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2021

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REPORT & PROGRAM SCOPE

2021 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 2021 Annual Report focuses on the 2020 - 2021 fiscal year (FY 20 - 21), spanning July 1, 2020 - June 30, 2021. This report continues to inform legislators and stakeholders about the program's progress towards becoming a 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 preserve the efficacy of antibiotic drugs through a comprehensive 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 lead and support California stakeholders in this shared goal.



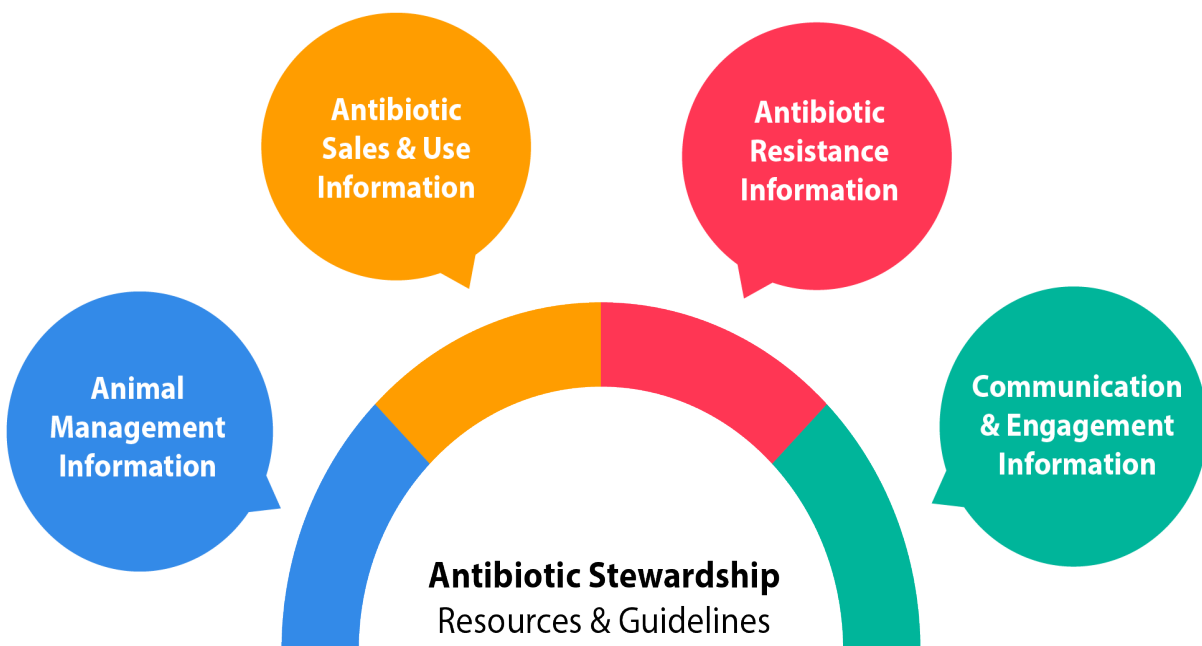
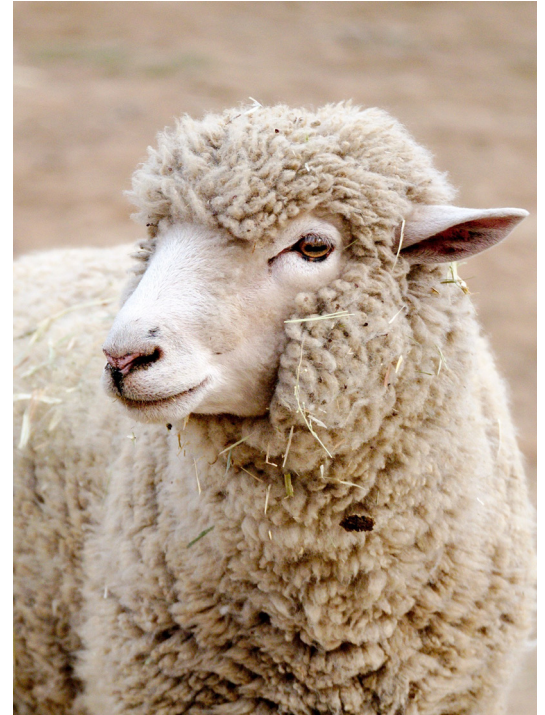
During FY 20 - 21, as the world continued to adjust to a new normal after the disruption by the SARS-CoV-2 pandemic, the steady rhythm of agriculture in California reassured and grounded us. Just like those we serve, this resilience motivated the AUS program in its planning, growth, and celebration of successes. AUS continued to expand



its understanding of California’s wide-ranging animal agricultural sectors through new collaborations and approaches to better serve our varied stakeholders.

AUS is proud of continuing its strong collaborations with academic researchers in the field of livestock antibiotic resistance, including award-winning AUS-funded research that received national recognition from the National Institute of Antimicrobial Resistance Research and Education (NIAMRRE) this year. 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 20 - 21, 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 educate and increase awareness of antibiotic drug preservation and 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 in data collection, trainings, educational outreach and engagement efforts.

AUS Outreach & Engagement

13 presentations 
reaching over **373** people

185 farms engaged
 across **12** studies



VFD Calculator

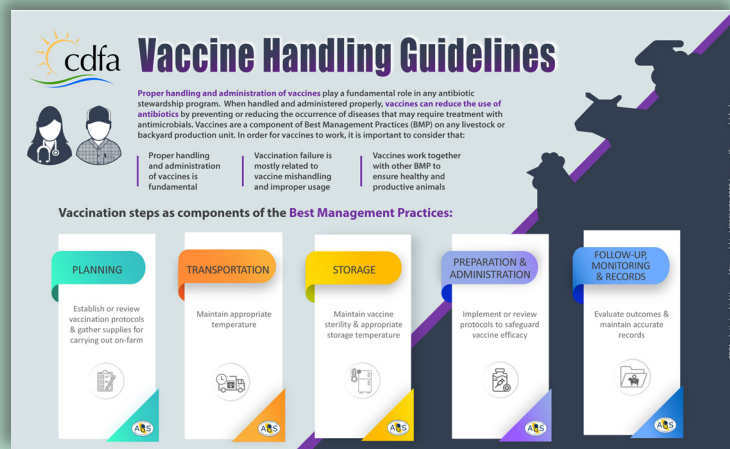
Public-private partnership between AUS and the Veterinary Information Network (VIN) to create a **Veterinary Feed Directive (VFD) Calculator**, publicly available to assist veterinarians in accurate VFD calculations in all types of livestock. Website link: <https://www.vin.com/VFD>



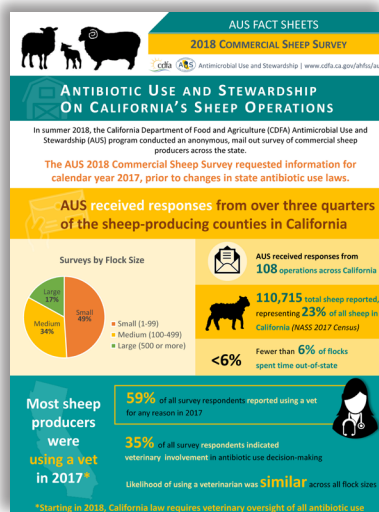
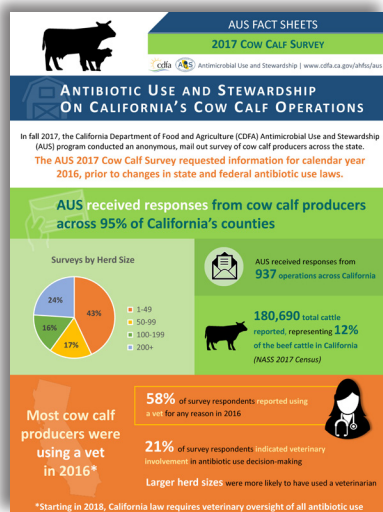
Find AUS publications, as well as scientific research papers resulting from AUS-funded projects, on our **website**: <https://www.cdfa.ca.gov/ahfss/AUS/Outreach.html>

Vaccine Best Management Practices for Veterinarians and Producers

A stepwise guidance document to help veterinarians and producers implement safe vaccine planning and handling procedures to effectively prevent primary and secondary bacterial diseases in livestock. These documents have been released in both English and Spanish.



Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive.



AUS Survey Fact Sheets

One-page fact sheets containing infographics that highlight key findings from AUS' recent Cow Calf and Commercial Sheep surveys. These documents have been released in both English and Spanish.



Online Restricted Livestock and California Prescription Drugs Evaluation

Inspections of online retailers who sell livestock drugs to ensure compliance with California laws and regulations

Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive.



Animal Management Strategies

Which health promotion and infection prevention practices are being used in California?

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 infographics highlight AUS' work in this area over the past fiscal year. Please refer to the Appendix for additional detail; more information will be provided in separate publications.



Dairy Cows

A large majority (73 - 87%) of responding dairies reported vaccinating cows for respiratory disease, coliform mastitis, and reproductive disease.

For a Deeper Look – see published paper on page 19



Results from an economic model conclude that it is economically feasible to implement selective dry cow therapy with the potential to reduce the use of antibiotics around the dry period by at least 29%, on select farms.

For a Deeper Look – see published paper on page 20



Beef Cattle

A literature review on pinkeye in beef cattle determined that additional research is necessary to support effective non-antibiotic treatment options.

For a Deeper Look – see published paper on page 22



CDFA provided field staff and funding in its collaboration with USDA to support expansion of the USDA NAHMS Health Management on U.S. Feedlots 2021.

Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 20 - 21.



Dairy Heifers

A study of weaned dairy heifers in California is exploring relationships between farm-level practices and antibiotic resistance in bacteria associated with bovine respiratory disease (BRD).



Commercial Sheep

An AUS-funded project has received 70 survey responses over 35 California counties, which will be analyzed to determine novel and effective future outreach materials for sheep producers.



Community of Practice

Researchers are implementing a strategy to support farm employees by tapping into their thirst for knowledge and building community through focused work groups.



Aquaculture

Survey development is in progress for distribution to California aquaculture producers to better understand disease concerns and industry practices. A literature review is also being performed to identify published resources for best practices in the aquaculture industry.

Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 20 - 21.



Goat

USDA NAHMS 2019 Goat Study: Veterinarian Use

In the USDA NAHMS Goat study, **56.2%** of California goat operations consulted a veterinarian for any reason related to goat health, productivity, or management in the 12 months prior to survey administration. Details of these results include:



Veterinarian use by operation size



43.5% of
small operations
(5 - 19 head)



66.7% of
medium operations
(20 - 99 head)



70.4% of
large operations
(100 head or more)

Veterinarian use by primary production of the operation



60.5% of
meat goat operations



55.0% of
dairy goat operations



48.4% of
"other" goat operations

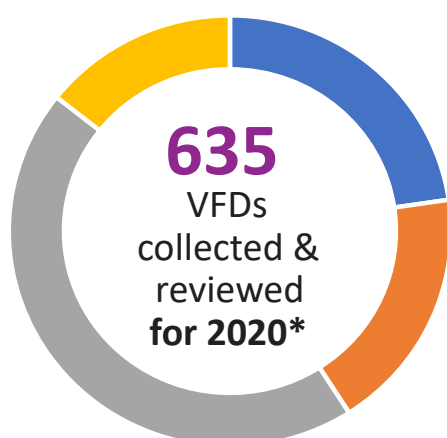
Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 20 - 21.



Antibiotic Sales & Use

Which 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, 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 (144)
- Gastrointestinal Disease (116)
- Both (284)
- Other (91)

**Number of VFDs collected for calendar year 2020. For more information, see AUS' VFD Summary Report. Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 20 - 21.*

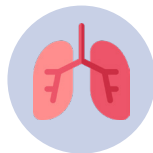
Antibiotic Use

Understanding how and why antibiotics are used is essential for antibiotic stewardship.



Dairy Heifers

The **top three diseases** for which antibiotic drugs were used to treat dairy heifers from birth to 180 days of age, as reported by the study farms, were (% of all antibiotic drug treatments recorded):



Pneumonia (56%)



Diarrhea (14%)



Pinkeye (13%)



Commercial Poultry

Samples were collected from broiler chickens and turkey flocks across California, resulting in *Salmonella spp.*, *E. coli*, and *Campylobacter* isolates that will be **tested for antibiotic resistance** and **matched with antibiotic use data**.

Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 20 - 21.



Goat

USDA NAHMS 2019 Goat Study: Antibiotic Use

In the USDA NAHMS 2019 Goat study, **36.1%** of California goat producers reported **not** using antibiotics during the 12 months prior to survey administration.



Producers that reported **not** using antibiotics by operation size



48.0% of
small operations
(5 - 19 head)



25.3% of
medium operations
(20 - 99 head)



29.5% of
large operations
(100 head or more)

Producers that reported **not** using antibiotics by primary production of the operation



37.1% of
meat goat operations



43.7% of
dairy goat operations



26.6% of
"other" goat operations

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Antibiotic Resistance

How are we looking at trends in antibiotic resistance?

During FY 20 - 21, AUS-funded research continued to evaluate antibiotic resistance trends through multi-year studies and newly commissioned projects. These antibiotic resistance trends are evaluated and analyzed through 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 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 strategies that may be implemented by California's livestock producers to help mitigate the development of antibiotic resistance. 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

Frequency of multi-drug resistance among fecal *E. coli* isolates was observed to be higher in winter versus summer, which may represent seasonal trends.

For a Deeper Look – see published paper on page 18

#1

Protocols have been developed to evaluate different methods for recovery of *Mannheimia haemolytica* and *Pasteurella multocida* from the respiratory tract in an effort to streamline collection of samples from dairy cows for generation of customized antibiograms.

AUS studies show that there is a transient association between antibiotic drug treatment and ceftiofur-resistant *Enterobacteriaceae* in early lactation dairy cows.

For a Deeper Look – see published paper on page 22

#4

Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 20 - 21.



Dairy Heifers

The finding from a study that sampled the upper respiratory tract of weaned dairy heifers on farms in California suggests widespread antibiotic resistance of bovine respiratory pathogens; for some respiratory pathogens, >50% of isolates were resistant to seven antibiotics from four different classes commonly used to treat pneumonia. This finding raises concern for the future efficacy of antibiotic drugs used for treatment of bovine respiratory disease in this animal production class. In the same group of cattle, enteric bacterial susceptibility, which is often monitored to help understand potential implications of antibiotic resistance in public health, appeared to have limited direct contemporaneous association with bovine respiratory pathogen antibiotic resistance.



Beef Cattle

The DNA of the microbial community in 80 fecal samples collected from beef cattle raised in different feeding systems and at different timepoints has been extracted for metagenomic analysis. Additionally, composite fecal samples from Holstein steers fed one of three experimental diets have been collected from three timepoints and stored for characterization of the fecal resistome using whole genome sequencing.



Sheep

439 isolates from sheep carcasses sampled at a processing facility will be tested to create antibiograms of respiratory bacteria recovered from healthy animals.

Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 20 - 21.



Commercial Poultry

From the 106 broiler chicken flocks sampled in 2021, *Salmonella* and *E. coli* bacterial isolates most commonly demonstrated reduced susceptibility to streptomycin, sulfonamides, or tetracycline, often in combination; many bacterial isolates were susceptible to all antibiotics assessed. Specific resistance patterns in the *Salmonella* isolates were highly dependent on *Salmonella* serotype.



Goat

For the USDA NAHMS 2019 Goat study, over 50 California goat operations submitted fecal samples from nearly 800 goats for enteric microbe testing, which includes antimicrobial susceptibility testing. Fortunately, very few California goat samples tested positive for foodborne pathogens. There were robust numbers of indicator bacteria isolated and the NAHMS collaborating labs are continuing to conduct the testing of these isolates.



CAHFS Testing

AUS funding helped support the California Animal Health & Food Safety (CAHFS) Laboratory to perform 1,093 antimicrobial susceptibility tests for clinical samples submitted from multiple livestock sources.

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

Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 20 - 21.



Communication & Engagement

How are we reaching people and improving our outreach efforts?

Key components of the AUS program mission include continuous 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 20 - 21, AUS presented many online educational opportunities, facilitating the reach for these informative sessions to those who could not participate in person. The following highlights are from AUS' work in this topic area over the past fiscal year. Please refer the Appendix for additional detail; more information will be provided in separate publications.

Partnering
for Dairy Antimicrobial Stewardship
Online Webinar Series — for Farmers and Veterinarians of the West

Over **100** veterinarians and producers attended an AUS-hosted virtual, month-long **stewardship-focused conference**, “Partnering for Dairy Antimicrobial Stewardship: A Conference for Farmers and Veterinarians in the West”

Veterinarians appreciated receiving more **online** and **in-person training** regarding the utilization of **antibiograms**

Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 20 - 21.



A response rate of **nearly 60%** from California goat producers in Phase II of the USDA NAHMS 2019 Goat study reflected **strong participation**

CSTE Youth in Agriculture Project

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AUS has partnered with the California Department of Public Health (CDPH) and a local theater company, who have acquired external funding through the Council of State and Territorial Epidemiologists (CSTE), to **produce educational materials** for 5 to 8-year-old children regarding **zoonotic diseases, proper hygiene, and antibiotic resistance**. This project encourages engagement with a veterinarian, especially when addressing sick animals and using antibiotics.

AUS increased its **use of social media** to engage and promote various projects and activities with the wider public

VFD compliance outreach

AUS is providing **outreach to feed producers** about proper VFD documentation

Facilitated funding opportunities

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CDFA AUS efforts helped to maintain and secure **8 nominations** through USDA NIFA to **alleviate veterinarian shortages in rural communities** through the Veterinary Medicine Loan Repayment Program (VMLRP)

AUS created **continuing education opportunities** for veterinarians and producers through the July 2020 Dairy Conference, antibiogram webinars, and California Temporary Licensing Curriculum classes

Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 20 - 21.



AUS-Funded Publications

How our researchers are building on current scientific knowledge

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 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 that have been released in the 2020 - 2021 fiscal year. Of note, due to publishing cycles and timing, some of the research detailed in the publications below may have occurred in prior fiscal years. The ten AUS-funded research journal papers in this section have been numbered if they were referenced within the body of report for ease of linking the research reference to the more detailed publication. For more information, please click on the links provided.



Abdelfattah EM, Ekong PS, Okello E, Chamchoy T, Karle BM, Black RA, Sheedy D, ElAshmawy WR, Williams DR, Califano D, Tovar LF. Epidemiology of antimicrobial resistance (AMR) on California dairies: descriptive and cluster analyses of AMR phenotype of fecal commensal bacteria isolated from adult cows. PeerJ. 2021;9. <https://peerj.com/articles/11108/>

Description: This study describes the occurrence of antibiotic resistance in commensal *Escherichia coli* and *Enterococcus/ Streptococcus spp.* isolated from fecal samples of dairy cows and assesses the variation in antibiotic resistance profiles across regions and seasons following the implementation of the Food and Agricultural Code (FAC) Sections 14400 - 14408 (formerly known as Senate Bill, SB 27) in California.



Abdelfattah EM, Ekong PS, Okello E, Williams DR, Karle BM, Rowe JD, Marshall ES, Lehenbauer TW, Aly SS. 2019 Survey of Antimicrobial Drug Use and Stewardship Practices in Adult Cows on California Dairies: Post Senate Bill 27. *Microorganisms*. 2021 Jul;9(7):1507.507.

<https://doi.org/10.3390/microorganisms9071507>

Ekong PS, Abdelfattah EM, Okello E, Williams DR, Lehenbauer TW, Karle BM, Rowe JD, Marshall ES, Aly SS. 2018 Survey of antimicrobial drug use and stewardship practices in adult cows on California dairies: post-Senate Bill 27. *PeerJ*. 2021 Jul 13;9:e11515.

<https://peerj.com/articles/11515.pdf>

Description: In this project, surveys were sent out to 1282 California dairies in both 2018 and 2019 to determine and evaluate changes in antibiotic use, health management, and antibiotic drug stewardship practices of adult cows on California dairies following the initiation of implementation of California Food and Agriculture Code 14400 - 14408 (formerly SB 27).



Basbas C, Byrne BA, Chigerwe M, Escobar ED, Hodzic E, Pires AF, Pereira RV. Detection of Cephalosporin and Fluoroquinolone Resistance Genes via Novel Multiplex qPCR in Fecal *Salmonella* Isolates From Northern Californian Dairy Cattle, 2002 - 2016. *Frontiers in Microbiology*. 2021;12.

<https://doi.org/10.3389/fmicb.2021.601924>

Description: In this study, *Salmonella* isolates obtained from dairy cattle were screened for beta-lactam resistance genes, focusing on genes linked to resistance to cephalosporin drugs, and quinolone resistance genes. Testing included whole genome studies focusing on isolates resistant to quinolones to identify potential chromosomal mutations leading to resistance to quinolone drugs. Temporal distribution of genetic elements was evaluated for links to antibiotic resistance, as well as potential trends or factors that could have influenced changes in their prevalence.





Ekong PS, Abdelfattah EM, Okello E, Williams DR, Lehenbauer TW, Karle BM, Rowe JD, Aly SS. 2018 Survey of factors associated with antimicrobial drug use and stewardship practices in adult cows on conventional California dairies: immediate post-Senate Bill 27 impact. PeerJ. 2021 Jul 13;9:e11596.
<https://peerj.com/articles/11596/>

Description: This project examined good antibiotic drug stewardship practices on conventional dairies in California using survey data from 2018 that was previously described in another publication. The authors applied machine learning to model the associations between management practices and seven outcome variables relating to antibiotic use and stewardship.



Hommels NM, Ferreira FC, van den Borne BH, Hogeveen HT. Antibiotic use and potential economic impact of implementing selective dry cow therapy in large U.S. dairies. Journal of Dairy Science. 2021 Apr 30.
<https://doi.org/10.3168/jds.2020-20016>

Description: In this study, the objectives were to evaluate the economic feasibility of implementing selective dry cow therapy (SDCT) in large U.S. dairy herds and to estimate the potential reduction in antibiotic use around the dry period if SDCT management is adopted. Cow-level data were obtained from the Dairy Herd Improvement Association and individual dairy herds in California. Logistic regression models were used to predict the incidence risk of subclinical and clinical mastitis in the subsequent lactation for 96 last test-day somatic cell score categories. This study showed that it is economically feasible on some farms to reduce antibiotic use associated with dry cow therapy in large U.S. dairy herds. This contributes to the efforts of reducing antibiotic use worldwide.



Michael A, Kelman T, Pitesky M. Overview of quantitative methodologies to understand antimicrobial resistance via minimum inhibitory concentration. *Animals*. 2020 Aug;10(8):1405.

<https://doi.org/10.3390/ani10081405>

Description: Minimum Inhibitory Concentration (MIC) testing is a common method of measuring the susceptibility of bacteria to antibiotic drugs. Several quantitative techniques exist for analyzing MIC data, but the application of these methods is not consistent across studies and no guidelines exist for how to choose the most appropriate method. The purpose of this paper is to outline important considerations for selecting the appropriate analytic method to use with MIC data based on the purpose and context of the study.



Okello E, Williams DR, ElAshmawy WR, Adams J, Pereira RV, Lehenbauer TW, Aly SS. Survey on antimicrobial drug use practices in California preweaned dairy calves. *Frontiers in Veterinary Science*. 2021;8.

<https://doi.org/10.3389/fvets.2021.636670>

Description: This survey allows immediate assessment of the impact of VFD final rule implementation and provides baseline data for future evaluation of the impact of VFD as well as SB 27 regulatory changes. The knowledge gained from this study is a valuable resource that could guide future recommendations for best health management practices and promote antibiotic stewardship efforts.





Sheedy DB, Okello E, Williams DR, Precht K, Cella E, Lehenbauer TW, Aly SS. Effect of Antimicrobial Treatment on the Dynamics of Ceftiofur Resistance in *Enterobacteriaceae* from Adult California Dairy Cows. *Microorganisms*. 2021 Apr;9(4):828.

<https://doi.org/10.3390/microorganisms9040828>

Description: This study investigates the time to peak population and time to return to pre-treatment population of phenotypically ceftiofur-resistant enteric commensal bacteria in response to systemic antibiotic treatment, in commercial dairy cows during the first 60 days of lactation, on two California dairies each across two seasons.



Sheedy DB, Samah FE, Garzon A, Fausak E, Van Noord M, Angelos JA, Maier GU. Non-antimicrobial approaches for the prevention or treatment of infectious bovine keratoconjunctivitis in cattle applicable to cow-calf operations: A scoping review. *Animal*. 2021 Jun 1;15(6):100245.

<https://www.sciencedirect.com/science/article/pii/S1751731121000872>

Description: Findings of the AUS 2017 Cow Calf Survey of California producers showed that pinkeye was one of the top three diseases of concern in this livestock population. In response, AUS funded a study to further explore options for producers to reduce the burden of this disease. In this scoping review, various non-antibiotic options for management of pinkeye were explored, resulting in the determination that further research is needed on the efficacy of fly control, and on non-antibiotic treatment options such as topical disinfectants or immune stimulants. The continued search for a viable vaccine, as well as identifying genetic markers associated with traits that confer resistance to the disease, are also needed.



Looking Ahead

What's next?

AUS has accomplished much in FY 20 - 21 and is looking forward to continuing this success in FY 21 - 22. 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 and areas of focus anticipated for the next fiscal year.



Dairy Cows

Using robotic milking data to better assist dairy producers and veterinarians to more accurately identify cattle with mastitis and to enable administration of more targeted antibiotic therapy



VFD Collection

Continued collection, reporting, and analysis of VFD orders to feed distributors



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



VFD Outreach to Veterinarians

Provide educational outreach to veterinarians in California that have written incomplete or incorrect VFDs and share strategies to help veterinarians incorporate best practices and avoid future VFD errors

Above is a selection of highlights from the work AUS completed over FY 20 - 21; it is not comprehensive. Ongoing studies report results over a number of years; results presented here were compiled in FY 20 - 21.

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 involvement provides valuable information that the program incorporates into publications and recommendations, impacting California agriculture. Antibiotic resistance is a threat to both human and animal health. By working together, we can find ways to minimize the risk of antibiotic resistance and can preserve the effectiveness of antibiotics for the future.



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



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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, from our research contractors to those who participated in our education and outreach initiatives. 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	<i>University of California, Davis</i>
Dr. Claire Burbick	<i>Washington State University</i>
Dr. Rosie Busch	<i>University of California, Davis</i>
Dr. Pedro Carvalho	<i>University of California, Davis</i>
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Dr. Sarah Depenbrock	<i>University of California, Davis</i>
Dr. Fernanda Ferreira	<i>University of California, Davis</i>
Dr. Heather Fritz	<i>California Animal Health and Food Safety Laboratory System</i>
Dr. Jackson Gross	<i>University of California, Davis</i>
Dr. Ashley Hill	<i>California Animal Health and Food Safety Laboratory System</i>
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Dr. Richard Pereira	<i>University of California, Davis</i>
Dr. Celina Phillips	<i>California State University, Chico</i>
Dr. Maurice Pitesky	<i>University of California, Davis</i>
Dr. Noelia Silva del Rio	<i>University of California, Davis</i>
Dr. Randall Singer	<i>University of Minnesota</i>
Dr. Bill Sischo	<i>Washington State University</i>
Dr. Martin Smith	<i>University of California, Davis</i>
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APPENDIX

The following pages represent high-level summaries of a selection of the studies and projects supported by AUS during FY 20 - 21. 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. Commercial Aquaculture Stewardship Guidelines and Best Management Practices

Addressing the most prominent disease challenges necessitating the use of antibiotics by various aquaculture sector types

Questions: What are the predominant disease challenges in California aquaculture? How are antibiotics used in these systems to prevent, control, and treat disease? What guidelines could help producers make informed decisions regarding antibiotic use and fish health on their farms?

Significance to CA: California aquaculture producers need tools to enhance their decisions regarding antibiotic use and animal health on their farms. This project aims to identify the extent of current antibiotic use and provide guidance on best practices for the diverse aquaculture production types in California.

Research Team: A university specialist in aquaculture from the University of California, Davis, Department of Animal Science Cooperative Extension, along with a graduate student and a workgroup of experts representing the aquaculture industry, academia, regulatory agencies, and veterinary medicine.

Summary: The aquaculture industry in California can be categorized into sectors based on product, supply chain, and antibiotic needs. The goal of this project is to create guidelines specific to the aquaculture sectors in California to reduce exposure of bacteria to medically important antibiotics and optimize use of antibiotics while maintaining a standard of animal health and welfare. This project will survey aquaculture producers about disease, antibiotic use, and management practices. Additionally, this project will include a literature review regarding the types of antibiotic products used in aquaculture; antibiotic resistance; disease prevention and control strategies; and antibiotic stewardship principles for the industry. Antibiotic stewardship guidelines for the California aquaculture industry will be compiled from literature, the industry survey report, input from the industry experts, AUS collaborators, and the workgroup. The guidelines are expected to benefit California aquaculture producers, their veterinarians, and the food supply chain.

Study Progress: The research team has organized a workgroup of industry and university experts that will provide input and critique research products from this project. Researchers are gathering literature from various databases of peer-reviewed publications regarding antibiotic use in aquaculture, with an emphasis on how California's unique geography and climate may influence fish health and disease. The research team is also finalizing a California aquaculture industry survey that will collect information on key aspects of antibiotic use, disease prevalence, and management practices in the various sectors.

How This Helps AUS: The project will develop materials, such as antibiotic stewardship guidelines, to aid California's aquaculture industry in tackling disease challenges requiring the use of antibiotics, thereby improving animal health and the targeted use of antibiotics.

Next Steps: The survey will be issued statewide, and data will be used to summarize California-specific disease challenges and antibiotic usage to inform development of stewardship guidelines. These guidelines will be user-friendly and provide explanations and solutions to relevant health issues to each aquaculture sector. Additionally, alternatives to specific antibiotic therapies in practice within the industry will be evaluated as part of guideline development. The guides will be distributed in English and Spanish to all aquaculture producers in California. An informational video will also be produced to extend these guidelines to a broader audience.

II. USDA National Animal Health Monitoring System (NAHMS) Health Management on U.S. Feedlots 2021

Nationwide study of U.S. feedlot operations to provide information regarding animal health and management practices

Question: What are the most important health issues facing the U.S. feedlot industry and what are the health management practices used, including antibiotic use practices?

Significance to CA: The California feedlot industry is an important part of the state's agricultural landscape. NAHMS studies are nationwide and typically report results by region, rather than by state. AUS collaborated with USDA's National Agricultural Statistics Service (NASS) and NAHMS to expand the 2021 Feedlot Study in California with the aim to obtain a representative sample from the state.

Research Team: A NAHMS team comprised of veterinarians, epidemiologists, and statisticians with longstanding experience conducting studies of this nature.

Summary: A two-phase study in line with previous USDA NAHMS studies: Phase I involves a general management survey of feedlot producers administered by NASS and Phase II involves a more in-depth NAHMS survey of animal health practices. CDFA provided funding to expand Phase I and offered personnel to help conduct Phase II. Eight CDFA staff were fully trained to administer the Phase II survey. Additionally, AUS provided feedback to NAHMS on the questionnaire design and also helped field-test the survey questionnaires. This study is designed to gather valuable information on the U.S. feedlot industry, including management practices associated with important beef cattle diseases. The study will also describe antibiotic stewardship on feedlot operations. Through AUS' collaborative efforts with NAHMS, the study expansion is designed to elicit California-level data in these aforementioned topic areas.

Study Progress: Phase I of the study began March 1st, 2021, Phase II began June 9th, 2021, and all data collection in California was concluded by October 2021. After data collection is completed, NAHMS will perform analysis of the study information.

How This Helps AUS: This collaborative study not only fulfills the mandate of FAC Section 14405(b) to avoid duplication of monitoring efforts, but also provides the opportunity for the California feedlot industry to provide information that is representative of the state and can be compared with national-level results reported by NAHMS. The findings from this study will help AUS develop appropriate antibiotic stewardship guidelines and best management practices for the feedlot industry.

Next Steps: NAHMS has begun data validation and cleaning. As NAHMS analyzes the data, information will be shared with AUS as appropriate. AUS will await the results and use them to serve the feedlot producers in the state.

III. Addressing On-Farm Antibiotic Drug Use Practices Through a Community of Practice-Based Approach

Communities of Practice as a professional development strategy to improve on-farm decision-making and use of antibiotics in animal agriculture

Question: Can a Community of Practice (CoP) approach improve the on-farm professional development of farmers and farm employees to address the effective and appropriate use of antibiotics on dairy and small ruminant farms in California?

Significance to CA: Despite Californian veterinarians' role as legal stewards of antibiotic use in livestock and in providing broad oversight as the prescriber, it is the farmer or employees of the farm that often identify individual animals and administers antibiotics based on veterinary protocols. Decision-making by the farmer or employee is often influenced by various factors such as previous experience, risk aversion, and costs; hence there may be a disconnect between antibiotic prescriber expectations and actions of the end users. This project seeks to identify and address that disconnect to achieve appropriate and judicious use of antibiotics.

Research Team: A university researcher specialized in professional development and a small ruminant herd health extensionist and production veterinarian with the University of California, Davis School of Veterinary Medicine, Veterinary Medicine Extension, along with a team of fellow university researchers and veterinarians.

Summary: Five cases, that comprise of individuals within an operational unit on a farm (i.e. maternity unit, hospital unit), will participate in this project; cases will vary based on size, commodity, time, and geography. Researchers will use a sequenced implementation schedule over a three-year period, whereby subsequent on-farm application of the CoP-based model will be informed by prior on-farm CoP outcomes. This data-driven approach will help refine the operational management model through incremental, systematic improvements. Qualitative data will be collected and analyzed to ascertain the effectiveness of the CoP model. A quantitative, pre-assessment and post-project evaluation will be developed to help better understand changes in on-farm antibiotic use and animal health.

Study Progress: The change management process is designed to go beyond simply solving the immediate challenges to address deeper systemic, cultural, and procedural barriers. At this time, two farms have been recruited to participate in this project, and participants for the CoP on each farm were identified. A CoP was developed during the fiscal year and facilitated on their first case, shaped to address employee involvement in antibiotic decision-making. A case focus allows for recommendations and conversations to be tailored to the needs of the employees who focus on key management systems within the farm.

How This Helps AUS: A CoP-based approach to producers' professional development can serve as a transferable model to influence farmer or farm employee decision-making behavior, shifting towards a better appreciation and adherence to judicious use of antibiotics on farms across California.

Next Steps: This project will expand to an additional three cases over the next two years. CoPs from each case will continue to meet regularly. The research team will assess the impact of the CoP intervention on changes and adoption of best practices for antibiotic use through exit interviews involving the herd veterinarian, farmer, and a focus group with each CoP. Additional resource materials will be made available to the AUS team at the end of the project to allow for greater application of CoP methodology beyond this contract period.

IV. Assessment of Antibiotic Resistance in Beef Cattle in California

Assess antibiotic resistance gene profiles and the microbial population in fecal samples from beef cattle raised in different production systems in California and the effect of an antibiotic alternative on the resistome of fecal samples from Holstein steers using a metagenomics approach

Questions: What are the resistance and microbiome profiles of enteric bacteria isolated from California beef cattle raised in different grass-fed and conventional feedlot production systems? What are the effects on resistance profiles of enteric bacteria isolated from Holstein beef cattle fed with an ionophore antibiotic compared to an antibiotic alternative?

Significance to CA: California raises an estimated 1,570,343 beef cattle across the state (NASS 2017), making it an important component of the California livestock industry. Production system and diet can have a major effect on antibiotic drug resistance in beef cattle. Better understanding these effects will help to inform beef producers and their veterinarians when making management decisions and how they relate to antibiotic drug resistance.

Research Team: University of California, Davis researchers and Cooperative Extension specialists with extensive experience with beef cattle production systems, management practices, and antibiotic resistance.

Summary: This study has two objectives. Objective 1 is to use banked samples from a previous study of cattle raised in grass-fed and conventional production systems in California to characterize and compare the fecal resistomes and microbiomes. Objective 2 will build upon an ongoing study of cattle finished at the Desert Research and Extension Center, University of California feedlot and characterize and compare the fecal resistome of Holstein steers fed with either an ionophore antibiotic, antibiotic alternative, or no additive to assess the effect of different feed additives on the degree of antibiotic resistance present in the feces of the study steers.

Study Progress: Objective 1: A total of 80 samples were selected from a previous project (10 samples/ 4 feeding systems/ 2 sampling times). The DNA from the microbial community in each sample was extracted. All DNA samples were submitted to the Genome Center at University of California, Davis for metagenome library preparation and shotgun sequencing. Objective 2: The first half of the fecal sampling has occurred.

How This Helps AUS: This project will aid the California beef industry and public as a whole in advancing the understanding of antibiotic resistance as it relates to differing beef production systems and ionophore antibiotic vs. antibiotic alternative feed additives fed to Holstein steers in California. Findings from this project will directly feed into future resources in this topic area, inform on the need for additional research, and help to advance antibiotic resistance trend monitoring through metagenomic analysis, all to support statewide goals.

Next Steps: The basic bioinformatics analysis will be conducted in Objective 1. The sample collections will continue through December 2021 for Objective 2.

V. Animal Poo and You – Staying Healthy Around Animals: A Multimedia Primer on Zoonotic Disease Prevention for Youth in Agriculture

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A collaboration with the California Department of Public Health (CDPH) and Bike City Theater Company, using a One Health approach, to provide education to youth aged 5 to 8 years old engaging in agricultural activities about zoonotic diseases and antibiotic drug resistance in an interactive and engaging format

Questions: How do we educate youth regarding zoonotic diseases and antibiotic drug resistance? What are the most important lessons to be learned that would be understood by this age group? How do you engage youth in the 5 to 8-year-old age range in learning about zoonotic diseases and antibiotic drug resistance?

Significance to CA: In summer 2019, an outbreak of Shiga-toxin-producing *Escherichia coli* (STEC) enteritis linked to livestock at a county fair was identified in San Diego County, California. Of 13 cases identified in the outbreak, 10 were children between the ages of 1 and 13 years. Subsequent to the 2019 outbreak, CDPH identified an unmet need for materials and resources designed to inform fair organizers on best practices for prevention of zoonotic diseases. This project will target a specific age range to help educate and engage youth participating in agricultural activities about the importance of antibiotic resistance and zoonotic diseases.

Research Team: CDPH reached out to California Department of Food and Agriculture (CDFA), California Foundation for Agriculture in the Classroom, UC Davis Cooperative Extension, as well as a local theater group, Bike City Theater Company, to develop materials, including song scripts, animations, and educational materials to be distributed to youth agricultural organizations and other rural youth groups.

Summary: Funded by a grant from the Council of State and Territorial Epidemiologists (CSTE), *Animal Poo and You* is an integrated curriculum designed to introduce basic concepts of zoonotic disease prevention to youth engaged in organized agricultural education. Lessons are designed and developed using vocabulary and images, presented in a musical narrative, appropriate to youth aged 5 - 8 years. Each video lesson presents the student with information on a specific area of zoonotic disease prevention and may be viewed individually or in a classroom setting. An Instructors' Guide provides a summary of the video lesson, additional information on the topic, and activities and resources that the instructor can use to further reinforce the learning objectives.

Study Progress: The team has developed five song scripts and has hired an animator. Recording of the songs will be completed in August 2021. Educational materials are being produced and edited for final production estimated to be completed after the spring of 2022.

How This Helps AUS: Education of youth on the importance of zoonotic diseases and antibiotic resistance helps raise awareness of these key concepts that they will carry into their future in agriculture. By educating youth at a young age about the importance of these concepts, AUS will be able to better support California's livestock community through science-based learning and a One Health approach.

Next Steps: Once the five lessons are complete, which includes an animated song and educational materials for each section, the packages will be distributed to youth groups in California after the expected completion in the spring of 2022.

VI. Antibigram Pilot Project

Evaluation of an antibiogram framework from commercial dairy farms in California for bovine respiratory disease bacterial pathogens

Questions: What are the most effective methods for offering the generation of customized antibiograms as a service to California's veterinarians and producers? How can this service realistically be implemented on-farm?

Significance to CA: Antibigrams, which consist of cumulative antibiotic susceptibility testing (CAST) data for select bacterial pathogens from clinical cases over time, represent an important tool for antibiotic therapy decision-making. This study aims to produce foundational data that will support the implementation of a CAST program in commercial dairy farms in California, supporting statewide efforts to improve antibiotic stewardship.

Research Team: The research team leading this project at University of California, Davis has long-standing relationships with California dairies as well as expertise and previous work focused on herd health, veterinary epidemiology, and antibiotic resistance.

Summary: Antibigrams can provide California's veterinarians with an additional tool for initial antibiotic therapy decision-making; however, it must be determined how to potentially implement this service on-farm in a practical and effective manner. The goals of this project include: 1) evaluating a framework for longitudinal collection of samples from dairy cattle with clinical signs of bovine respiratory disease (BRD) and evaluation of BRD bacterial pathogens using antibigrams; and 2) identifying an approach that maximizes effectiveness of sampling, storing, and transporting nasopharyngeal samples submitted for culture and antibiotic susceptibility testing. This will be accomplished by collecting nasopharyngeal samples from dairy cattle with clinical signs of BRD to isolate BRD pathogens, *Mannheimia haemolytica* and *Pasteurella multocida*. The study will collect samples from up to three large (> 1,000 lactating cows) commercial dairy farms in California over two years and customized antibigrams will be provided to the participating dairies.

Study Progress: Commercial dairies have been enrolled in the study, and the research team has initiated in-lab evaluation of methods for recovery of *M. haemolytica* and *P. multocida*, including the effects of types of deep nasopharyngeal sampling, transport media, temperature, and time of storage.

How This Helps AUS: This project provides not only direct benefit to commercial dairy producers that participate in the study by offering customized antibigrams, but also supports AUS' multiple ongoing projects with the goal of more widely offering antibiogram services to California's veterinarians and producers. The study activities provide foundational proof-of-concept information that is essential to this larger goal, which would provide a service of benefit to industry and the public in offering an important tool for promoting responsible antibiotic use across the state.

Next Steps: The research team will continue to evaluate methods related to sampling, transport, storage, and recovery of the BRD pathogens. Additionally, participating dairies will be sampled over a two-year period to generate data for customized antibigrams. These antibigrams will be provided, as well as analyzed to evaluate factors that influence data interpretation. Peer-reviewed publication regarding study findings and presentation at professional meetings are anticipated. The results of this study will also feed directly into AUS monitoring and stewardship activities.

VII. Pilot Study of Resistance Profiles of Ovine Respiratory Pathogens

*Prevalence and antibiotic resistance profiles of ovine respiratory pathogens (*Mannheimia haemolytica* and *Pasteurella multocida*) from healthy California sheep: Results from a pilot survey*

Question: What is the prevalence and antibiotic resistance profile of bacteria frequently associated with ovine respiratory disease found in healthy sheep in California?

Significance to CA: California ranks second in the nation for sheep production. Bacteria from food animals that are currently evaluated through the National Antimicrobial Resistance Monitoring System (NARMS) are of gastrointestinal origin and are either of a food safety concern (*Campylobacter spp.* and *Salmonella spp.*) or considered to be indicator organisms (*E. coli* and *Enterococcus spp.*) for evaluating antibiotic resistance. Resistance among the common ovine respiratory pathogens, *M. haemolytica* and *P. multocida*, is poorly understood and represents a major gap in the currently available information veterinarians could use for making treatment decisions that support judicious use of antibiotics.

Research team: CDFA Antimicrobial Use and Stewardship (AUS) team in collaboration with California Animal Health Food Safety Laboratory (CAHFS) Veterinary Diagnostician.

Summary: Microbroth dilution minimum inhibitory concentration (MIC) testing will be performed on all target isolates cultured from healthy sheep to provide cumulative antibiotic susceptibility data for veterinarians, as well as surveillance information for comparison with other available databases.

Study progress: Collection of samples for culture, isolation, and antibiotic sensitivity testing is in progress. Data analysis will be performed upon completion of susceptibility testing. Results are anticipated to be submitted for peer-review scientific publication.

How this helps AUS: Results generated from this study will provide AUS with data to support long-term antibiotic resistance trend monitoring in sheep and help inform treatment decisions for ovine respiratory disease and prudent use of antibiotics at the farm level. Efforts to monitor antibiotic resistance trends are essential for promotion of antibiotic stewardship and minimizing antibiotic resistance in the food supply chain.

Next steps: Meetings with stakeholders will be arranged to share results and discuss findings. Peer-reviewed publication of the study findings are planned. Additionally, cumulative susceptibility of isolates from clinical samples tested at CAHFS will be compared to those collected for this project to identify / describe any differences. This study's results will feed directly into AUS surveillance and stewardship activities in California's small ruminant population.