis.* 2025 Jul;31(7):1425-1427. doi:10.3201/eid3107.250134. Epub 2025 Jun 4. PMID: 40464560; PMCID: PMC12205469.
https://pubmed.ncbi.nlm.nih.gov/40464560/

II. Pathology of highly pathogenic avian influenza (HPAI: H5N1) in dairy cows and fetuses in California, with emphasis on lesions, virus distribution in tissues and potential routes of shedding

Principal Investigator

Dr. Todd Cornish, California Animal Health and Food Safety Laboratory

Better understand pathogenesis of disease, including all tissue sites of infection and replication and risks to pregnant dairy cattle and their fetuses

Project Objective

This study will improve our understanding of the pathogenesis of HPAI infection in dairy cattle in the field, including examination of potential reproductive effects of infection in pregnant dairy cattle. If this virus has the ability to induce abortions or fetal deformities, then routine testing for the virus must be incorporated into all reproductive loss/abortion investigations at veterinary diagnostic laboratories.

Progress

Preliminary results were presented at the joint CDFA Animal Health Branch and AUS Annual Meeting this year with more results expected in Fall 2025.

III. Evaluation and development of an on-farm ready-to-use protocol for inactivation of HPAI H5N1 through milk acidification

Principal Investigator
Dr. Richard Pereira, University of California, Davis

Evaluate acidification of milk as an option for inactivating H5N1 under field conditions and use of treated milk for feeding preweaned dairy calves; develop on-farm guide for milk acidification

Project Objective

The goal of this project is to evaluate the use of on-farm milk acidification for inactivation of H5N1 to support on-farm disposal of non-saleable milk containing H5N1, thereby addressing current biocontainment bottlenecks for H5N1. For this goal, specific aims will focus on: 1) Evaluate and optimize milk acidification on deactivation of H5N1 in raw cow milk; 2) Evaluate on-farm protocols for using milk acidification to deactivate H5N1; and 3) Development of a guideline for ready-to-use on-farm milk acidification system for deactivation of H5N1 containing milk.

Progress

Progress details can be found in the following publication and additional publications forthcoming:

Crossley, B.M., Miramontes, C.C., Rejmanek, D., Gallardo, R., and Pereira, R. (2025) **In-laboratory inactivation of H5N1 in raw whole milk through milk acidification: Results from a pilot study.** *Journal of Dairy Science,* Volume 108, Issue 3, 2025, Pages 2264-2275, ISSN 0022-0302.
https://doi.org/10.3168/jds.2024-25985

IV. Supply and milk market impacts of H5N1 in California: Economic data analysis to improve understanding and projections

Principal Investigator
Dr. Daniel A. Sumner, University of California, Davis

Aid in understanding potential impacts of HPAI on milk supplies and market impacts, including prices, quantities, incomes, and expenditures across affected groups

Project Objective

The rapid spread of Avian Influenza (H5N1) among dairy herds in California has raised many issues that are being evaluated and addressed, including economic issues of dairy farm costs, milk supply, and potential price impacts for producers and consumers.

Limited prior work has projected dairy industry-wide economic impacts of H5N1, and to the researchers' knowledge there has not been a data-based study assessing potential milk supply and market impacts of the spread of H5N1 in dairy cattle. The research team drew upon and adapted previously developed economic models of milk cow replacement and herd dynamics over time, models of aggregate milk supply and demand, including impacts of policy, and used their own previous economic research on animal disease economics, especially for contagious diseases that spread across and within herds. Previously, models of the economics of animal disease have seldom included careful treatment of the economics of the herd dynamics and replacement, which is vital in the present application. This project initiated a rapid, but thorough, economic analysis. This approach allowed for the development and application of newly adapted data-driven economic models of the California milk supply and demand, which incorporates farm supply, milk processing, demand for milk products, and relationships to local, national, and global product markets. This was followed by an assessment of the impact and projected impacts of H5N1 on production costs and trace these impacts through the supply

chain considering likely market and other responses. The project is designed to aid in understanding the potential impacts of the spread of H5N1 in California on the pattern of milk supplies and, hence, the market impacts, including prices, quantities, incomes, and expenditures across affected groups, which may include farm, feed suppliers, farm workers, processors, exporters, and consumers.

Progress

CDFA has received multiple reports from the researchers as the outbreak and data have evolved and the models have been updated with newer data. Analyses are continuing in advance of formal publication of the research results. Preliminary results can be found in the following publication:

Sambucci, O., Sumner, D.A., and Van Fleet, E.A. (2025) **Avian Influenza and the Economics of California Eggs and Milk: Some Early Assessments.** ARE Update 28(3): 1–4. University of California, Giannini Foundation of Agricultural Economics. https://s.giannini.ucop.edu/uploads/pub/2025/02/27/v28n3.pdf

V. Longitudinal evaluation of H5N1 shedding, transmission routes, clinical presentation and pathology in infected dairy calves in California

Principal Investigator

Dr. Wendi Jackson, California Animal Health and Food Safety Laboratory

Evaluate H5N1 viral transmission dynamics in dairy calves that can inform management decisions and biosecurity measures to reduce disease spread

Project Objective

The recent detection of HPAI (H5N1 clade 2.3.4.4b) in California dairy cattle and its sustained transmission within and between herds has significantly impacted dairy production in California through decreased milk production/sales, increased morbidity and treatment costs, and impairment of animal movement and sales. Cows clinical for H5N1 infection may carry fetuses to term but little is known about the in-utero risk for infection or the transmission routes to calves following parturition. Heifer calves may be raised on-farm or transferred to calf raising facilities until ~120 days of age before returning to the dairy as replacement heifers. Bull calves are moved to a calf ranch within 24-48 hours of birth to be reared until 180-210 days of age when they are then shipped to feedlots to be finished as beef cattle. For reasons related to calf welfare and volume of calves born daily on dairies, there are no transport restrictions in place (at this time) that prevent calves from being moved off farm from confirmed H5N1 infected dairies to these calf raising facilities where they may be comingled with calves from uninfected dairies. Experimental inoculation of aerosolized virus to dairy calves has demonstrated that calves can become infected and subsequently shed virus through nasal swab fluid confirmed by virus isolation. Calves infected experimentally displayed mild clinical signs of respiratory infection. Histological findings documented so far include suppurative tracheitis, bronchitis, bronchiolitis, and interstitial pneumonia. The same studies also found that calves seroconverted and had detectable antibodies to the nucleoprotein of Influenza A virus weeks

to months post infection. No studies available in the literature have evaluated the routes of transmission of H5N1 to dairy bull and heifer calves under natural conditions through colostrum/milk feeding, transport to the calf ranch or between calves on calf raising facilities in California, evaluated environmental samples, or summarized postmortem findings in this setting. There is also no current data or guidance on the risk of transmission from infected heifer calves upon return to their home dairy, or from bull calves upon entry to a feedlot, where these animals may introduce disease to naïve regions and herds/pen mates.

Progress

Project is underway and results are expected in 2026.