2019

USDA APHIS VS National Animal Health Laboratory Network (NAHLN) Antimicrobial Resistance Pilot Project

YEAR 2 REPORT: 2019

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Executive Summary

The National Animal Health Laboratory Network (NAHLN) antimicrobial resistance (AMR) pilot project aims to demonstrate the viability of implementing a sampling stream for monitoring AMR profiles in animal pathogens routinely isolated by U.S. veterinary clinics and diagnostic laboratories. The project provides AMR profiles for livestock/production and companion animals that are clinically ill, compared to other national surveillance programs that evaluate healthy animals.

This report describes AMR data collected and funded by the United States Department of Agriculture (USDA) during the second year of the pilot, January 1 – December 31, 2019. In 2019, 24 laboratories participated; 23 were NAHLN member and 1 was associated with a U.S. college of veterinary medicine. This is a 26.3% increase from the 19 laboratories enrolled during the initial year of the pilot.

Bacterial isolates were selected to represent both pathogens of veterinary importance and zoonotic bacteria monitored through other national food-borne pathogen surveillance systems. Data from 5,430 isolates were submitted in 2019, a 69% increase over 2018. Isolates surveyed in 2019 were: *Escherichia coli (E. coli)* – 2,743 isolates across all animal species*; Salmonella enterica* spp. – 850 isolates from cattle; *Mannheimia haemolytica* – 612 isolates from cattle; *Streptococcus suis* – 167 isolates from swine; *Pasteurella multocida* – 51 isolates from poultry; *Streptococcus equi* – 57 isolates from horses; *S. equi* ssp. *zooepidemicus (S. zooepidemicus)* – 359 isolates from horses; and *Staphylococcus intermedius* group – 1,061 isolates from dogs and cats.

The project evaluated antimicrobial resistance for antibiotics with animal- and bacterial-specific breakpoints, as reported in *VET08 Performance Standards for Antimicrobial Disk and Dilution Susceptibility Tests for Bacteria Isolated from Animals, 4th edition* (CLSI, 2018).

Across production animals, resistance rates for *M. haemolytica* in cattle showed a slight decreasing trend, with over 75% of isolates being pan-susceptible to all antimicrobials. Antimicrobial resistance in swine *S. suis* isolates was at or below 15%, with the exception of tetracycline, which had a resistance rate of 98%. Veterinary clinical breakpoints are not available for the other bacterial pathogens monitored in cattle, swine, and poultry, so evaluation of resistance trends was not possible.

For companion animals, *E. coli* antimicrobial resistance in dogs exhibited a slight overall downward trend. More bacteria were identified in 2019 as candidates for screening for extended beta lactamase resistance over 2018 for both dogs and cats. Isolates of *S. equi* and *S. zooepidemicus* in horses showed extremely low resistance to penicillin and cephalosporins (1% or lower), but were highly resistant to fluoroquinolones, tetracyclines and aminoglycosides (84%-100% resistance).

Results for 2019 show that oxacillin resistance (OX^R) in *S. intermedius* group isolates continues to increase in dogs. These OX^R isolates also continue to exhibit high resistance rates (60 – 100%) to all other antimicrobial classes for which CLSI canine breakpoints are available. Additionally, 62.3% of the OX^R isolates were also categorized as multi-drug resistant (MDR), the highest MDR rate of all animal/bacterial categories. This is an increase from 2018, where 56.9% of isolates in this category were classified as MDR.

Introduction

The United States National Action Plan for Combatting Antibiotic Resistant Bacteria (CARB) calls for collaborative action by the U.S. Government to strengthen our resources to address increasing antimicrobial resistance observed in both humans and animals. Within the USDA Animal and Plant Health Inspection Service (APHIS), the gap in information on antimicrobial resistance trends in sick animal populations was addressed for the second year through the pilot project established through the National Animal Health Laboratory Network (NAHLN), working in collaboration with veterinary diagnostic laboratories and clinics throughout the U.S.

Second-year goals of the NAHLN AMR pilot project continue to be: monitor AMR profiles in animal pathogens for trends in antimicrobial resistance phenotypes and genotypes; identify new or emerging resistance profiles; help monitor the continued usefulness of antimicrobials over time; and provide information back to participating laboratories, other federal agencies, and industry stakeholders regarding these trends.

Participating laboratories selected isolates obtained from routine clinical cases and performed antimicrobial susceptibility testing using a commercially available testing platform (Sensititre®). Laboratories then submitted the data to the NAHLN for monitoring. This report outlines the results of this monitoring.

Materials and Methods

Laboratory enrollment

The NAHLN distributed a request through the American Association of Veterinary Laboratory Diagnosticians (AAVLD) to gauge 2019 project participation interest. Participation was open to public and private veterinary diagnostic laboratories and clinics in the United States. Twenty-four laboratories enrolled during the second year, an increase of five laboratories over 2018. Participating laboratories were from Alabama, California, Colorado, Florida, Georgia, Indiana, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Missouri, Mississippi, Nebraska, New York, North Dakota, Ohio, Pennsylvania, South Dakota, Texas, Washington, and Wisconsin (Figure 1). Twenty-three of these laboratories were State or University-associated veterinary diagnostic laboratories with membership in the NAHLN. One laboratory was not a NAHLN member, but associated with a U.S. college of veterinary medicine.

Figure 1. Geographic distribution by state of laboratories in the 2019 NAHLN AMR pilot project.

States of participating laboratories are shaded in dark grey.

Pathogens monitored

Selection of bacterial species to monitor was adjusted based on results from 2018. For 2019, *Salmonella* monitoring was discontinued for all animals except for cattle, as the goal of 100 isolates per animal species was not reached in 2018. Thus, insufficient numbers of isolates were available through this surveillance stream to indicate AMR trends among clinically ill animals at a national level. To replace *Salmonella* monitoring, the following pathogens were chosen for evaluation in 2019: *Streptococcus suis* in swine, *Pasteurella multocida* in poultry, and *Streptococcus equi* plus *S. equi* ssp. *zooepidemicus (S. zooepidemicus)* in horses. A complete list of pathogens monitored in 2019 for each animal species, resulting in 14 bacterial pathogen-host animal species categories is provided in Table 1.

Table 1. Pathogen/animal species and number of categories for monitoring.

Bacterial pathogen	Animal Species	No. of Categories
Escherichia coli	cattle, swine, poultry, horses, dogs, cats	6
Mannheimia haemolytica	cattle	1
Salmonella enterica	cattle	1
Streptococcus suis	swine	1
Pasteurella multocida	poultry	1
Streptococcus equi	horses	1
Streptococcus equi ssp. *zooepidemicus*	horses	1
Staphylococcus intermedius group*	dogs, cats	2

*Includes *S. intermedius, S. pseudintermedius* and *S. delphini*.

Participating laboratories were instructed to select only isolates that were associated with clinical disease or diagnostic findings, and limit submissions to only one isolate from the same herd/flock, farm/household, or owner. To minimize local or regional bias in the aggregate dataset, laboratories were asked to submit data from no more than 40 isolates for each bacterial pathogen-host animal category, except for *Mannheimia, E. coli* and *Staphylococcus* categories, which were capped at 65 isolates each per laboratory.

Antimicrobial Susceptibility Testing and Reporting

Antimicrobial susceptibility testing (AST) was conducted in the same manner as in 2018. All testing was performed using the Sensititre™ broth microdilution platform (Thermo Fisher Scientific, Waltham, MA; https://assets.thermofisher.com/TFS-Assets/MBD/brochures/Sensititre-Plate-Guide-Booklet-EN.pdf). Testing used the same Sensititre™ microdilution plates as the previous year, to facilitate data comparison across years. Plate usage was based on animal species and pathogen, as outlined in Table 2.

Table 2. Sensititre™ plates used for Year 2 of the pilot project.

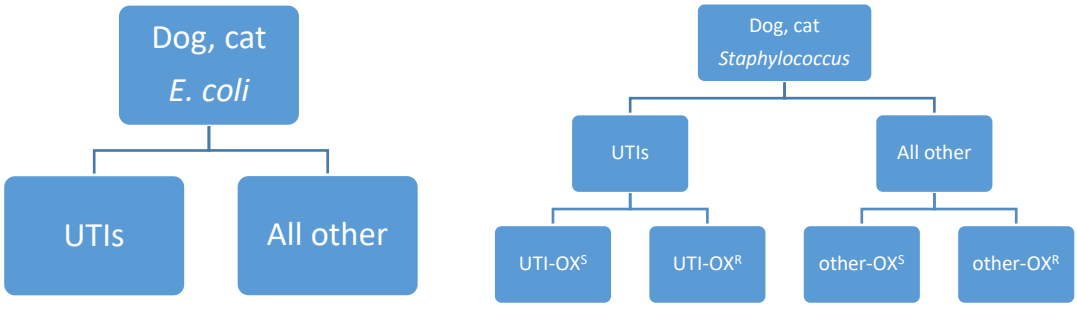
Bacterial Pathogen	Animal Species					
	Cattle	Swine	Poultry	Horses	Cats	Dogs
E. coli	BOPO6F or BOPO7F	BOPO6F or BOPO7F	Avian1F	Equin1F	COMPGN1F	COMPGN1F
Salmonella spp.	BOPO6F or BOPO7F	N/A*	N/A	N/A	N/A	N/A
M. haemolytica	BOPO6F or BOPO7F	N/A	N/A	N/A	N/A	N/A
P. multocida	N/A	N/A	Avian1F	N/A	N/A	N/A
S. intermedius grp.	N/A	N/A	N/A	N/A	COMPGP1F	COMPGP1F
S. suis	N/A	BOPO6F or BOPO7F	N/A	N/A	N/A	N/A
S. equi	N/A	N/A	N/A	Equin1F	N/A	N/A
S. zooepidemicus	N/A	N/A	N/A	Equin1F	N/A	N/A

**N/A = not applicable.*

Minimum inhibitory concentration (MIC) data were compiled across all laboratories for each animal/pathogen combination monitored. MIC data are provided for all antimicrobials present on the commercial plates used in this pilot, regardless of whether there is a label or indication for therapeutic, preventative, or control type of use. Susceptible, intermediate, and resistant interpretations are only provided for those antimicrobials with established pathogen-specific and host animal-specific clinical breakpoints according to the Clinical Laboratory Standards Institute's *VET08* standard (CLSI, 2018).

Companion animal *E. coli* and *Staphylococcus intermedius* group isolates were differentiated into isolates cultured from urinary tract infections (UTIs) and all other non-UTI sources in order to more accurately apply MIC breakpoint interpretations (Figure 2). *S. intermedius* group isolates were further separated into oxacillin-sensitive (OX^S) and oxacillin-resistant (OX^R) groups based on human-derived breakpoints. This distinction was made to identify isolates potentially carrying methicillin resistant genetic elements, thus rendering isolates resistant to additional β-lactam antimicrobials, including penicillin and extended spectrum β-lactam cephalosporins.

Figure 2. Breakdown of companion animal isolates for AST.



UTIs = isolates recovered from urinary tract infections; OX^S = oxacillin sensitive; OX^R = oxacillin resistant.
Oxacillin sensitivity/resistance based on human breakpoints

Epidemiological data reported

Laboratories were requested to assign a unique identifier (ID) to each isolate to eliminate all personally identifiable information associated with an isolate. Additional information reported for each isolate included the following:

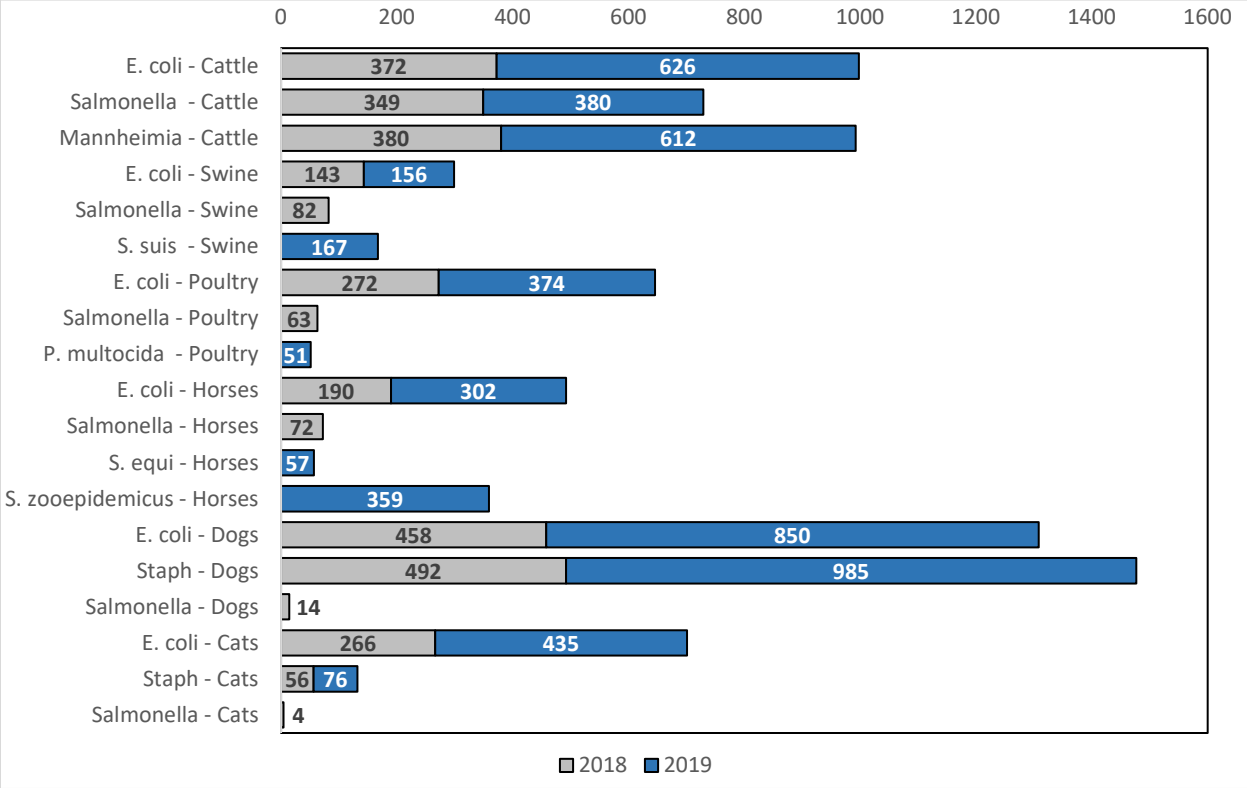
- purpose of submission (for example, general diagnostic)
- bacterial organism (genus/species/serotype)
- date of isolation
- animal species
- state of origin of animal
- specimen/source tissue isolate was recovered from (for example, oropharyngeal swab, lung tissue, or feces)
- final diagnosis or results for case

Results

Data provided in this report represents isolates recovered from routine diagnostic samples submitted to participating laboratories between January 1 and December 31, 2019. The target for 2019 was 6,000 isolates across all bacterial pathogen and animal species. Towards this goal, NAHLN received data submissions from 5,430 isolates, a 69% increase over 2018. Individually, each laboratory could submit up to 720 isolates across all 14 bacterial pathogen-animal host species categories. However, regional differences in animal populations, availability of resources, and variability in annual case load all impact the ability of any single laboratory to meet this maximum. For the second year of this pilot, individual laboratory submissions ranged from 58 to 449, with an average of 225 submissions per lab. This is an increase over 2018 submissions, which ranged from 24 to 229 submissions per laboratory, and averaged 170 submissions per laboratory. The total number of isolates submitted in 2019 for each category is shown in Figure 3.

The pilot project goal of 400 isolates per category was met or exceeded for all canine pathogens, bovine *E.coli*, bovine *M. haemolytica,* and feline *E. coli*. Unsurprisingly, laboratories from the Midwest were most likely to meet or exceed individual laboratory goals (40-65 isolates per category) for bovine and porcine isolates, echoing the geographic location of these animals in the United States. Conversely, three categories received data from fewer than 100 isolates across all 24 laboratories; poultry *P. multocida*, equine *S. equi*, and feline *S. intermedius* group. Although these numbers are somewhat low, this correlates with submission rates for these pathogens described in the 2015 survey of U.S. veterinary diagnostic laboratories (Dargatz, et. al., 2017). Conversely, canine *S. intermedius* group isolates were most commonly submitted in 2019, with seven laboratories meeting the individual goal of 65 isolates per laboratory (Figure 3).

Figure 3. Overall numbers of isolates submitted for 2018-2019 of the APHIS NAHLN AMR Pilot Project, by animal and bacterial pathogen category.



Cattle

General

Information on production type (dairy, beef) and age was not collected for 2019. All aggregate data on MICs represent antimicrobials from both the BOPO6F and BOPO7F plates; thus isolate numbers may differ between antibiotics.

Cattle – *E. coli*

The year 2 dataset represents 626 isolates, a 68.3% increase over year 1. Ceftiofur and ampicillin are the only two antimicrobials with clinical breakpoints for *E. coli* in cattle, both for treating specific clinical indications (ampicillin for metritis; ceftiofur for mastitis).

In 2019, there were ten isolates associated with mastitis and one isolate from a metritis case. One of the ten mastitis isolates was resistant to ceftiofur. The single metritis isolate was susceptible to ampicillin. Due to the low numbers of isolates for both of these categories, comparisons to year 1 data were not conducted. All MIC data for bovine *E. coli* isolates are in Table 3, Appendix A.

Trends for clinical signs or indications associated with *E. coli* infections are shown in Table 4, Appendix A. Diarrhea/enteric infections were again the majority (64.1%), followed by septicemia (9.6%) and pneumonia (7.7%). Remaining indications and clinical signs can be found in Table 4.

Cattle – *Salmonella* spp.

MIC data for the 380 AST profiles submitted for *Salmonella* is available in Table 5, Appendix A. Dublin, Cerro, Typhimurium, and Montevideo were the most frequently identified of the 48 different *Salmonella* serotypes reported in 2019, representing approximately 67% (255/380) of the dataset. Because many of the serotypes are infrequently reported, a closer look at the 20 most frequently isolated serotypes from 2018 and 2019 are shown in Figure 4, Appendix A. A full list of all serotypes recovered for both 2018 and 2019 is provided in Table 6, Appendix A.

Serotype Dublin was the most common serotype associated with clinical submissions for cattle for 2019. Diagnoses reported in association with these submissions included diarrhea/enteric disease, septicemia, pneumonia, and abortion/neonatal death. Serotypes Cerro, Montevideo, and Typhimurium were detected in more than 10% of all submissions to the AMR pilot, in which diarrhea/enteric disease was reported. All serotypes associated with clinical signs are provided in Table 7, Appendix A.

Cattle – *Mannheimia haemolytica*

Data for 612 isolates were submitted in 2019, representing a 61.1% increase over 2018. As expected, all isolates were associated with pneumonia or respiratory disease. Of these, 69.4% (425/612) were pan-susceptible, slightly higher than the 2018 pan-susceptible percentage 65.3%, indicating a slight downward trend in resistance for *M. haemolytica* isolates. MIC values for all antimicrobials and antibiotic classes is shown in Table 8, Appendix A.

Resistance to individual antimicrobials also showed a decreasing trend compared to 2018 (Figure 5, Appendix A), with the exception of tetracycline, gamithromycin, and tildipirosin. While it is unknown why this increase in resistance is being observed, these three antibiotics are present only on the newer BOPO7F plate. Thus, it is possible that there were not sufficient numbers of isolates tested in 2018 to

accurately establish a baseline of resistance, as only 92 isolates were tested with the BOPO7 plate in 2018, compared to 139 isolates in 2019.

In 2019, 10.9% (67/612) of the isolates were resistant to only one antimicrobial, and 3.1% (19/612) were resistant to two antimicrobials. Of the remaining 187 isolates, 101 isolates (16.5%, 101/612) were resistant to three or more classes of antimicrobials, thus meeting the MDR definition. This is slightly lower than the MDR rate of 18.7% in 2018. Seventeen of the 101 MDR isolates (16.8%) from 2019 were resistant to 11 of the 12 antimicrobials with bovine breakpoints, which is higher than 2018, where 5/71 (7.0%) of all MDR isolates were resistant to 10 of the 12 antimicrobials. Table 9, Appendix A provides the complete analysis of antimicrobial resistance for the bovine *M. haemolytica* isolates.

Swine

General

As with the cattle isolates, all aggregate data shown for swine MICs represent antimicrobials from both the BOPO6F and BOPO7F plates; thus total isolate numbers may differ between antimicrobials.

Swine – *E. coli*

In 2019, AST profiles for 156 swine isolates were submitted, an increase of 9.1%. The MIC data for these isolates is shown in Table 10, Appendix B. Similar to 2018, 72.4% (113/156) of the isolates were associated with diarrhea/enteric disease, 10.9% (17/156) were from pneumonia/respiratory disease cases, and 4.5% (7/156) were associated with septicemia. See Table 11 Appendix B for a complete list of clinical signs and diagnoses associated with porcine *E. coli* infections.

Swine – *Streptococcus suis*

Streptococcus suis, a significant cause of pneumonia and meningitis in weanling pigs, was added to the pilot project in 2019. Sixteen laboratories submitted data for 167 isolates. There are six antimicrobials with breakpoints established for *Streptococcus* from swine. These are ceftiofur, enrofloxacin, ampicillin, penicillin, florfenicol, and tetracycline. MIC values for all antimicrobials are in Table 12, Appendix B.

For those six antimicrobials with breakpoints, 35.9% (60/167) of the isolates were susceptible to all antimicrobials. Resistance to at least one antimicrobial was observed in 50.9% (85/167) of the isolates, and another 10.7% (18/167) were resistant to two antimicrobials.

Four isolates were resistant to three or more antimicrobials, and met the definition of multi-drug resistance. Two isolates were resistant to ceftiofur, penicillin, and tetracycline. One was resistant to enrofloxacin, penicillin, and tetracycline. The remaining isolate was resistant to ceftiofur, enrofloxacin, penicillin, and tetracycline.

Among the 107 isolates resistant to at least one antimicrobial, 92.5% (99/107) were resistant to tetracycline. 22.4% (24/107) were resistant to penicillin, 1 was resistant to ampicillin, and 1 isolate each was resistant to ceftiofur or enrofloxacin, respectively.

Pneumonia and other respiratory diseases accounted for 56.9% of all diagnoses reported for *S. suis* isolate submissions. Final diagnoses of sepsis/septicemia and meningitis/encephalitis were the second and third most common at 9.6% and 9.0%, respectively. Additional diagnoses are presented in Table 13, Appendix B.

Poultry

General

For the second year, this pilot project monitored AMR in bacterial isolates recovered from domestic chickens, turkeys, and ducks only. Breakpoints for antimicrobials have not been established for either *E. coli* or *P. multocida*, with the exception of enrofloxacin. However, approval for use of enrofloxacin in poultry was withdrawn by FDA in 2005. Thus, data for 2019 are provided for all antimicrobials on the commercial avian plate (AVIAN1F) regardless of therapeutic use.

Poultry – *E. coli*

Data from 374 poultry *E. coli* isolates was submitted in 2019, an increase of 37.5% from the first year of the pilot project. The submitted isolates included 253 from chickens, 4 from ducks, and 117 from turkeys. MIC data is presented both as aggregate data for all poultry (Table 14, Appendix C), chickens and ducks combined (Table 15, Appendix C), and turkeys (Table 16, Appendix C).

Antimicrobial resistance to enrofloxacin remained steady compared to 2018, with a 1.9% rate of resistance for 2019 compared to 1.1% resistance for 2018 across all poultry.

All diagnoses associated with poultry infections are provided in Table 17, Appendix C. For chickens, colibacillosis/septicemia/*E. coli* infections were the most common indications (29.6%, 75/253), followed by reproductive tract/yolk sac infections (20.2%, 51/253) and peritonitis/hepatitis (12.6%, 32/253). Colibacillosis/septicemia/*E. coli* infections were also the most common indications for turkeys (23.1%, 27/117), followed by respiratory infections (21.3%, 25/117). The 4 duck isolates were associated with bacteremia (2), infection of the oviduct (1), and an upper respiratory tract infection (1).

Poultry – *Pasteurella multocida*

A total of 51 isolates were submitted for 2019: 39 from chickens, 9 from turkeys, and 3 from ducks. MIC information is presented as combined data in Table 18, Appendix C. Data for chickens/ducks combined is in Table 19, Appendix C, and MIC information for turkeys is in Table 20, Appendix C.

As expected, the diagnosis of fowl cholera/septicemia was the most commonly reported disease across chickens, ducks, and turkeys. Joint infections and pneumonia/respiratory infection were also given as a final diagnosis for 12.8% (5/39) and 7.7% (3/39) of chicken isolates, respectively. A full listing of all final diagnoses provided associated with poultry species are given in Table 21, Appendix C.

Horses

General

As noted in the 2018 APHIS NAHLN AMR pilot project report (USDA, 2019), the breakpoint interpretive values for both doxycycline and enrofloxacin are: susceptible ≤ 0.12 μg/ml; intermediate = 0.25 μg/ml; and resistant ≥ 0.5 μg/ml (CLSI, 2018). However, the doxycycline dilutions present on the Sensitire™ EQUIN1F plate are 2 -16 μg/ml. Thus, because isolates reported with a value of ≤ 0.25 μg/ml are unable to be interpreted as either sensitive or intermediate (unable to distinguish between those with a value =0.25 μg/ml, thus intermediate and those with a value <0.25, thus sensitive), only isolates reported with values of 0.5 μg/ml or higher could be definitively interpreted as resistant. Similarly, enrofloxacin dilutions on the EQUIN1F plate range from 0.25 to 2 μg/ml. As with doxycycline, only those isolates with a MIC value at or above 0.5 μg/ml can be interpreted as resistant, but isolates reported with a MIC of ≤

0.25 μg/ml are unable to be interpreted as either sensitive or intermediate (Appendix D). Additionally, separate breakpoints have been established for adult animals and foals for amikacin; all information provided in Appendix D is based on adult breakpoints. As with the other animal species, summary MIC data is given for all antimicrobials found on the equine AST plates, regardless of therapeutic use for the pathogens surveyed.

Horses – *E. coli*

For 2019, AST results from 302 equine isolates were submitted, an increase of 59.8% from 2018. Four antimicrobials have breakpoints established for *E. coli* from horses. These are amikacin, gentamicin, enrofloxacin, and doxycycline. Overall, 64.6% (195/302) of these isolates in 2019 were susceptible to all four antimicrobials (Table 22, Appendix D), slightly lower than we observed in 2018, where 67.7% (128/189) of all isolates were susceptible to the same four antimicrobials. For 2019, there were 34 isolates resistant to three or more antimicrobials. Of these, 30/302 (9.9%) were classified as MDR, and 4 of the 30 MDR isolates were resistant to all 4 antimicrobials.

Trends in antimicrobial resistance for 2018-2019 are shown in Figure 6, Appendix D. The data shows a slight increase in resistance from 2018 for all four antimicrobials (amikacin, gentamicin, enrofloxacin, and doxycycline). However, amikacin resistance may be erroneously interpreted due to the lack of epidemiological information to correctly interpret whether the isolates are from foals or adult animals.

Reproductive tract infections (metritis, endometritis, placentitis, uterine infection, and reproductive failure) accounted for the majority (44.7%, 135/302) of all *E. coli* infections identified in 2019. See Table 23, Appendix D for more information on types of infections associated with *E. coli* in horses.

Horses – *Streptococcus equi* and *S. zooepidemicus*

In 2019, 18 laboratories submitted data from 57 equine *S. equi* isolates, and 22 laboratories submitted data from 359 S. *zooepidemicus* isolates. For *Streptococcus* spp., there are seven antimicrobials with breakpoints established in horses. These antimicrobials are cefazolin, ceftiofur, amikacin, enrofloxacin, ampicillin, penicillin, and doxycycline.

As described for equine *E. coli* isolates, equine *Streptococcus* interpretive breakpoints for sensitive and intermediate for cefazolin, enrofloxacin, and doxycycline are below the lowest dilution present on the EQUIN1F plate. Specifically, equine cefazolin interpretive breakpoints are: susceptible ≤ 2 μg/ml; intermediate = 4 μg/ml; and resistant ≥ 8 μg/ml (CLSI, 2018), and cefazolin dilutions present on the EQUIN1F plate are 4 – 16 μg/ml. Enrofloxacin dilutions on the EQUIN1F plate range from 0.25 to 2 μg/ml, whereas the equine *S. equi* and *S. zooepidemicus* breakpoints are: susceptible ≤ 0.12 μg/ml; intermediate = 0.25 μg/ml; and resistant ≥ 0.5 μg/ml (CLSI, 2018). Finally, doxycycline dilutions present on the EQUIN1F plate are 2 -16 μg/ml, but the CLSI interpretive breakpoints for *S. equi* and *S. zooepidemicus* breakpoints are: susceptible ≤ 0.12 μg/ml; intermediate = 0.25 μg/ml; and resistant ≥ 0.5 μg/ml (CLSI, 2018).

Thus, only cefazolin MICs at or above 8 μg/ml, doxycycline MICs at or above 4 μg/ml and enrofloxacin MICs at or above 0.5 μg/ml could be interpreted as resistant. Furthermore, breakpoints for intermediate and resistant values for ampicillin and ceftiofur have not been established in horses.

Based on MIC values collected, the 57 *S. equi* isolates were relatively resistant to amikacin, enrofloxacin, and doxycycline (resistance of 84.2%, 94.7%, and 100%, respectively). Conversely, cefazolin and penicillin resistance rates were very low, at 0% and 1.8%, respectively (Table 24, Appendix D).

The *S. zooepidemicus* isolates showed a similar pattern of resistance. Amikacin, enrofloxacin, and doxycycline again had resistance of 86.9%, 97.5%, and 100% to these antimicrobials, whereas cefazolin and penicillin resistance was 1.1% for both (Table 25, Appendix D).

Although resistance to enrofloxacin and doxycycline in both *S. equi* and *S. zooepidemicus* appears high, it is worth noting that new breakpoints for these antimicrobials for equine *Streptococcus spp*. were recently released by CLSI in 2018. Prior to this date, MIC interpretations for these pathogens were most likely extrapolated from tetracycline breakpoints for either swine or humans. The resistance breakpoint for both enrofloxacin and tetracycline in swine is ≥ 2 μg/ml, and the tetracycline resistance breakpoint for humans is ≥ 8 μg/ml, significantly higher than the ≥ 0.5 μg/ml resistant breakpoint recently established for horses for these antimicrobials.

Clinical signs and diagnoses associated with equine *S. zooepidemicus* infections are provided in Table 26, Appendix D. Reproductive tract infections and pneumonia/respiratory infections accounted for almost 75% of all cases at 36.8% and 36.5%, respectively, with abscess/skin/wound infections accounting for 15.3% of all diagnoses.

Dogs

General

Two pathogens were monitored in dogs for 2019; *E. coli* and *Staphylococcus intermedius* group. Due to the low numbers of *Salmonella* spp. isolates reported in 2018, this pathogen was removed from routine monitoring in 2019.

Dogs – *E. coli*

For 2019, data from 850 canine *E. coli* isolates were submitted, which is an overall increase of 85.2% over 2018, where data from 459 isolates were submitted. These isolates were split into two categories, isolates recovered from urinary tract infections (UTIs) (550), and those associated with all other (non-UTI) infections (300).

Extended spectrum β-lactamase (ESBL) producing bacteria are an increasing concern in both human and veterinary medicine. For *E. coli*, isolates with growth at or above a MIC of ≥ 8 μg/mL for cefpodoxime or a MIC of ≥ 2 μg/mL for ceftazidime may indicate ESBL production. While ESBL screening was not a primary objective for this pilot project, isolates meeting this criteria are identified in Appendix E and Appendix F

Dogs – *E. coli* – urinary tract infections

The number of isolates submitted in 2019 for canine *E. coli* UTIs increased by 87.7%, from 293 isolates to 550 isolates.

While ESBL screening was outside the scope of this pilot project, there were 77 isolates with MIC values at or above 8 μg/mL for cefpodoxime and 61 isolates with MICs at or above 2 μg/mL for ceftazidime that would be considered candidates for this screening (Table 27, Appendix E). These numbers are slightly

higher than in 2018, where 59 and 44 isolates met the criteria for cefpodoxime and ceftazidime ESBL screening, respectively.

An overall decreasing trend of antimicrobial resistance was noted across all antimicrobials from 2018 to 2019 (Figure 7, Appendix E). Amikacin resistance was the lowest, at only 0.5% of the isolates (3/550), down from 0.7% in 2018. Cephalexin was the antimicrobial with the highest percentage of resistant isolates, at 15.8% (86/550). This is again lower than reported in 2018, where 21.8% of the isolates were classified as resistant to cephalexin.

Of the 550 canine *E. coli* isolates, only 13 (2.4%) met the MDR definition. One of these 13 isolates was resistant to four antimicrobial classes, which included 11 of the 12 antimicrobials with established breakpoints (Table 28, Appendix E). The remaining 12 MDR isolates were also resistant to four antimicrobial classes, and to 9 of 12 antimicrobials. Interestingly, all of these 12 isolates were resistant to either an aminoglycoside or to piperacillin/tazobactam, but not both. Amoxicillin/clavulanate results were not evaluated as part of the MDR panel, as only the 'S' interpretive category has been established for canine UTIs.

Dogs – *E. coli* – Non-urinary tract infections

Similar to the *E. coli* UTI infections, an increase of 80.7% was seen in the number of isolates submitted in 2019 for canine *E. coli* non-UTI infections. Table 29, Appendix E provides all MIC results for these isolates.

Non-UTI isolates from dogs also showed an overall decreasing trend of antimicrobial resistance (Figure 8, Appendix E), and had very similar resistance patterns to UTI isolates for the aminoglycosides and fluoroquinolones. However, resistance to both ampicillin and amoxicillin/clavulanate remained at 99.3% for both antimicrobials in the non-UTI group.

Only two (0.7%) of the non-UTI isolates were susceptible to all the antimicrobials tested. Conversely, 71.3% (214/300) were resistant to at least three different antimicrobial classes, categorized as MDR (Table 30, Appendix E). Of these 214 isolates, there was one strain resistant to 11 of the 12 antimicrobials with canine breakpoints; another 13 isolates were resistant to 10 antimicrobials. Within the cephalosporin class of antimicrobials, cephalexin resistance was significantly higher, with 205/300 (68.3%) of isolates being resistant. Both cefazolin and cefpodoxime resistance was considerably lower at 25.6% and 21%. There were 126 isolates resistant to cephalexin that were also categorized as MDR (Table 30, Appendix E). Most of these were also resistant to ampicillin and amoxicillin/clavulanate, suggesting there may be a common genetic element that is conferring this phenotype.

Abscesses, wounds, and skin infections were most frequently associated with non-UTI *E. coli* infections (28.7%), followed by reproductive tract infections (16.0%), then ear infections (13.3%). Table 31, Appendix E provides information on additional clinical diagnoses associated with *E. coli*, and compares all diagnoses for 2018 – 2019. .

Dogs – *Staphylococcus intermedius* group – General

The canine *S. intermedius* category received the most submissions across all laboratories again in 2019, with 950 isolates provided by 19 laboratories. As with *E. coli*, isolates were separated into those associated with urinary tract infections (173), and all other (non-UTI) isolates (777).

Oxacillin resistance was again evaluated as an indicator of methicillin resistance in 2019. If resistant, the isolate is then considered to be resistant to all β-lactam antimicrobials. The human breakpoint value of ≥0.5 μg/mL was used as the cutoff for resistance for isolates for both the canine and feline datasets because no breakpoint for oxacillin has been established in either dogs or cats.

Dogs – *S. intermedius* group – urinary tract infections

Laboratories submitted 173 isolates from clinical cases associated with urinary tract infections. There are six antimicrobials with breakpoints established for canine Staphylococcal infections. However, amoxicillin/clavulanate does not have breakpoints for intermediate or resistant interpretations, so resistance was not calculated for this antimicrobial. Additionally, resistance to amikacin may be under-reported due to an inadequate range of dilutions on the Sensititre COMPGP sensitivity plate, which does not include the canine sensitive or intermediate breakpoints at or below 16 μg/mL.

Dogs – S. intermedius group – Urinary tract infections – Oxacillin sensitive

Of the 173 isolates associated with UTIs, 76.8% (133/173) were susceptible to oxacillin (OX^S) using the human breakpoint value of ≥0.5 μg/mL (Table 32, Appendix E). Overall resistance was much lower for this group of isolates, and ranged from a low of 0.8% resistant (cefazolin and amikacin) to a high of 6% resistance (enrofloxacin).

No MDR isolates were identified (Table 33, Appendix E). Resistance data for 2018-2019 for all antimicrobials with canine UTI breakpoints are shown in Figure 9, Appendix E.

Dogs – S. intermedius group – Urinary tract infections – Oxacillin resistant

Only 40 UTI isolates from 2019 that were categorized as OX^R. However, resistance to all three of the fluoroquinolone antimicrobials was much higher than the corresponding OX^S isolates, with 60% of isolates classified as resistant (Table 34, Appendix E). Although it appears there is a significant decrease in amikacin resistance from 2018 to 2019 (Figure 10, Appendix E), this is likely due to the low number of OX^R UTI isolates in this category; only 10 in 2018 and 40 in 2019. Antimicrobial resistance analysis for all canine OX^R *S. intermedius* UTI isolates can be found in Table 35, Appendix E.

Dogs – *S. intermedius group* – non-urinary tract infections

There were 777 *S. intermedius* group isolates submitted that were not associated with urinary tract infections. This is an 87.7% increase over the 414 isolates submitted in 2018 for this category. Similar to 2018, the majority of these isolates were associated with skin/wound/abscess infections (59.3%, 461/777) and otitis/ear infections (24.2%, 188/777). Additional signs and diagnoses for 2018-2019 are presented in Table 36, Appendix E.

Dogs – S. intermedius group – Non-urinary tract infections – Oxacillin sensitive

Of the 777 total, 485 isolates met the criteria of OX^S isolates associated with non-UTI infections. MIC values for all antimicrobials tested are given in Table 37, Appendix E. Trends in resistance patterns from 2018 to 2019 were stable (Figure 11, Appendix E). Ampicillin again showed the highest resistance rates in 2019 at 40.2%, comparable to the 39.2% reported last year. Antimicrobials with the lowest resistance were again the cephalosporins and aminoglycosides, at less than 1%.

Multi-drug resistance was observed in only 10.1% (49/485) OX^S isolates. Encouragingly, none of the 49 MDR isolates were resistant to more than four antimicrobial classes (Table 38, Appendix E). Tetracyclines were the most frequently observed resistant antimicrobial class, followed by penicillins,

then cephalosporins (Table 38). As observed for canine UTI infections, a subgroup of 15 isolates exhibited uniform resistance to cephalosporin and tetracycline antimicrobials and were also resistant to either clindamycin or ampicillin, again suggesting a genetic element(s) that confers resistance to ampicillin only. This is supported by other non-MDR isolates that were susceptible to all cephalosporins, but also demonstrated resistance to either ampicillin or clindamycin.

Dog – S. intermedius group – Non-urinary tract infections – Oxacillin resistant

There were 292 isolates in the OX^R category, representing 37.6% of all non-UTI isolates from dogs. Table 39, Appendix E provides all MIC distributions for all antimicrobials tested. Compared to other animal/pathogen combinations, this group of isolates had considerably higher resistance to all antimicrobials, with fluoroquinolone, lincosamide, and tetracycline resistance between 70.9% and 82.2% (Figure 12, Appendix E).

MDR was also the highest across all animal/pathogen species in the canine OX^R *S. intermedius* isolates, with 182 (62.3%) isolates resistant to three or more antimicrobial categories. Of those 182 isolates, 167 are pan-resistant to all tetracycline, fluoroquinolone, and lincosamide antimicrobials evaluated, and another three are also resistant to at least one aminoglycoside antimicrobial (Table 40, Appendix E). It is also worth noting that, because all isolates in this category are oxacillin resistant, they are also considered resistant to penicillin, cephalosporin, and β-lactamase combination drugs.

Clinical diagnoses associated with the OX^R non-UTI isolates were very similar to the overall non-UTI group; approximately 2/3 (66.8%) are associated with skin/wound/abscess infections, followed by otitis/ear infections (14.4%). The remaining clinical signs or diagnoses are given in Table 41, Appendix E.

Cats

General

Minimum inhibitory concentration data is provided for all antimicrobials found on the COMPGN1F and COMPGP1F plates, regardless of therapeutic use for the pathogens surveyed. Isolates associated with urinary tract infections were identified and analyzed separately from the remaining isolates.

Cats – *E. coli*

Data from 435 isolates were submitted in 2019. Feline *E. coli* isolates were again categorized into those associated with UTIs (78.1%, 340/435) or those from infections other than UTIs (21.8%, 95/435).

Cats – *E. coli* – urinary tract infections

Only three antimicrobials have breakpoints established for urinary tract infections in cats: cefovicin, amoxicillin/clavulanate, and ampicillin. All of the 340 feline UTI isolates submitted for 2019 were resistant to both amoxicillin/clavulanate and ampicillin, and 35 (10.3%) were resistant to cefovicin (Table 42, Appendix F).

Overall, more isolates were identified as candidates for ESBL screening in 2019 than the previous year. For this year, 12.1% (41/340) of all isolates had MIC values at or above 8 μg/mL for cefpodoxime compared to 9.6% (19/198) in 2018. For ceftazidime, 7.1% (24/340) had MIC values of 2 μg/mL in 2019 compared to 6.6% (13/198) in 2018.

Similar resistance patterns for these antimicrobials were also seen in 2018-2019 (Figure 13, Appendix F). By default, all 35 of the isolates resistant to cefovicin also meet the definition of MDR, since they are also resistant to ampicillin and amoxicillin/clavulanate.

Cats – *E. coli* – Non-urinary tract infections

A total of 95 isolates were categorized as non-UTI infections in 2019. MIC values for these isolates are in Table 43, Appendix F. Resistance profiles for 2018-2019 are provided in Figure 14, Appendix F. Resistance to fluoroquinolone antimicrobials increased slightly (5.3 – 6.3% in 2019, compared to 1.5%-2.9% last year), but remained under 10% in 2019. Resistance to ampicillin and amoxicillin/clavulanate remained close to 100%. Six isolates were classified as MDR. Six isolates had MIC values for cefpodoxime that met the criteria for ESBL testing, and three met this criteria for ceftazidime. Diagnoses associated with multi-drug resistance included peritonitis/ascites (2), nasal infection (1), ear infection (1), enteritis (1), and vaginitis (1).

The two most common clinical sign/indications for *E. coli* isolates other than UTIs were enteric infections (22.1%) and abscess/skin/wound infections (21.1%). Additional diagnoses and comparison to 2018 clinical signs/diagnoses are located in Table 44, Appendix F.

Cats – *Staphylococcus intermedius* group – general

Feline staphylococcal infections were not reported in large numbers either year of the project. For 2019, only 76 isolates were submitted for this category, similar to the 62 isolates submitted in 2018. Isolates were divided into those associated with urinary tract infections (32), and those recovered from infections other than UTIs (44).

Cats – *S. intermedius* group – urinary tract infections

Overall, 42.1% of the isolates (32/76) were associated with UTIs. For 2019, 21 of these 32 isolates (65.6%) were categorized as OX^S, and the remaining 11 isolates as OX^R.

Only two antimicrobials have breakpoints established for *Staphylococcus spp*. UTIs in cats; these are amoxicillin/clavulanic acid and ampicillin. One of the 21 isolates (4.8%) showed resistance to amoxicillin/clavulanate, and six (33.3%) were resistant to ampicillin (Table 45, Appendix F). This is similar to 2018 results, where no isolates resistant to amoxicillin/clavulanate and 2 (of 14) were resistant to ampicillin. MIC values for the remaining 11 OX^R isolates are shown in Table 46, Appendix F.

Cats – *S. intermedius* group – non-urinary tract infections

There were 44 isolates in this category, representing 57.9% of all *S. intermedius* strains reported from cats. These were further classified into OX^S (50%, 22/44) and OX^R (50%, 22/44).

For the OX^S subgroup, resistance to both amoxicillin/clavulanate and ampicillin was 31.8% and 4.5%, respectively (Table 47, Appendix F). Breakpoints for several fluoroquinolones are also established for feline non-UTI infections; resistance to these antimicrobials were between 4.5% (enrofloxacin and marbofloxacin) and 22.7% (pradofloxacin). However, because of low numbers of isolates in this group, the resistance level for pradofloxacin likely does not represent the true resistance of this bacterial population for this antimicrobial.

Isolates in the OX^R subgroup demonstrated considerably higher resistance levels to enrofloxacin (68.2%) and marbofloxacin (59.1%), while pradofloxacin remained at 22.7% (Table 49, Appendix F).

A comparison of clinical signs/diagnoses for OX^S and OX^R isolates is shown in Table 50, Appendix F. No major differences were observed regarding diagnoses between OX^S and OX^R isolates. Overall, abscesses, skin infections and wounds accounted for approximately half of all *S. intermedius* infections (45.5%, 10/22 for both OX^S and OX^R), followed by otitis/ear infections.

Summary

In summary, this report provides an initial look at antimicrobial resistance trends over the last 2 years for six animal species, covering both livestock and companion animals. While resistance appears to be stable or even potentially decreasing in livestock, interpretation of the MIC data is limited due to the lack of interpretive breakpoints for many important antimicrobials used in animals.

A challenge that continued from 2018 through 2019 was the ability to collect a sufficient number of isolates for certain bacterial pathogens in order to accurately predict AMR trends at a national level. Because many variables may affect submission numbers, including the number and type of diagnostic cases submitted to a laboratory in a given year, it will be important to consistently monitor these pathogens for a minimum of 3 years to determine if this trend continues.

Goals for the upcoming year are to incorporate genetic monitoring of antimicrobial resistance genes (genotype), and to compare bacterial genotypes to antimicrobial susceptibility MIC profiles (phenotypes) for antibiotics tested in this pilot.

References:

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2. Dargatz, DA, MM Erdman and B Harris. 2017. A survey of methods used for antimicrobial susceptibility testing in veterinary diagnostic laboratories in the United States. J. Vet. Diag. Invest. Sep;29(5):669-675.
3. USDA, 2019. USDA APHIS AMR Pilot Project Report, Year 1. https://www.aphis.usda.gov/animal_health/nahln/downloads/2018%20APHIS%20AMR%20Pilot%20Project%20EOY%20Report-05.01.2019.pdf

APPENDIX A: MIC Distributions and Clinical Signs for *E. coli, Salmonella* spp., and *M. haemolytica* in Cattle

CATTLE – *E. COLI*

Table 3. MIC distribution for *E. coli* isolates recovered from cattle in 2019.

Antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	16	>16	32	>32	64	>64	<=256	>256	Total Isolates§	% R*
3rd gen cephalosporin	Ceftiofur**		117			300		23			14			8			49	115								626	NC
aminocyclitol	Spectinomycin															25			365		50		31	155			626	
aminoglycoside	Gentamicin						516				28			6			2		7	67							626	
aminoglycoside	Neomycin												410				11		9		34	162					626	
fluoroquinolone	Danofloxacin	495		9		14		9	99		0																626	
fluoroquinolone	Enrofloxacin	493		8		15		11			4	95															626	
folate pathway antagonist	Sulfadimethoxine																								220	406	626	
folate pathway antagonist	Trimethoprim/sulfamethoxazole†									436		190															626	
lincosamide	Clindamycin		0			0		0			0			0			0		1	625							626	
macrolides	Gamithromycin						2				7			80			182	42									313	
macrolides	Tildipirosin						5				31			205			59	0	10	3							313	
macrolides	Tilmicosin									1	1		3	1			1		2	308	29	1	182	97			626	
macrolides	Tulathromycin						1				4			63		283	198		65		7		1	4			626	
macrolides	Tylosin				0			0			0			0	0		0		0		2	624					626	
penicillin	Ampicillin§		3			0		11			130			139			7		3	333							626	NC
penicillin	Penicillin	0		1		0		0			1			1			2	621									626	
phenicol	Florfenicol		0			1		2			67			274			60	222									626	
pleuromutilin	Tiamulin						0				0			0			3		4		25	594					626	
tetracycline	Chlortetracycline				0			21			37			21			11	223									313	
tetracycline	Oxytetracycline				0			42			37			4			1	229									313	
tetracycline	Tetracycline				4			67			31			2			6	203									313	

Bovine-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018)

§ Total number of isolates for each antimicrobial reflect a combination of the BOPO6F and BOPO7F plates. Not all antimicrobials in the table are present on both plates, leading to differences in total numbers of isolates.

* % R = percentage of resistant isolates. NC = not calculable due to low numbers of isolates identified from mastitis and metritis cases.

**Ceftiofur breakpoints have been established for mastitis cases only for *E. coli* infections in cattle. Because there were only 10/612 isolates in this table that were reported to be from mastitis cases, overall % resistance is not reported.

§ Ampicillin breakpoints have been established for metritis cases only for *E. coli* infections in cattle. Because there were only 1/612 isolates in this table that were reported to be from metritis cases, overall % resistance is not reported.

†Trimethoprim/sulfamethoxazole concentration on plate = 2/38 µg/mL.

Table 4. Clinical signs and diagnoses associated with bovine *E. coli* infections.

Clinical signs/indications	COUNT 2018	% 2018	COUNT 2019	% 2019
DIARRHEA, ENTERIC INFECTIONS	217	58.3%	401	64.1%
SEPSIS, SEPTICEMIA	40	10.8%	60	9.6%
PNEUMONIA, RESPIRATORY INFECTIONS	36	9.7%	48	7.7%
UNDETERMINED, DIAGNOSIS NOT PROVIDED	23	6.2%	44	7.0%
OTHER DIAGNOSIS*	16	4.3%	7	1.1%
ABORTION, NEONATAL DEATH	14	3.8%	18	2.9%
NEPHRITIS, HEPATITIS, PERITONITIS	9	2.4%	18	2.9%
MASTITIS	5	1.3%	10	1.6%
UTERINE INFECTIONS, METRITIS	3	0.8%	2	0.3%
WOUNDS, JOINT INFECTIONS	3	0.8%	10	1.6%
URINARY TRACT INFECTIONS, CYSTITIS	3	0.8%	3	0.5%
ENCEPHALITIS	3	0.8%	5	0.8%
TOTAL	372		626	

*Other diagnoses for 2018 = esophagitis (1), lymphoma (1), ruptured penis (1), hepatic iron/copper accumulation (1), attaching and effacing *E. coli* (1), serositis/polyserositis (2), anaphylaxis (2), hepatocellular degeneration/necrosis (1), respiratory acidosis (1), genital tract infection (1), myocardial necrosis (1), *Mycoplasma weyanii* infection (1), fatty liver (1), and gastric torsion (1)
Other diagnoses for 2019 = endocarditis (1), epicarditis (1), copper deficiency (1), acute kidney failure (1), hypoxemia (1), mycotic rumenitis (1), bloat (1).

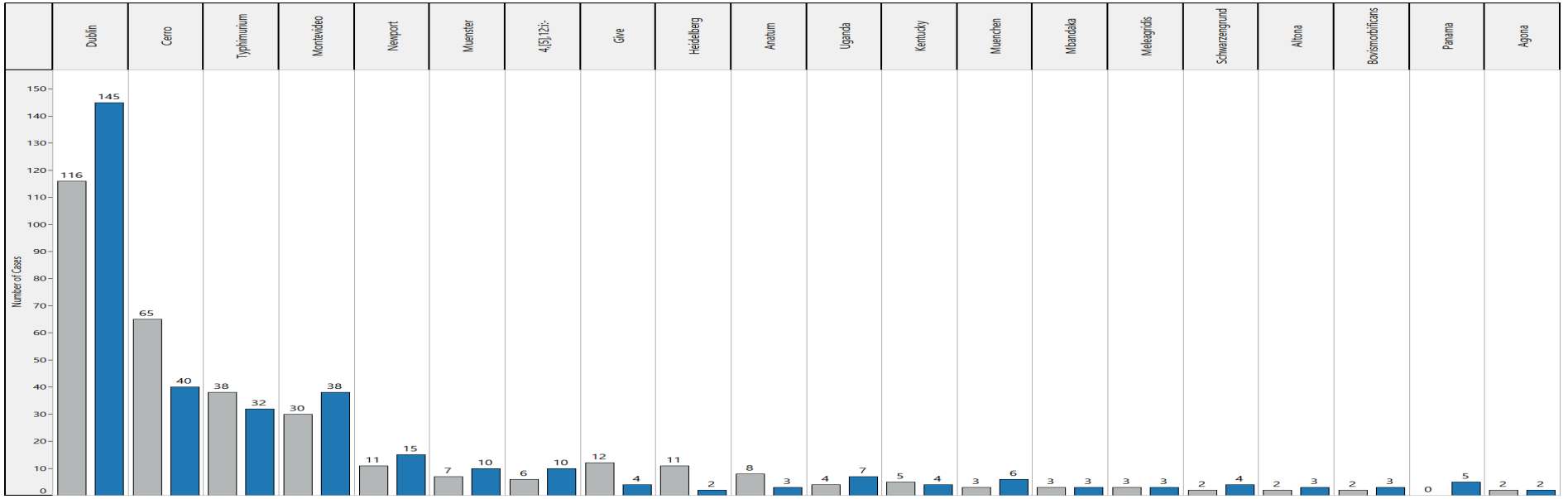
CATTLE – *SALMONELLA* SPP.

Table 5. MIC distribution for *Salmonella* spp. isolates recovered from cattle in 2019.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	>1	<=2	2	>2	<=4	4	<=8	8	>8	16	>16	32	>32	64	>64	<=256	>256	Total Isolates[§]
3rd gen cephalosporin	**Ceftiofur**		5			47		175			3			6		20	124								380
aminocyclitol	**Spectinomycin**														7			86		225		47	15			380
aminoglycoside	**Gentamicin**						361				9			1		4		2	3							380
aminoglycoside	**Neomycin**												305			0		0		1	74					380
fluoroquinolone	**Danofloxacin**	315		10		43		8	4		0															380
fluoroquinolone	**Enrofloxacin**	314		6		45		9			3	3														380
folate pathway antagonist	**Sulfadimethoxine**																							130	250	380
folate pathway antagonist	**Trimethoprim/sulfamethoxazole[†]**									361		19														380
lincosamide	**Clindamycin**		0			0		0			0			0		0			380							380
macrolides	**Gamithromycin**						0				1			102		122	3									228
macrolides	**Tildipirosin**						0	0			0			26		118	0	77	7							228
macrolides	**Tilmicosin**									0			0			0		0	228	1		35	116			380
macrolides	**Tulathromycin**						0				1			13	149	61		138		12		1	5			380
macrolides	**Tylosin**				0			0			0			0		0		0		0	380					380
Penicillins	**Ampicillin**		0			16		181			19			2		0			162							380
Penicillins	**Penicillin**	0		0		0		0			2			7		167	204									380
phenicol	**Florfenicol**		2			0		5			99			99		5	170				0					380
pleuromutilin	**Tiamulin**				1		0				0			0		0		1		2	376					380
tetracycline	**Chlortetracycline**				2			26			32			8		1	83									152
tetracycline	**Oxytetracycline**				12			41			15			1		0	83									152
tetracycline	**Tetracycline**				32			64			29			0		0	103									228

[§] Total number of isolates for each antimicrobial reflect a combination of the BOPO6F and BOPO7F plates. Not all antimicrobials in the table are present on both plates, leading to differences in isolate totals.
[†] Trimethoprim/sulfamethoxazole concentration on plate = 2/38 µg/mL.

Figure 4. The twenty most prevalent *Salmonella* serotypes for cattle in 2018 and 2019.



2018 data is represented by grey bars, 2019 data is represented by blue bars.

Table 6. Overall prevalence of bovine *Salmonella* serotypes for 2018-2019.

Salmonella Serotype	COUNT 2018	% of Total for 2018	COUNT 2019	% of Total for 2019	Salmonella Serotype	COUNT 2018	% of Total for 2018	COUNT 2019	% of Total for 2019
Dublin	116	33.2%	145	38.2%	**Havana**	0	0.0%	2	0.5%
Cerro	65	18.6%	40	10.5%	**Heidelberg**	11	3.2%	2	0.5%
Montevideo	30	8.6%	38	10.0%	**Infantis**	1	0.3%	2	0.5%
Typhimurium	38	10.9%	32	8.4%	**Liverpool**	1	0.3%	2	0.5%
Newport	11	3.2%	15	3.9%	**London**	0	0.0%	2	0.5%
4,[5],12:i:-	6	1.7%	10	2.6%	**9,12:L,Z28:-**	0	0.0%	1	0.3%
Muenster	7	2.0%	10	2.6%	**Bareilly**	0	0.0%	1	0.3%
Uganda	4	1.1%	7	1.8%	**Barranquilla**	0	0.0%	1	0.3%
Muenchen	3	0.9%	6	1.6%	**Cannstatt**	0	0.0%	1	0.3%
Panama	0	0.0%	5	1.3%	**Derby**	1	0.3%	1	0.3%
Give	12	3.4%	4	1.1%	**Grumpensis**	0	0.0%	1	0.3%
Kentucky	5	1.4%	4	1.1%	**Hartford**	0	0.0%	1	0.3%
Schwarzengrund	2	0.6%	4	1.1%	**Idikan**	1	0.3%	1	0.3%
Altona	2	0.6%	3	0.8%	**IV_44:z4,z24:-**	0	0.0%	1	0.3%
Anatum	8	2.3%	3	0.8%	**Kiambu**	2	0.6%	1	0.3%
Bovismorbificans	2	0.6%	3	0.8%	**Litchfield**	0	0.0%	1	0.3%
Mbandaka	3	0.9%	3	0.8%	**Livingstone**	0	0.0%	1	0.3%
Meleagridis	3	0.9%	3	0.8%	**O:9 non-motile**	0	0.0%	1	0.3%
Oranienburg	1	0.3%	3	0.8%	**Othmarschen**	0	0.0%	1	0.3%
Orion	0	0.0%	3	0.8%	**Rough O:K:1,5**	0	0.0%	1	0.3%
Ouakam	0	0.0%	3	0.8%	**Rough O:z4,z23:-**	0	0.0%	1	0.3%
Thompson	0	0.0%	3	0.8%	**S. 6,7:g,m,s:e,n,z15**	0	0.0%	1	0.3%
Agona	2	0.6%	2	0.5%	**Saint-Paul**	1	0.3%	1	0.3%
Brandenburg	0	0.0%	2	0.5%	**Senftenberg**	1	0.3%	1	0.3%
					TOTAL	349		380	

Table 7. Frequency of bovine *Salmonella* serotypes associated with clinical signs/diagnoses for 2019.

DIARRHEA/ENTERIC DISEASE		
SEROTYPE	COUNT	%
Dublin	65	24.7%
Cerro	38	14.4%
Montevideo	31	11.8%
Typhimurium	27	10.3%
4,[5],12:i:-	10	3.8%
Newport	10	3.8%
Muenster	8	3.0%
Muenchen	5	1.9%
Panama	4	1.5%
Uganda	4	1.5%
Anatum	3	1.1%
Give	3	1.1%
Kentucky	3	1.1%
Mbandaka	3	1.1%
Oranienburg	3	1.1%
Orion	3	1.1%
Ouakam	3	1.1%
Schwarzengrund	3	1.1%
Thompson	3	1.1%
Altona	3	1.1%
Agona	2	0.8%
Bovismorbificans	2	0.8%

DIARRHEA/ENTERIC DISEASE, continued		
SEROTYPE	COUNT	%
Brandenburg	2	0.8%
Havana	2	0.8%
Heidelberg	2	0.8%
Liverpool	2	0.8%
London	2	0.8%
Meleagridis	2	0.8%
Barranquilla	1	0.4%
Cannstatt	1	0.4%
Grumpensis	1	0.4%
Idikan	1	0.4%
Infantis	1	0.4%
IV_44:z4,z24:-	1	0.4%
Kiambu	1	0.4%
Litchfield	1	0.4%
Livingstone	1	0.4%
O:9 non-motile	1	0.4%
Othmarschen	1	0.4%
Rough O:K:1,5	1	0.4%
Rough O:z4,z23:-	1	0.4%
Saint-Paul	1	0.4%
Senftenberg	1	0.4%
TOTAL	263	

SEPTICEMIA		
SEROTYPE	COUNT	%
Dublin	45	90.0%
Montevideo	2	4.0%
Bovismorbificans	1	2.0%
Derby	1	2.0%
Newport	1	2.0%
TOTAL	50	

PNEUMONIA		
SEROTYPE	COUNT	%
Dublin	24	70.6%
Give	1	2.9%
Infantis	1	2.9%
Meleagridis	1	2.9%
Montevideo	1	2.9%
Muenster	1	2.9%
Newport	2	5.9%
6,7:g,m,s:e,n,z15	1	2.9%
Schwarzengrund	1	2.9%
Typhimurium	1	2.9%
TOTAL	34	

UNDETERMINED		
SEROTYPE	COUNT	%
Dublin	3	21.4%
Cerro	2	14.3%
Montevideo	2	14.3%
Newport	2	14.3%
9,12:L,Z28:-	1	7.1%
Bareilly	1	7.1%
Muenchen	1	7.1%
Panama	1	7.1%
Uganda	1	7.1%
TOTAL	14	

ABORTION/NEONATAL DEATH		
SEROTYPE	COUNT	%
Dublin	3	50.0%
Kentucky	1	16.7%
Montevideo	1	16.7%
Uganda	1	16.7%
TOTAL	6	

OTHER*		
SEROTYPE	COUNT	%
Dublin	5	38.5%
Typhimurium	4	30.8%
Hartford	1	7.7%
Montevideo	1	7.7%
Muenster	1	7.7%
Uganda	1	7.7%
TOTAL	13	

*Other diagnoses = hepatitis (6), peritonitis (2) lymphoma (1), mastitis (2), cystitis (1), and ruminal tympany (1).

CATTLE – *MANNHEIMIA HAEMOLYTICA*

Table 8. MIC distribution for *Mannheimia haemolytica* isolates recovered from cattle in 2019.

antimicrobial class	Antimicrobial \ MIC value (µg/mL)	<=0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	>1	<=2	2	>2	<=4	4	<=8	8	>8	16	>16	32	>32	64	>64	<=256	>256	Total Isolates[§]	% R*
3rd gen cephalosporin	**Ceftiofur**		599			6		3			3			1		0	0									612	0.0%
aminocyclitol	**Spectinomycin**														7			120		393		6	86			612	14.1%
aminoglycoside	**Gentamicin**						46				436			53		1		4	72							612	
aminoglycoside	**Neomycin**												124			351		12		8	117					612	
fluoroquinolone	**Danofloxacin**	478		10		20		10	94																	612	17.0%
fluoroquinolone	**Enrofloxacin**	482		7		23		7			0	93														612	15.2%
folate pathway antagonist	**Trimethoprim/sulfamethoxazole**									605		7														612	
folate pathway antagonist	**Sulphadimethoxine**																							365	247	612	
lincosamide	**Clindamycin**		2			0		1			2			24		320		155	108							612	
macrolide	**Gamithromycin**						343				44			3		6	77									473	16.3%
macrolide	**Tildipirosin**						303			0	76			23		3		1	67							473	14.4%
macrolide	**Tilmicosin**									39			63	227		134		32	85	5		3	24			612	19.1%
macrolide	**Tulathromycin**						4				6			65	384	34		11		14		9	85			612	15.4%
macrolide	**Tylosin**				2			0			0			0		3		14		143	450					612	
penicillin	**Ampicillin**		521			21		6			1			1		10		9	43							612	14.9%
penicillin	**Penicillin**	242		211	1	75		17			2			0		7	57									612	13.6%
phenicol	**Florfenicol**		25			286		195			42			7		6	51									612	9.3%
pleuromutilin	**Tiamulin**				1		0	3			3			13		234		297		51	10					612	
tetracycline	**Chlortetracycline**				42			46			9			10		16	16									139	
tetracycline	**Oxytetracycline**				76			15			1			0		4	43									139	
tetracycline	**Tetracycline**				300			36			7			15		13	102									473	24.3%

Bovine-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018)

[§] Total number of isolates for each antimicrobial reflect a combination of the BOPO6F and BOPO7F plates. Not all antimicrobials in the table are present on both plates, leading to differences in total numbers of isolates.

* % R = percentage of resistant isolates.

[†]Trimethoprim/sulfamethoxazole concentration on plate = 2/38 µg/mL.

Figure 5. Antimicrobial resistance trends in bovine *Mannheimia haemolytica* isolates, 2018-2019.

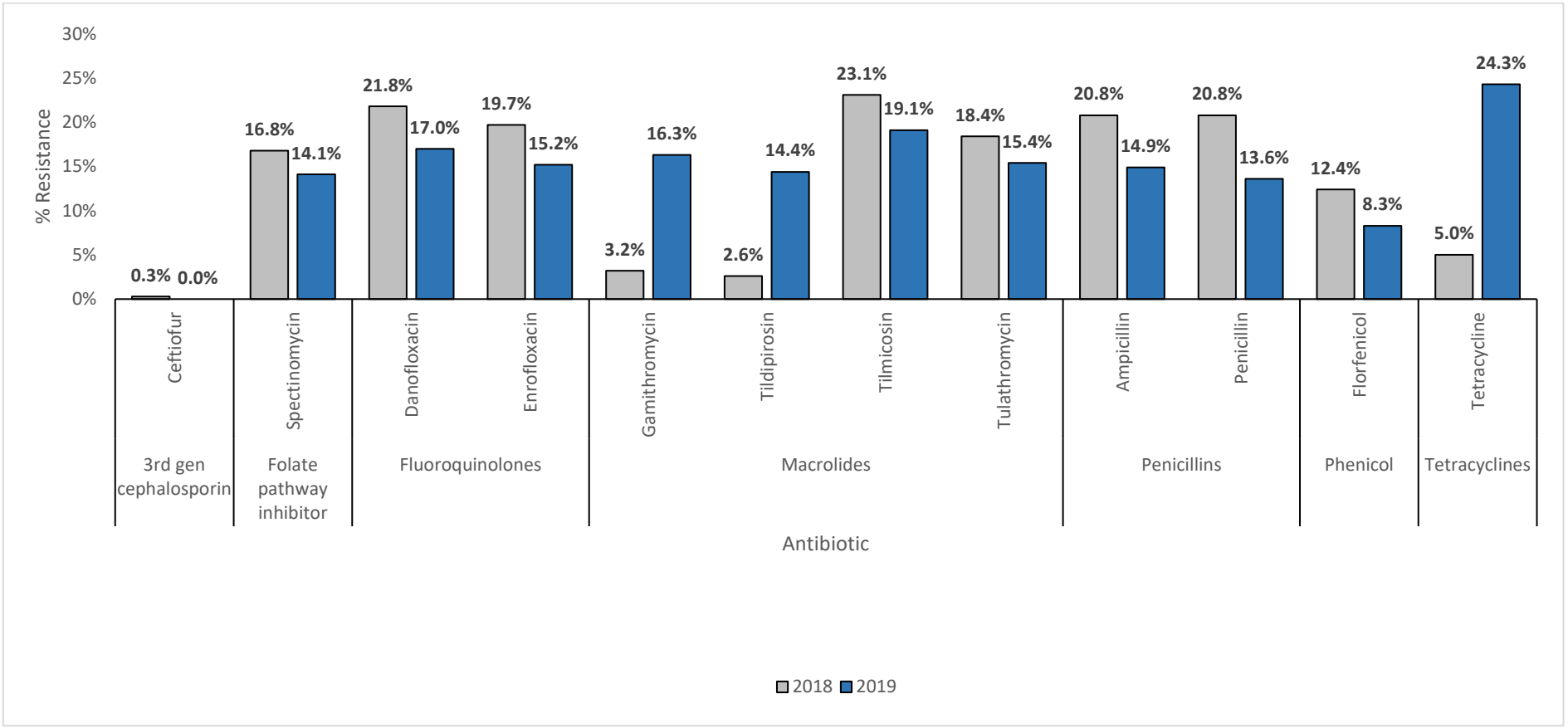


Table 9. Antimicrobial resistance analysis for bovine *Mannheimia haemolytica* isolates.

		Number of resistant isolates by antimicrobial class and individual antibiotic											
		CEPHALO-SPORIN	FOLATE PATHWAY INHIBITOR	FLUOROQUINOLONE		MACROLIDE				PENICILLIN		PHENICOL	TETRACYCLINE
No. of antibiotic resistant phenotypes per isolate	No. isolates	Ceftiofur No. resistant	Spectinomycin No. resistant	Danofloxacin No. resistant	Enrofloxacin No. resistant	Gamithromycin* No. resistant	Tilmicosin No. resistant	Tildipirosin No. resistant	Tulathromycin* No. resistant	Ampicillin No. resistant	Penicillin No. resistant	Florfenicol No. resistant	Tetracycline* No. resistant
11	17	0	17	17	17	17	17	17	17	17	17	17	17
10	19	0	17	19	19	19	19	19	18 (1 intermediate susceptibility)	19	17 (2 intermediate susceptibility)	5 (2 intermediate susceptibility)	19
9	21	0	19	20	20	20 (1 intermediate susceptibility)	21	18	19 (2 intermediate susceptibility)	12	9 (12 intermediate susceptibility)	13 (1 intermediate susceptibility)	18 (3 intermediate susceptibility)
8	11	0	11	11	10 (1 intermediate susceptibility)	7	11	5	11	6	4 (4 intermediate susceptibility)	5	7
7	12	0 (1 intermediate susceptibility)	9	12	11 (1 intermediate susceptibility)	3 (1 intermediate susceptibility)	12	2	11 (1 intermediate susceptibility)	9	9 (3 intermediate susceptibility)	2 (1 intermediate susceptibility)	4
6	7	0	3	5 (2 intermediate susceptibility)	3 (4 intermediate susceptibility)	3 (1 intermediate susceptibility)	7	4	6 (1 intermediate susceptibility)	1	1 (3 intermediate susceptibility)	5	4
5	8	0	2	6	5 (1 intermediate susceptibility)	2	6 (1 intermediate susceptibility)	2	4 (2 intermediate susceptibility)	4	3 (2 intermediate susceptibility)	2 (1 intermediate susceptibility)	4
4	7	0	1	5	4 (1 intermediate susceptibility)	0	6	0	1 (3 intermediate susceptibility))	2	3	5	1
3	16	0	3	5 (3 intermediate susceptibility)	4 (4 intermediate susceptibility)	5 (2 intermediate susceptibility)	10 (2 intermediate susceptibility)	1	6 (1 intermediate susceptibility)	5	6 (1 intermediate susceptibility)	2 (1 intermediate susceptibility)	1 (1 intermediate susceptibility)
2	20	0	3 (1 intermediate susceptibility)	1	0 (1 intermediate susceptibility)	1	5 (6 intermediate susceptibility)	0 (1 intermediate susceptibility)	1 (1 intermediate susceptibility)	13	13	0	3 (4 intermediate susceptibility)
1	49	0	1 (1 intermediate susceptibility)	3 (6 intermediate susceptibility)	0 (9 intermediate susceptibility)	0	3 (7 intermediate susceptibility)	0 (1 intermediate susceptibility)	0 (1 intermediate susceptibility)	3	1 (11 intermediate susceptibility)	1 (1 intermediate susceptibility)	37 (1 intermediate susceptibility)
0	425	0	0 (4 intermediate susceptibility)	0 (9 intermediate susceptibility)	0 (8 intermediate susceptibility)	0 (1 intermediate susceptibility)	0 (16 intermediate susceptibility)	0 (1 intermediate susceptibility)	0 (1 intermediate susceptibility)	0	0 (38 intermediate susceptibility)	0	0 (6 intermediate susceptibility)
TOTAL	612	0	86	104	93	77	117	68	94	91	83	57	115

APPENDIX B: MIC Distributions and Clinical Signs for *E. coli* and *S. suis* in Swine

SWINE – *E. COLI*

Table 10. MIC distribution for *E. coli* isolates recovered from swine. No antimicrobial interpretive breakpoints have been established for *E. coli* isolates from swine.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	16	>16	32	>32	64	>64	<=256	>256	Total Isolates[§]
3rd gen cephalosporin	Ceftiofur		26			74		6			3			2			17	28									156
aminocyclitol	Spectinomycin															15			71		6		6	58			156
aminoglycoside	Gentamicin						96				6			2			4		10	38							156
aminoglycoside	Neomycin												100				2		6		7	41					156
fluoroquinolone	Danofloxacin	100		7		11		7	31		0																156
fluoroquinolone	Enrofloxacin	101		6		7		10			13	19															156
folate pathway antagonist	Trimethoprim/ sulfamethoxazole[†]									109	0	47															156
folate pathway antagonist	Sulphadimethoxine																								53	103	156
lincosamide	Clindamycin		0			0		0			0			0			0		0	156							156
macrolide	Gamithromycin						0				2			26			47	18									93
macrolide	Tildipirosin						1				7			57			16		2	10							93
macrolide	Tilmicosin												0	0			0		1	93	2		39	21			156
macrolide	Tulathromycin						2				0			13		74	42		8		6		2	9			156
macrolide	Tylosin tartrate				0			0			0			0	0		0		0		1	154		1			156
penicillin	Ampicillin		1			0		0			22			26			1		1	105							156
penicillin	Penicillin	0		0		1		0			0			0			0	155									156
phenicol	Florfenicol		0			0		0			24			79			22	31									156
pleuromutalin	Tiamulin						0				0			0			0		3		8	145					156
tetracycline	Chlortetracycline				0			4			5			2			3	49									63
tetracycline	Oxytetracycline				0			9			3			0			0	51									63
tetracycline	Tetracycline				0			13			4			0			0	76									93

[§] Total number of isolates for each antimicrobial reflect a combination of the BOPO6F and BOPO7F plates. Not all antimicrobials in the table are present on both plates, leading to differences in isolate totals.
[†]Trimethoprim/sulfamethoxazole concentration on BOPO6F AND BOPO7F plates = 2/38 µg/mL.

Table 11. Clinical signs and diagnoses associated with porcine *E. coli* infections.

CLINICAL SIGNS/ INDICATIONS	2018 Count	2018 %	2019 Count	2019 %
DIARRHEA/ENTERIC DISEASE	97	67.8%	113	72.4%
PNEUMONIA/RESPIRATORY DISEASE	23	16.1%	17	10.9%
OTHER DIAGNOSIS/UNKNOWN*	10	7.0%	13	8.3%
SEPSIS/SEPTICEMIA	5	3.5%	7	4.5%
ABORTION/PLACENTITIS	6	4.2%	3	1.9%
ABSCESS/WOUND INFECTION	2	1.4%	3	1.9%
TOTAL	143		156	

* 2018 other/unknown diagnoses: skin infection (1), normal uterine flora (1), meningitis (1), nephritis (1), pleuritis (2), mulberry heart disease (1), nonspecific acute circulatory changes (1), and unknown diagnosis (2)
2019 other/unknown diagnoses: epidermiditis (1), infection [not otherwise specified] (3), rotavirus (2), arthritis (3), PRRS (1), toxicity/edema (1), urinary tract infection (1), hematopoiesis (1)

SWINE – *S. SUIS*

Table 12. MIC distribution for *Streptococcus suis* isolates recovered from swine in 2019.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	16	>16	32	>32	64	>64	<=256	>256	Total Isolates[§]	% R*
3rd gen cephalosporin	Ceftiofur		134			10		9			7			3			3	1								167	2.4%
aminocyclitol	Spectinomycin															54			78		10		6	19			167	
aminoglycoside	Gentamicin						50				36			57			17		3	4							167	
aminoglycoside	Neomycin												54				34		45		16	18					167	
fluoroquinolone	Danofloxacin	12		57		70		22	6		0																167	
fluoroquinolone	Enrofloxacin	27		66		59		11			1	3															167	2.4%
folate pathway antagonist	Trimethoprim/ sulfamethoxazole[†]									161		6															167	
folate pathway antagonist	Sulphadimethoxine																								59	108	167	
lincosamide	Clindamycin		25			3		1			3			8			5		7	115							167	
macrolide	Gamithromycin						23				4			4			3	68									102	
macrolide	Tildipirosin						3				4			4			14		0	77							102	
macrolide	Tilmicosin									10			5	6			17		0	78	2		4	45			167	
macrolide	Tulathromycin						2				5			5		25	1		2		4		15	108			167	
macrolide	Tylosin				21			13			1			1			2		0		6	123					167	
penicillin	Ampicillin		161			1		4			0			0			0		0	1							167	0.6%
penicillin	Penicillin	120		15		6		12			7			1			3	3									167	15.6%
phenicol	Florfenicol		4			8		63			83			9			0	0									167	0.0%
pleuromutalin	Tiamulin				45			33			22			5			10		16		10	26					167	
tetracycline	Chlortetracycline				4			2			2			5			7	45									65	
tetracycline	Oxytetracycline	0			4			3			1			0			9	48									65	
tetracycline	Tetracycline				1			1			4			2			6	88									102	98.0%

[§] Total number of isolates for each antimicrobial reflect a combination of the BOPO6F and BOPO7F plates. Not all antimicrobials in the table are present on both plates, leading to differences in isolate totals.

* % R = percentage of resistant isolates.

[†]Trimethoprim/sulfamethoxazole concentration on BOPO6F AND BOPO7F plates = 2/38 µg/mL.

Table 13. Clinical signs and diagnoses associated with porcine *Streptococcus suis* infections.

CLINICAL SIGNS/ INDICATIONS	2019 Count	2019 %
PNEUMONIA/RESPIRATORY DISEASE	95	56.9%
SEPSIS/SEPTICEMIA	16	9.6%
MENINGITIS/ENCEPHALITIS	15	9.0%
OTHER DIAGNOSIS*/UNKNOWN	15	9.0%
ENDOCARDITIS/PERICARDITIS	10	6.0%
DIARRHEA/ENTERIC DISEASE	5	3.0%
JOINT INFECTION	5	3.0%
DERMATITIS/EPIDERMITIS	3	1.8%
ABORTION/REPRODUCTIVE TRACT INFECTION	3	1.8%
TOTAL	167	

*Other diagnosis: peritonitis (1), influenza (2), PRRS (1), salmonellosis (1), sudden death (1), unknown/undetermined (9)

APPENDIX C: MIC Distributions and Clinical Signs for *E. coli* and *P. multocida* in Poultry.

POULTRY - *E. COLI* CHICKENS, DUCKS AND TURKEYS COMBINED

Table 14. MIC distribution for *E. coli* isolates recovered from chickens, ducks and turkeys, combined.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<= 0.12	0.12	<= 0.25	0.25	<= 0.5	0.5	<= 1	1	<=2	2	>2	<=2.5	4	>4	<=8	8	>8	16	>16	20	>20	<=32	32	>32	64	>64	128	256	>256	512	1024	> 1024	Total Isolates	% R*
3rd gen cephalosporin	Ceftiofur			78			252		17		5			1	21																			374	
aminocoumarin	Novobiocin					2			1		0			0	371																			374	
aminocyclitol	Spectinomycin															53			225					20		10	66							374	
aminoglycoside	Gentamicin					153			117		12			1			4	87																374	
aminoglycoside	Neomycin									269	0			24			5		2					12	62									374	
aminoglycoside	Streptomycin															225			11					24		51		37	14	0	6	4	2	374	
Fluoro-quinolone	Enrofloxacin**	340			19		5		2		1	7																						374	1.9%
folate pathway antagonist	Sulphadimeth-oxine																						45	0		83		74	26	146				374	
folate pathway antagonist	Trimethoprim/ sulfamethoxazole†					342			2		0	30																						374	
folate pathway antagonist	Sulphathiazole																						221			9		8	1	135				374	
lincosamide	Clindamycin					1			0		0			0	373																			374	
macrolide	Erythromycin	1			0		0		1		1			1	370																			374	
macrolide	Tylosin												1								0	371		0	2									374	
penicillin	Amoxicillin			1			1		8		65			143			31	0	2	123														374	
penicillin	Penicillin	1	1		1		0		0		1			1			7	362																374	
phenicol	Florfenicol							8			110			232			19	5																374	
tetracycline	Oxytetracycline			2			6		112		58			2			0	194																374	
tetracycline	Tetracycline			2			10		127		40			0			1	194																374	

Poultry-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018).

* % R = percentage of resistant isolates.

** Enrofloxacin is not approved for use in poultry in the U.S. as of 2017.

†Trimethoprim/sulfamethoxazole concentrations on AVIAN1F plate = 0.5/9.5 µg/mL, 1/19 µg/mL, and 2/38 µg/mL.

POULTRY – *E. COLI* – CHICKENS AND DUCKS

Table 15. MIC distribution for *E. coli* isolates recovered from chickens and ducks in 2019. Data includes results from 4 ducks.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	<=2	2	>2	<=2.5	4	>4	<=8	8	>8	16	>16	20	>20	<=32	32	>32	64	>64	128	256	>256	512	1024	>1024	Total Isolates	% R*
3rd gen cephalosporin	Ceftiofur			60			171		8		0			1	17																			257	
aminocoumarin	Novobiocin					2			0		0			0	255																			257	
aminocyclitol	Spectinomycin															40			153					12		3	49							257	
aminoglycoside	Gentamicin					114			75		9			1			1	57																257	
aminoglycoside	Neomycin									207	0			18			4		0					5	23									257	
aminoglycoside	Streptomycin															172			11					19		27		14	8	0	3	1	2	257	
Fluoro-quinolone	Enrofloxacin§	230			16		3		1		1	6																						257	2.3%
folate pathway antagonist	Sulphadimeth-oxine																						36	0		66		58	20	77				257	
folate pathway antagonist	Trimethoprim/ sulfamethoxazole†					241			2		0	14																						257	
folate pathway antagonist	Sulphathiazole																						175			6		5	1	70				257	
lincosamide	Clindamycin					1			0		0			0	256																			257	
macrolide	Erythromycin	1			0		0		0		1			1	254																			257	
macrolide	Tylosin												0								0	255		0	2									257	
penicillin	Amoxicillin			1			1		6		51			104			26	0	1	67														257	
penicillin	Penicillin	1	1		1		0		0		0			0			7	247																257	
phenicol	Florfenicol							7			89			144			13	4																257	
tetracycline	Oxytetracycline			2			5		93		46			2			0	109																257	
tetracycline	Tetracycline			2			9		102		34			0			1	109																257	

Poultry-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018).

* % R = percentage of resistant isolates.

§ Enrofloxacin is not approved for use in poultry in the U.S. as of 2017.

† Trimethoprim/sulfamethoxazole concentrations on plate = 0.5/9.5 µg/mL, 1/19 µg/mL, and 2/38 µg/mL.

POULTRY – *E. COLI* – TURKEYS

Table 16. MIC distribution for *E. coli* isolates recovered from turkeys.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	<=2	2	>2	<=2.5	4	>4	<=8	8	>8	16	>16	20	>20	<=32	32	>32	64	>64	128	256	>256	512	1024	>1024	Total Isolates	% R*
3rd gen cephalosporin	Ceftiofur			18			81		9		5			0	4																			117	
aminocoumarin	Novobiocin					0			1		0			0	116																			117	
aminocyclitol	Spectinomycin															13			72					8		7	17							117	
aminoglycoside	Gentamicin					39			42		3			0			3	30															117	
aminoglycoside	Neomycin									62	0			6			1		2					7	39									117	
aminoglycoside	Streptomycin															53			0					5		24		23	6	0	3	3	0	117	
Fluoro-quinolone	Enrofloxacin**	110			3		2		1		0	1																					117	0.9 %
folate pathway antagonist	Sulphadimeth-oxine																						9	0		17		16	6	69				117	
folate pathway antagonist	Sulphathiazole					101			0		0	16																					117	
folate pathway antagonist	Trimethoprim/ sulfamethox-azole†																						46			3		3	0	65				117	
lincosamide	Clindamycin					0			0		0			0	117																			117	
macrolide	Erythromycin	0			0		0		1		0			0	116																			117	
macrolide	Tylosin												1								0	116		0	0									117	
penicillin	Amoxicillin			0			0		2		14			39			5	0	1	56														117	
penicillin	Penicillin		0		0		0		0		1			1			0	115																117	
phenicol	Florfenicol							1			21			88			6	1																117	
tetracycline	Oxytetracycline			0			1		19		12			0			0	85																117	
tetracycline	Tetracycline			0			1		25		6			0			0	85																117	

Poultry-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018).

* % R = percentage of resistant isolates.

** Enrofloxacin is not approved for use in poultry in the U.S. as of 2017.

†Trimethoprim/sulfamethoxazole concentrations on plate = 0.5/9.5 µg/mL, 1/19 µg/mL, and 2/38 µg/mL.

Table 17. Clinical signs and diagnoses associated with poultry *E. coli* infections in 2019.

Final Diagnosis	Total Chickens	Total Turkeys	Total Ducks	All Poultry
E. COLI INFECTION/SEPTICEMIA/COLIBACILLOSIS	75	27	2	104
PNEUMONIA/BRONCHITIS/URT† INFECTIONS	28	25	1	54
REPRODUCTIVE TRACT/YOLK SAC INFECTION	51	1	1	53
OTHER	22*	26**		48
PERITONITIS, HEPATITIS	32	6		38
UNKNOWN	14	15		29
ENTERITIS	12	6		18
JOINT INFECTION	8	5		13
PERICARDITIS, EPICARDITIS	6	2		8
AIRSACCULITIS	3	2		5
MIXED/SECONDARY INFECTION	2	2		4
GRAND TOTAL	**253**	**117**	**4**	**374**

* Other diagnosis for chickens: Marek's Disease (5) dehydration (2), eye infection (2), IBV (2), avian pox (1), fowl cholera (1), injury (1), lymphoproliferative disease (1), meningoencephalitis (1), mycoplasma (1), otitis (1), parathyroid carcinoma (1), pododermatitis (1), *Pseudomonas* (1), visceral gout (1).

** Other diagnosis for turkeys: health screening (18), black head (1), *Brachyspira* (1), coccidiosis (1), lymphoproliferative disease (1), mycotic encephalitis (1), *Ornithobacterium rhinotrachelae* (1), *Salmonella* (1).

† URT = upper respiratory tract

POULTRY – *PASTEURELLA MULTOCIDA:* CHICKENS, DUCKS AND TURKEYS

Table 18. MIC distribution for *Pasteurella multocida* isolates recovered from all poultry in 2019. No antimicrobial interpretive breakpoints have been established for *P. multocida* isolates from poultry.

antimicrobial class	MIC value (μg/mL) / Antimicrobial	<=0.06	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	<=2	2	>2	<=2.5	4	>4	<=8	8	>8	10	16	20	>20	<=32	32	>32	64	128	256	>256	512	Total Isolates
3rd gen cephalosporin	Ceftiofur				50			1		0		0			0	0															51
aminocoumarin	Novobiocin						4			21		17			6	3															51
aminocyclitol	Spectinomycin																9				16				26		0					51
aminoglycoside	Gentamicin						2			7		29			12			1	0													51
aminoglycoside	Neomycin										12				22			13			3				0	1						51
aminoglycoside	Streptomycin																26				21				3		0	0	0		1	51
Fluoro-quinolone	Enrofloxacin		50			0		0		0		1	0																			51
folate pathway antagonist	Sulphadimethoxine																							16			8	4	4	19		51
folate pathway antagonist	Trimethoprim/sulfamethox-azole†						47			0		2	2																			51
folate pathway antagonist	Sulphathiazole																							23			10	12	2	4		51
lincosamide	Clindamycin						0			0		0			2	49															51
macrolide	Erythromycin		0			0		2		9		27			11	2															51
macrolide	Tylosin													1						7		19	24									51
penicillin	Amoxicillin				41			9		0		0			1			0			0											51
penicillin	Penicillin	26	0	14		8		0		2		0			0			0	1													51
phenicol	Florfenicol								47			2			1			1	0													51
tetracycline	Oxytetracycline				26			10		11		2			1			0	1													51
tetracycline	Tetracycline				25			12		11		0			2			0	1													51

†Trimethoprim/sulfamethoxazole concentrations on plate = 0.5/9.5 μg/mL, 1/19 μg/mL, and 2/38 μg/mL.

Table 19. MIC distribution for *Pasteurella multocida* isolates recovered from chickens and ducks in 2019. Table includes data from 3 duck isolates.

antimicrobial class	MIC value (μg/mL) / Antimicrobial	<=0.06	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	<=2	2	>2	<=2.5	4	>4	<=8	8	>8	10	16	20	>20	<=32	32	>32	64	128	256	>256	512	Total Isolates
3rd gen cephalosporin	Ceftiofur				41			1		0		0			0	0															42
aminocoumarin	Novobiocin						4			17		12			6	3															42
aminocyclitol	Spectinomycin																7				16				19		0					42
aminoglycoside	Gentamicin						1			7		24			9			1	0													42
aminoglycoside	Neomycin										11				17			11			2				0	1						42
aminoglycoside	Streptomycin																22				16				3		0	0	0		1	42
Fluoro-quinolone	Enrofloxacin		41			0		0		0		1	0																			42
folate pathway antagonist	Sulphadimethoxine																							14			7	3	3	15		42
folate pathway antagonist	Trimethoprim/sulfamethoxazole†						38			0		2	2																			42
folate pathway antagonist	Sulphathiazole																							20			8	9	2	3		42
lincosamide	Clindamycin						0			0		0			2	40															42
macrolide	Erythromycin		0			0		2		8		22			9	1															42
macrolide	Tylosin													1						5		18	18									42
penicillin	Amoxicillin				34			7		0		0			1			0			0											42
penicillin	Penicillin	21	0	14		5		0		1		0			0			0	1													42
phenicol	Florfenicol								38			2			1			1	0													42
tetracycline	Oxytetracycline				21			6		11		2			1			0	1													42
tetracycline	Tetracycline				20			8		11		0			2			0	1													42

No antimicrobial interpretive breakpoints have been established for *P. multocida* isolates from poultry.

†Trimethoprim/sulfamethoxazole concentrations on plate = 0.5/9.5 μg/mL, 1/19 μg/mL, and 2/38 μg/mL.

Table 20. MIC distribution for *Pasteurella multocida* isolates recovered from turkeys in 2019. No antimicrobial interpretive breakpoints have been established for *P. multocida* isolates from poultry.

antimicrobial class	Antimicrobial \ MIC value (µg/mL)	<=0.06	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	<=2	2	>2	<=2.5	4	>4	<=8	8	>8	10	16	20	>20	<=32	32	>32	64	128	256	>256	512	Total Isolates
3rd gen cephalosporin	Ceftiofur				9			0		0		0			0	0															9
aminocoumarin	Novobiocin						0			4		5			0	0															9
aminocyclitol	Spectinomycin																2				0				7		0				9
aminoglycoside	Gentamicin						1			0		5			3			0	0												9
aminoglycoside	Neomycin										1				5			2			1				0	0					9
aminoglycoside	Streptomycin																4				5				0		0	0	0		0	9
Fluoro-quinolone	Enrofloxacin		9			0		0		0		0	0																			9
folate pathway antagonist	Sulphadimethoxine																							2			1	1	1	4		9
folate pathway antagonist	Trimethoprim/sulfamethox-azole†						9			0		0	0																			9
folate pathway antagonist	Sulphathiazole																							3			2	3	0	1		9
lincosamide	Clindamycin						0			0		0			0	9															9
macrolide	Erythromycin		0			0		0		1		5			2	1															9
macrolide	Tylosin													0						2		1	6								9
penicillin	Amoxicillin				7			2		0		0			0			0			0											9
penicillin	Penicillin	5	0	0		3		0		1		0			0			0	0													9
phenicol	Florfenicol								9			0			0			0	0													9
tetracycline	Oxytetracycline				5			4		0		0			0			0	0													9
tetracycline	Tetracycline				5			4		0		0			0			0	0													9

†Trimethoprim/sulfamethoxazole concentrations on plate = 0.5/9.5 µg/mL, 1/19 µg/mL, and 2/38 µg/mL.

Table 21. Clinical signs and diagnoses associated with poultry *P. multocida* infections in 2019.

Final Diagnosis	Total Chickens	Total Turkeys	Total Ducks	Total Poultry
FOWL CHOLERA/SEPTICEMIA	29	7	3	39
JOINT INFECTION	5	0	0	5
OTHER/UNKNOWN*	2	2	0	4
PNEUMONIA/RESPIRATORY INFECTIONS	3	0	0	3
GRAND TOTAL	**39**	**9**	**3**	**51**

* Other/unknown diagnoses: no diagnosis – turkey (2); no diagnosis – chicken (1), health screening – chicken (1)

APPENDIX D: MIC Distributions and Clinical Signs for *E. coli, S. equi* and *S. zooepidemicus* in Horses

HORSES - *E. COLI*

Table 22. MIC distribution for *E. coli* isolates recovered from horses.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.06	0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	Cefazolin							0						232	0			4		5	61					302	
3rd gen cephalosporin	Ceftazidime							258				1			6			8		9		9		8	3	302	
3rd gen cephalosporin	Ceftiofur			77			153		7			5			1	59										302	
aminoglycoside	Amikacin**													275	0			14		5		1	7			302	8.9%
aminoglycoside	Gentamicin							218				17			3			1	63							302	21.2%
ansamycin	Rifampin							2				5	0		96	199										302	
B lactam/B-lactamase inhibitor combo	Ticarcillin/Clavulanic acid†																225			27		19		15	16	302	
B lactam/B-lactamase inhibitor combo	Ticarcillin																204			11		1		4	82	302	
carbapenem	Imipenem							297				5			0			0	0							302	
fluoroquinolone	Enrofloxacin§			264			4		5			1	28													302	12.6%
folate pathway antagonist	Trimethoprim/sulfamethoxazole†					181			1			2	0		0	118									302	
macrolide	Azithromycin			0			5		17			94			140	46									302	
macrolide	Clarithromycin							2				0			0			3	297							302	
macrolide	Erythromycin	0	0	1	0		0		2			0			0	0		2	297							302	
penicillin	Ampicillin			0		0	1		16	0		80		0	112			6		1		0	86			302	
penicillin	Oxacillin			2			0		0			0			0	300										302	
penicillin	Penicillin	0	1		1		0		0			0			0			4	296							302	
phenicol	Chloramphenicol										0			101				139		3	0	4	55			302	
tetracycline	Doxycycline§										204				14			10		23	51					302	32.5%
tetracycline	Tetracycline										214				2			1	85							302	

Equine-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are from CLSI Vet08, 4th ed. (2018).

* % R = percentage of resistant isolates.

**Amikacin breakpoints for adult animals are shown. Breakpoints for isolates from foals are: S ≤2, I = 4, R ≥8.

§Enrofloxacin and doxycycline dilutions on the antimicrobial sensitivity plate are above the breakpoint values for sensitive and intermediate. Thus interpretation of MIC data was restricted to only resistant values. Doxycycline breakpoints for horses are: S ≤0.12; I = 0.25; R ≥0.5, and enrofloxacin breakpoints for horses are: S ≤0.12; I = 0.25; R ≥0.5.

†Ticarcillin/clavulanate concentrations on plate = 8/2 µg/mL, 16/2 µg/mL, 32/2 µg/mL and 64/2 µg/mL. Trimethoprim/sulfamethoxazole concentrations on plate = 0.5/9.5 µg/mL, 1/19 µg/mL, 2/38, and 4/76 µg/mL.

Figure 6. Antimicrobial resistance trends in equine *E. coli* isolates, 2018-2019.

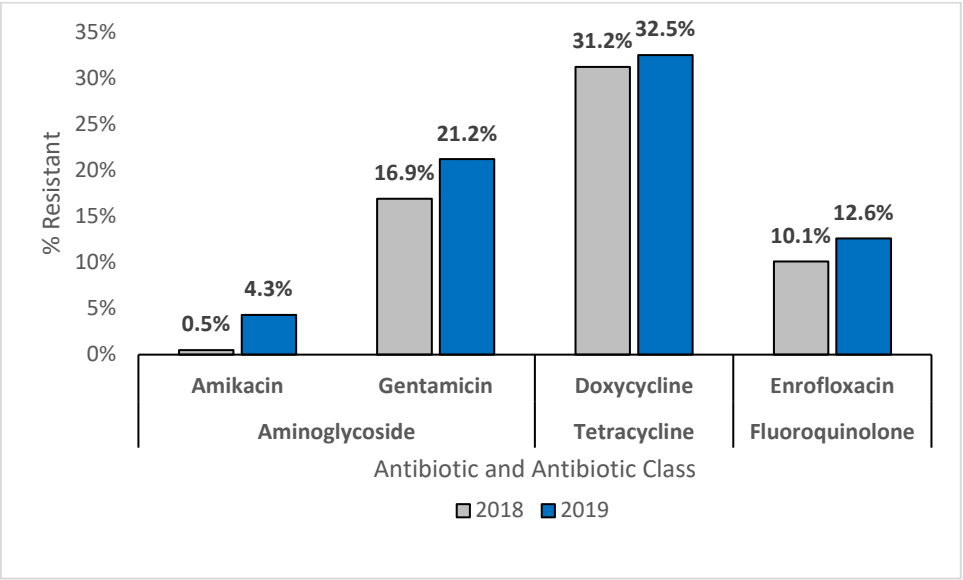


Table 23. Clinical signs and diagnoses associated with equine *E. coli* infections.

Clinical signs/indications	2018 Count	2018 %	2019 Count	2019 %
REPRODUCTIVE TRACT INFECTION	92	48.7%	135	44.7%
PNEUMONIA/RESPIRATORY TRACT INFECTION	8	4.2%	28	9.3%
PERITONEAL, LIVER, KIDNEY INFECTION	6	3.2%	26	8.6%
ABORTION/NEONATAL INFECTION	0	0 %	24	7.9%
DIARRHEA/ENTERIC INFECTION	19	10.1%	23	7.6%
ABSCESS/SKIN/WOUND INFECTION	26	13.8%	23	7.6%
SEPSIS/SEPTICEMIA	6	3.2%	13	4.3%
ARTHRITIS/JOINT INFECTION	4	2.1%	11	3.6%
URINARY TRACT INFECTION	2	1.1%	10	3.3%
OTHER*	4	2.1%	9	3.0%
UNKNOWN/NO DIAGNOSIS	22	11.6%	0	0.0%
TOTAL	**189**		**302**	

* 2018 other diagnoses: cast in stall (1), chronic kidney failure (1), jugular thrombosis (1), rhodococcal pneumonia/pneumocystis carinii, colitis (1)
2019 other diagnoses: vertebral fracture (1), myositis/cellulitis (3), lymphosarcoma (1), intestinal adhesion/obstruction (1), hematoma (1), grain overload (1), sequestrum of the canon bone (1)

HORSES – *STREPTOCOCCUS EQUI*

Table 24. MIC distribution for *S. equi* isolates recovered from horses.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.06	0.12	<=0.25	0.25	<=0.5	0.5	<=1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	Cefazolin**												57				0		0	0					57	0.0%
3rd gen cephalosporin	Ceftazidime							56			0			1			0		0		0		0	0	57	
3rd gen cephalosporin	Ceftiofur§			56			0		0		1			0	0										57	
aminoglycoside	Amikacin												8	0			1		5		7	36			57	84.2%
aminoglycoside	Gentamicin							7			4			4			22	20							57	
ansamycin	Rifampin							55			0	0		2	0										57	
B lactam/B-lactamase inhibitor combo	Ticarcillin/Clavulanic acid†															56			1		0		0	0	57	
B lactam/B-lactamase inhibitor combo	Ticarcillin															56			1		0		0	0	57	
carbapenem	Imipenem							57			0			0			0	0							57	
fluoroquinolone	Enrofloxacin**			3			6		42		4	2													57	94.7%
folate pathway antagonist	Trimethoprim/sulfamethoxazole†					54			3		0	0		0	0										57	
macrolide	Azithromycin			55			1		1		0			0	0										57	
macrolide	Clarithromycin							56			0			0			0	1							57	
macrolide	Erythromycin			55	0		1		0		0			0			0	1							57	
penicillin	Ampicillin§			56		0			0		0			0			0		1		0	0			57	
penicillin	Oxacillin			54			2		1		0			0	0										57	
penicillin	Penicillin	54	1		0		0		1		0			0			0	1							57	1.8%
phenicol	Chloramphenicol									0			53				4		0	0	0	0			57	
tetracycline	Doxycycline**									56				0			1		0	0					57	100.0%
tetracycline	Tetracycline									50				4			2	1							57	

Equine-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are from CLSI Vet08, 4th ed. (2018).

* % R = percentage of resistant isolates.

**Cefazolin, enrofloxacin and doxycycline dilutions on the antimicrobial sensitivity plate are above the breakpoint values for sensitive and intermediate. Thus interpretation of MIC data was restricted to only resistant values. Ampicillin breakpoints for horses are: S ≤0.5; I = 1; R ≥2, cefazolin breakpoints for horses are: S ≤2; I = 4; R ≥8, doxycycline breakpoints for horses are: S ≤0.12; I = 0.25; R ≥0.5, and enrofloxacin breakpoints for horses are: S ≤0.12; I = 0.25; R ≥0.5.

§ Breakpoints for intermediate and resistant values for ampicillin and ceftiofur have not been established for horses.

†Ticarcillin/clavulanate concentrations on plate = 8/2 µg/mL, 16/2 µg/mL, 32/2 µg/mL and 64/2 µg/mL. Trimethoprim/sulfamethoxazole concentrations on plate = 0.5/9.5 µg/mL, 1/19 µg/mL, 2/38, and 4/76 µg/mL.

HORSES – *STREPTOCOCCUS EQUI* SSP. *ZOOEPIDEMICUS*

Table 25. MIC distribution for *S. zooepidemicus* isolates recovered from horses.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.06	0.12	<=0.25	0.25	<=0.5	0.5	<=1	>=1	<=2	2	>2	<=4	4	>4	<=8	8	>8	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	Cefazolin**												355				2		0	2					359	1.1%
3rd gen cephalosporin	Ceftazidime							338			17			1			0		0		1		0	2	359	
3rd gen cephalosporin	Ceftiofur§			340			8		8		0			0	3										359	
aminoglycoside	Amikacin												30	0			17		49		31	232			359	86.9%
aminoglycoside	Gentamicin							44			35			33			43	204							359	
ansamycin	Rifampin							353			3			1	2										359	
B lactam/B-lactamase inhibitor combo	Ticarcillin/Clavulanic acid†															356			2		0		0	1	359	
B lactam/B-lactamase inhibitor combo	Ticarcillin												0			355			2		0		0	2	359	
carbapenem	Imipenem							357			1			0			0	1							359	
fluoroquinolone	Enrofloxacin**			9			99		234		12	5													359	97.5%
folate pathway antagonist	Trimethoprim/sulfamethoxazole†					331			9		4			4	11										359	
macrolide	Azithromycin			339			16		1		0			1	2										359	
macrolide	Clarithromycin							351			5			0			0	3							359	
macrolide	Erythromycin			345			6		0		3			1			1	3							359	
penicillin	Ampicillin§			346			8		1		0			2			0		0		0	2			359	
penicillin	Oxacillin			340			2		2		6			2	7										359	
penicillin	Penicillin	330	15		1		9		0		1			0			1	2							359	1.1%
phenicol	Chloramphenicol									0			336				18		2		2	1			359	
tetracycline	Doxycycline**									300				14			39		6	0					359	100.0%
tetracycline	Tetracycline									152				115			30	62							359	

Equine-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are from CLSI Vet08, 4th ed. (2018).

* % R = percentage of resistant isolates.

** Cefazolin, enrofloxacin and doxycycline dilutions on the antimicrobial sensitivity plate are above the breakpoint values for sensitive and intermediate. Thus interpretation of MIC data was restricted to only resistant values. Cefazolin breakpoints for horses are: S ≤2; I = 4; R ≥8, doxycycline breakpoints for horses are: S ≤0.12; I = 0.25; R ≥0.5, and enrofloxacin breakpoints for horses are: S ≤0.12; I = 0.25; R ≥0.5.

§ Breakpoints for intermediate and resistant values for ampicillin and ceftiofur have not been established for horses.

†Ticarcillin/clavulanate concentrations on plate = 8/2 µg/mL, 16/2 µg/mL, 32/2 µg/mL and 64/2 µg/mL. Trimethoprim/sulfamethoxazole concentrations on plate = 0.5/9.5 µg/mL, 1/19 µg/mL, 2/38, and 4/76 µg/mL.

Table 26. Clinical signs and diagnoses associated with equine *S. zooepidemicus* infections in 2019.

Clinical signs/indications	2019 Count	2019 %
REPRODUCTIVE TRACT INFECTION	132	36.8%
PNEUMONIA/RESPIRATORY TRACT INFECTION	131	36.5%
ABSCESS/SKIN/WOUND INFECTION	55	15.3%
OTHER*	14	3.9%
ARTHRITIS/JOINT INFECTION	9	2.5%
DIARRHEA/ENTERIC INFECTION	7	1.9%
EYE INFECTIONS	7	1.9%
PERITONEAL, LIVER, KIDNEY INFECTION	4	1.1%
TOTAL	359	

*Other diagnoses: urinary tract infection (1), sepsis/septicemia (1), cellulitis (1), otitis (1), perineural hemorrhage (1), umbilical cord torsion (1), clostridial myositis (1), mastitis (2), surveillance (4), necrotic muscle (1).

APPENDIX E: MIC Distributions and Clinical Signs for *E. coli* and *S. intermedius* group in Dogs

DOGS – E. COLI - URINARY TRACT INFECTIONS

Table 27. MIC distribution for *E. coli* UTI isolates recovered from dogs.

Antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	<=2	2	>2	<=4	4	>4	<=8	8	>8	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	**Cefazolin****						29			317			101			14		9		6	74			550	14.5%
1st gen cephalosporin	**Cephalexin****				0			1		2			162			274		24	87					550	15.8%
3rd gen cephalosporin	**Cefovecin****		36	0		235		167		27			7			3	75							550	14.2%
3rd gen cephalosporin	**Cefpodoxime[§]**						456			9			3			5	77							550	14.9%
3rd gen cephalosporin	**Ceftazidime[§]**											489	0			11		20	30					550	
aminoglycoside	**Amikacin**						0					531				16		3		0	0			550	0.5%
aminoglycoside	**Gentamicin**		19	0		331		167		16			1			1	15							550	2.9%
β lactam/β-lactamase inhibitor combo	**Amoxicillin/Clavulanic acid**[*†‡]**		0			0		4		55			303			106	82							550	
β lactam/β-lactamase inhibitor combo	**Piperacillin/tazobactam**														529			9		5		4	3	550	2.2%
carbapenem	**Imipenem**						547	0		1			0			2	0							550	
fluoroquinolone	**Enrofloxacin**	461		6		10		4		6			0	63										550	11.5%
fluoroquinolone	**Marbofloxacin**	458		7		13		5		2			0	65										550	11.8%
fluoroquinolone	**Orbifloxacin**						468			10			5			3	64							550	12.2%
fluoroquinolone	**Pradofloxacin**		478			6		2		5	59													550	11.6%
folate pathway antagonist	**Trimethoprim/sulfamethoxazole°**				491			3		0			0	56										550	
penicillin	**Ampicillin**[*†]**		0			2		10		160			208			19	151							550	
phenicol	**Chloramphenicol**								3				133			327		46		7	34			550	
tetracycline	**Doxycycline**		0			21		167		247			47			18	50							550	
tetracycline	**Tetracycline**											485				0		1	64					550	

Canine-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018).

*Percentage of resistant isolates.

**Antimicrobials with separate breakpoints for canine *E. coli* urinary tract infections (UTIs).

[§]Extended spectrum beta-lacatmase (ESBL) testing is indicated for isolates with MIC ≥ 8 mg/mL for cefpodoxime, or >2 mg/mL for ceftazidime.

[†]Breakpoints for intermediate and resistant values for amoxicillin/clavulanic acid and ampicillin have not been established for UTIs in dogs.

‡ Amoxicillin/clavulanic acid concentrations on plate are 0.25/0.12, 0.5/0.25, 1/0.5, 2/1, 4/2 and 8/4 µg/mL.

° Trimethoprim/sulfamethoxazole concentrations on plate are 0.12/2.38, 0.25/4.75, 0.5/9.5 µg/mL, 1/19 µg/mL, 2/38, and 4/76 µg/mL.

Figure 7. Antimicrobial resistance trends in canine *E. coli* UTI isolates, 2018-2019.

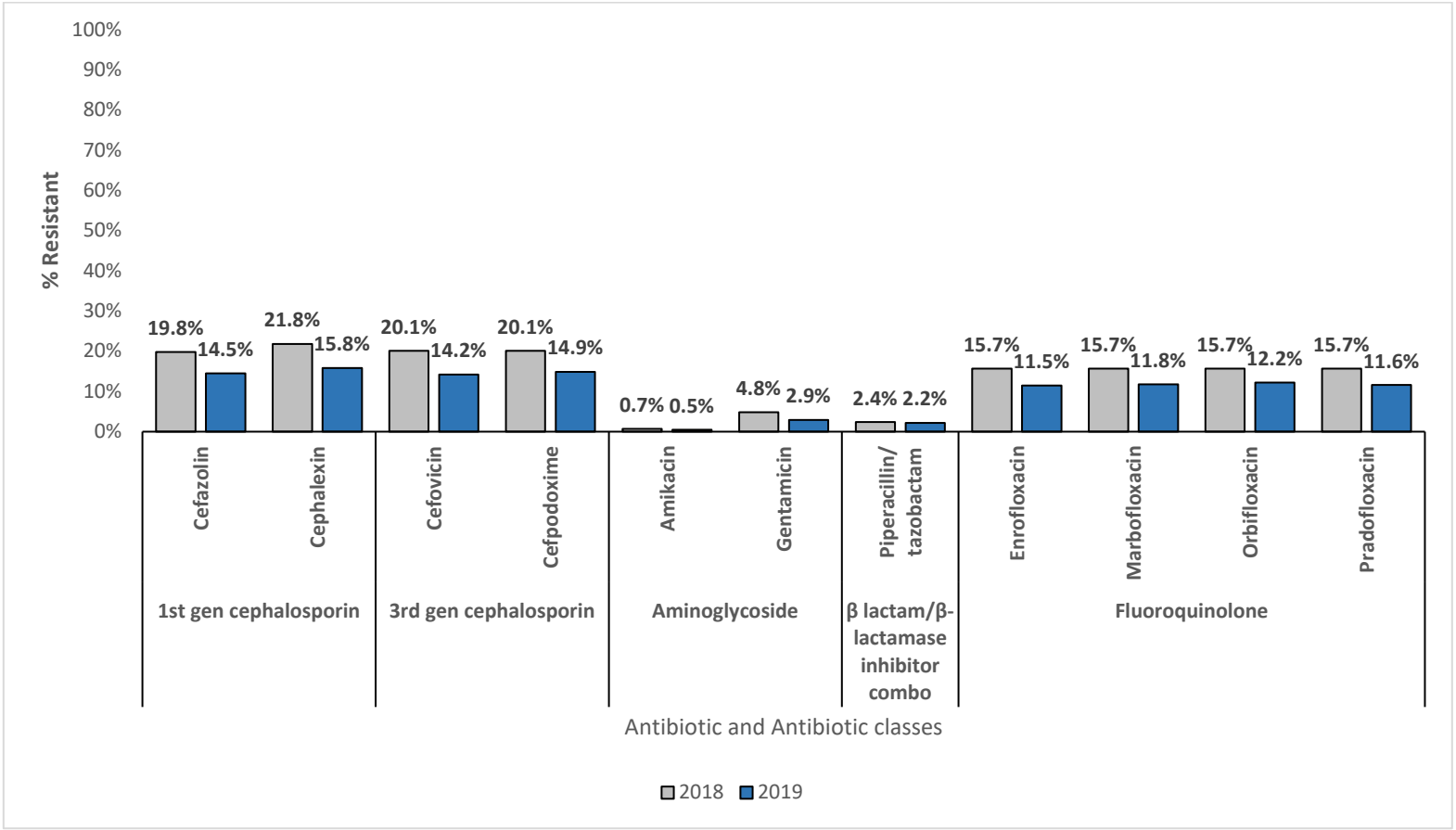


Table 28. Antimicrobial resistance analysis for canine *E. coli* UTI isolates.

		Number of resistant isolates by antimicrobial class and individual antibiotic										
No. of antibiotic resistant phenotypes per isolate	**No. isolates (% total)**	**AMINOGLYCOSIDE**		**CEPHALOSPORIN**				**FLUOROQUINOLONE**				**B LACTAM COMBO**
		Amikacin No. resistant	**Gentamicin No. resistant**	**Cefazolin No. resistant**	**Cefovecin No. resistant**	**Cefpodoxime No. resistant**	**Cephalexin No. resistant**	**Enrofloxacin No. resistant**	**Marbofloxacin No. resistant**	**Orbifloxacin No. resistant**	**Pradofloxacin No. resistant**	**Piperacillin/ tazobactam, No. resistant**
10	1	1	1	1	1	1	1	1	1	1	1	0
9	12	1 (2 intermediate susceptibility)	7	12	12	12	12	12	12	12	12	4
8	26	26	26	26	26	26	26	26	26	26	25	0 (3 intermediate susceptibility)
7	0	0	0	0	0	0	0	0	0	0	0	0
6	1	0 (1 intermediate susceptibility)	1	0 (1 intermediate susceptibility)	1	0 (1 intermediate susceptibility)	1	1	1	1	1	0 (1 intermediate susceptibility)
5	10	0	3	8	8	8	8 (1 intermediate susceptibility)	2 (1 intermediate susceptibility)	2	3 (1 intermediate susceptibility)	2 (1 intermediate susceptibility)	6
4	47	0 3 intermediate susceptibility)	0	25	26	26	26	21	21	21	21	1 (3 intermediate susceptibility)
3	4	0 (1 intermediate susceptibility)	0	1 (3 intermediate susceptibility)	3	3	3	0 (1 intermediate susceptibility)	1	1	1	0 (1 intermediate susceptibility)
2	8	0	1	1 (1 intermediate susceptibility)	0 (3 intermediate susceptibility)	5	6	0 (2 intermediate susceptibility)	1 (1 intermediate susceptibility)	1 (1 intermediate susceptibility)	0 (2 intermediate susceptibility)	1
1	12	1	4	0	1 (3 intermediate susceptibility)	1 (2 intermediate susceptibility)	4	0 (3 intermediate susceptibility)	0 (1 intermediate susceptibility)	1 (1 intermediate susceptibility)	0 (2 intermediate susceptibility)	0
0	429	0	0	0	0	0	0	0	0	0	0	0
TOTAL	550	3	16	74	86	78	82	63	65	67	63	12

DOGS – *E. COLI* - NON-URINARY TRACT INFECTIONS

Table 29. MIC distribution for *E. coli* non-UTI isolates recovered from dogs.

Antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	<=2	2	>2	<=4	4	>4	<=8	8	>8	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	**Cefazolin**						26			146			51			14		6		0	57			300	25.7%
1st gen cephalosporin	**Cephalexin**				1			0		1			93			125		10	70					300	68.3%
3rd gen cephalosporin	**Cefovecin**		27	0		116		79		17			4			1	56							300	
3rd gen cephalosporin	**Cefpodoxime****						229			0			8			4	59							300	21.0%
3rd gen cephalosporin	**Ceftazidime****											251	0			6		23	20					300	
aminoglycoside	**Amikacin**						0					285				13		2		0	0			300	0.7%
aminoglycoside	**Gentamicin**		12	0		163		92		8			2			0	23							300	7.7%
β lactam/β-lactamase inhibitor combo	**Amoxicillin/ Clavulanic acid†**		2			0		2		27			145			51	73				0			300	99.3%
β lactam/β-lactamase inhibitor combo	**Piperacillin/tazobactam**														288			6		3		1	2	300	2.0%
carbapenem	**Imipenem**						297	0		3			0			0	0							300	
fluoroquinolone	**Enrofloxacin**	246		7		6		0		1			1	39										300	13.3%
fluoroquinolone	**Marbofloxacin**	246		6		8		1		0			1	38										300	13.0%
fluoroquinolone	**Orbifloxacin**						253			5			0			2	40							300	14.0%
fluoroquinolone	**Pradofloxacin**		258			2		2		2	36													300	12.7%
folate pathway antagonist	**Trimethoprim/sulfamethoxazole§**				255			0		0			0	45										300	
penicillin	**Ampicillin**		2			0		10		74			92			7	115				0			300	99.3%
phenicol	**Chloramphenicol**								6				89			170		15		1	19			300	
tetracycline	**Doxycycline**		2			14		89		122			16			7	50							300	
tetracycline	**Tetracycline**											240				2		2	56					300	

Canine-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018).

*Percentage of resistant isolates.

**Extended spectrum beta-lactamase (ESBL) testing is indicated for isolates with MIC ≥ 8 mg/mL for cefpodoxime, or >2 mg/mL for ceftazidime.

†Amoxicillin/clavulanic acid concentrations on plate are 0.25/0.12, 0.5/0.25, 1/0.5, 2/1, 4/2 and 8/4 µg/mL.

§Trimethoprim/sulfamethoxazole concentrations on plate are 0.12/2.38, 0.25/4.75, 0.5/9.5 µg/mL, 1/19, 2/38, and 4/76 µg/mL.

Figure 8. Antimicrobial resistance trends in canine *E. coli* non-UTI isolates, 2018-2019.

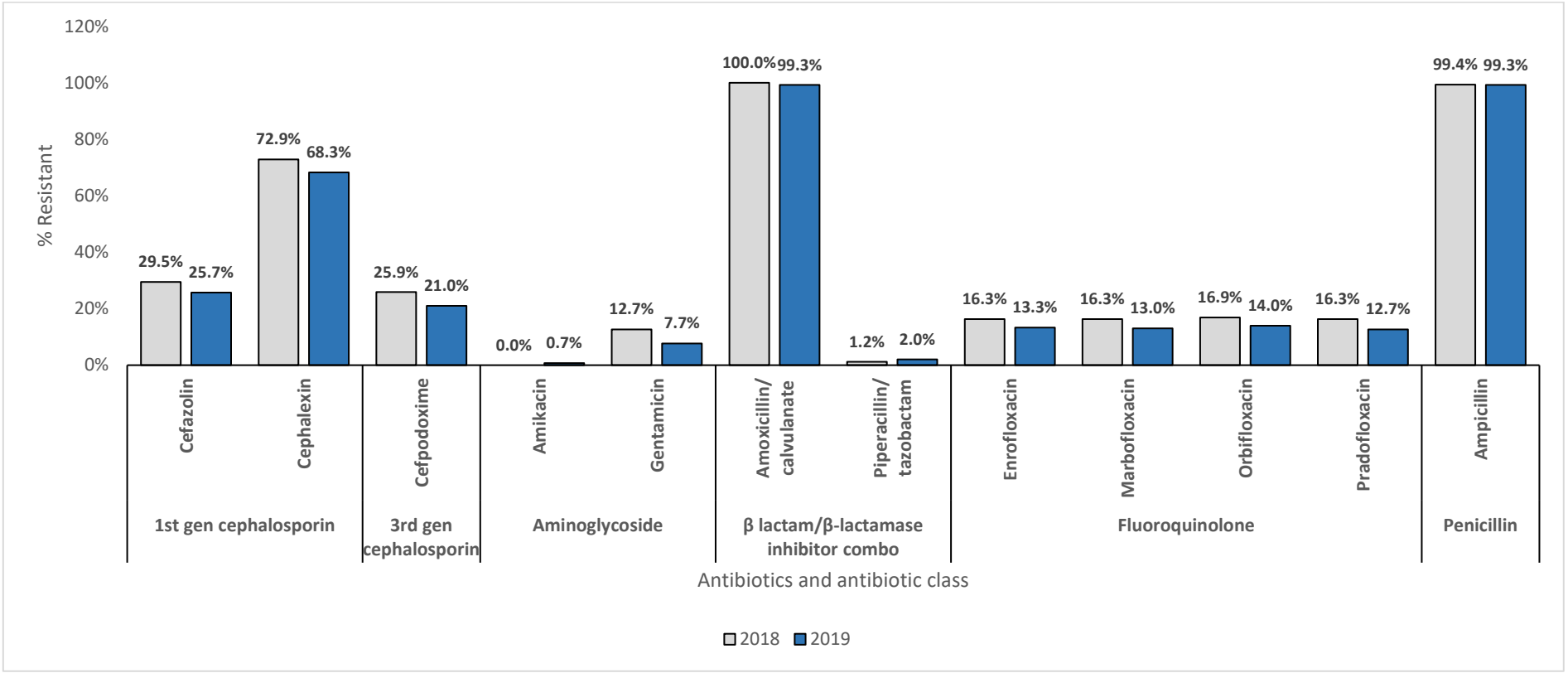


Table 30. Antimicrobial resistance analysis for canine *E. coli* non-UTI isolates.

		Number of resistant isolates by antimicrobial class and individual antibiotic											
		AMINOGLYCOSIDE		CEPHALOSPORIN			FLUOROQUINOLONE				B LACTAM COMBO		PENICILLIN
No. of antibiotic resistant phenotypes per isolate	No. isolates (% total)	Amikacin No. resistant	Gentamicin No. resistant	Cefazolin No. resistant	Cephalexin No. resistant	Cefpodoxime No. resistant	Enrofloxacin No. resistant	Marbofloxacin No. resistant	Orbifloxacin No. resistant	Pradofloxacin No. resistant	Piperacillin/ tazobactam No. resistant	Amoxacillin/ clavulanic acid No. resistant	Ampicillin No. resistant
11	1	0	1	1	1	1	1	1	1	1	1	1	1
10	13	0 (4 intermediate susceptibility)	10	13	13	13	13	13	13	13	3 (2 intermediate susceptibility)	13	13
9	18	0 (3 intermediate susceptibility)	2	18	18	16 (1 intermediate susceptibility)	18	18	18	18	0 (3 intermediate susceptibility)	18	18
8	3	0	1	2 (1 intermediate susceptibility)	3	1	3	3	3	2 (1 intermediate susceptibility)	0	3	3
7	2	0	1	1	2	1	1 (1 intermediate susceptibility)	1	2	1 (1 intermediate susceptibility)	0	2	2
6	11	0 (1 intermediate susceptibility)	4	8 (1 intermediate susceptibility)	8 (3 intermediate susceptibility)	7	4	3	5 (1 intermediate susceptibility)	3 (2 intermediate susceptibility)	2	11	11
5	23	0	0	23	23	23	0	0	0 (2 intermediate susceptibility)	0	0 (1 intermediate susceptibility)	23	23
4	12	1	3	8 (2 intermediate susceptibility)	11 (1 intermediate susceptibility)	1 (6 intermediate susceptibility)	0	0	0	0	0	12	12
3	131	1 (3 intermediate susceptibility)	1 (1 intermediate susceptibility)	3 (41 intermediate susceptibility)	126 (5 intermediate susceptibility)	0 (1 intermediate susceptibility)	0	0	0 (2 intermediate susceptibility)	0	0	131	131
2	84	0 (2 intermediate susceptibility)	0 (1 intermediate susceptibility)	0 (6 intermediate susceptibility)	0 (84 intermediate susceptibility)	0	0	0	0	0	0	84	84
1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	2	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	300	2	23	77	205	63	40	39	42	38	6	298	298

Table 31. Clinical signs and diagnoses associated with canine non-UTI *E. coli* infections.

CLINICAL SIGNS/INDICATIONS	2018 COUNT	2018 %	2019 COUNT	2019 %
ABSCESS/SKIN/WOUND INFECTION	51	30.7%	86	28.7%
REPRODUCTIVE TRACT INFECTIONS	16	9.6%	48	16.0%
OTITIS/EAR INFECTION	28	16.9%	40	13.3%
RESPIRATORY INFECTION/PNEUMONIA	16	9.6%	36	12.0%
DIARRHEA/ENTERIC INFECTIONS	17	10.2%	31	10.3%
NEPHRITIS, HEPATITIS, PERITONITIS	9	5.4%	17	5.7%
CHOLECYSTITIS	5	3.0%	14	4.7%
OTHER*	3	1.8%	12	4.0%
MASTITIS	2	1.2%	6	2.0%
SEPSIS/SEPTICEMIA	8	4.8%	4	1.3%
UNDETERMINED	6	3.6%	3	1.0%
PROSTATITIS	5	3.0%	3	1.0%
TOTAL	166		300	

*Other diagnoses Y1: neoplasia (1), proliferative bone lesion/delayed healing (1), canine herpesvirus (1).
Other diagnoses Y2: distemper (1), eye infection (2), dysautonomia (1), fasciitis (1), lymphosarcoma (1), joint infection (1), lymphadenopathy (1), osteomyelitis (1), parvovirus (2), squamous cell carcinoma (1).

DOGS - STAPHYLOCOCCUS INTERMEDIUS GROUP – URINARY TRACT INFECTIONS

DOGS – *S. INTERMEDIUS* GROUP - URINARY TRACT INFECTIONS-OX[S]

Table 32. MIC distribution for canine OX[S] *S. intermedius* group isolates recovered from urinary tract infections.

Antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.06	0.06	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	>0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	<=16	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	**Cefazolin**					0					0			130	0			2	1											133	0.8%
1st gen cephalosporin	**Cephalothin**										0			133				0	0											133	
3rd gen cephalosporin	**Cefovecin**	4	0	0	60		61		6			1			0			0			1	0							133	
3rd gen cephalosporin	**Cefpodoxime**										0			131				1		0	0	1							133	
aminoglycoside	**Amikacin**																			0			132			0	1			133	0.8%
aminoglycoside	**Gentamicin**													0			120				4			6	3					133	
ansamycin	**Rifampin**							0			133				0	0														133	
β lactam/β-lactamase inhibitor combo	**Amoxicillin/ Clavulanic acid**[†]**			0		131	0		0			1		1	0			0			0	0								133	
carbapenem	**Imipenem**							0			132				0			1	0											133	
fluoroquinolone	**Enrofloxacin**					109	0		6			8			2			1	7											133	6.0%
fluoroquinolone	**Marbofloxacin**							0			125	0			1			0	7											133	5.3%
fluoroquinolone	**Pradofloxacin[§]**			0		125			1			1			1	5														133	4.5%
folate pathway antagonist	**Trimethoprim/sulfamethoxazole[‡]**										0			116				1	16											133	
Glycopeptide	**Vancomycin**							0			131				1			1			0			0	0					133	
lincosamide	**Clindamycin**					0		114				0			0			1	18											133	
macrolide	**Erythromycin**			0		92	0		19			1			1			0	20											133	
nitrofuran	**Nitrofurantoin**																			0			132	0		0		1	0	133	
penicillin	**Ampicillin**			0		94		0	13			9			6			5			1	5								133	
penicillin	**Oxacillin°**					133	0	0	0			0			0	0														133	
penicillin	**Penicillin**	55	0		8	0	13		10			4			10			9			8	16								133	
phenicol	**Chloramphenicol**																0			119				2		4	8			133	
tetracycline	**Doxycycline**	0		93			3		1	36				0																133	
tetracycline	**Minocycline**					0		96				4			13	20														133	
tetracycline	**Tetracycline**			0		91			3			2	36		0			0	0											132	

Canine-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant.

Interpretive values based on CLSI Vet08, 4th ed. (2018).

*Percentage of resistant isolates.

**Interpretive breakpoints for intermediate and resistant have not been established for amoxicillin/clavulanic acid in canine urinary tract infections.

[§]Pradofloxacin is not approved for use in dogs in the U.S.

[†]Amoxicillin/clavulanic acid concentrations on plate are 0.25/0.12, 0.5/0.25, 1/0.5, 2/1, 4/2 and 8/4 µg/mL.

[‡]Trimethoprim/sulfamethoxazole concentrations on plate are 2/38 and 4/76 µg/mL.

°Human-derived breakpoints for oxacillin [S ≤0.25, R ≥0.5] were used to categorize oxacillin sensitive isolates.

Figure 9. Antimicrobial resistance trends in canine *S. intermedius* grp OX[S] isolates from UTIs, 2018-2019.

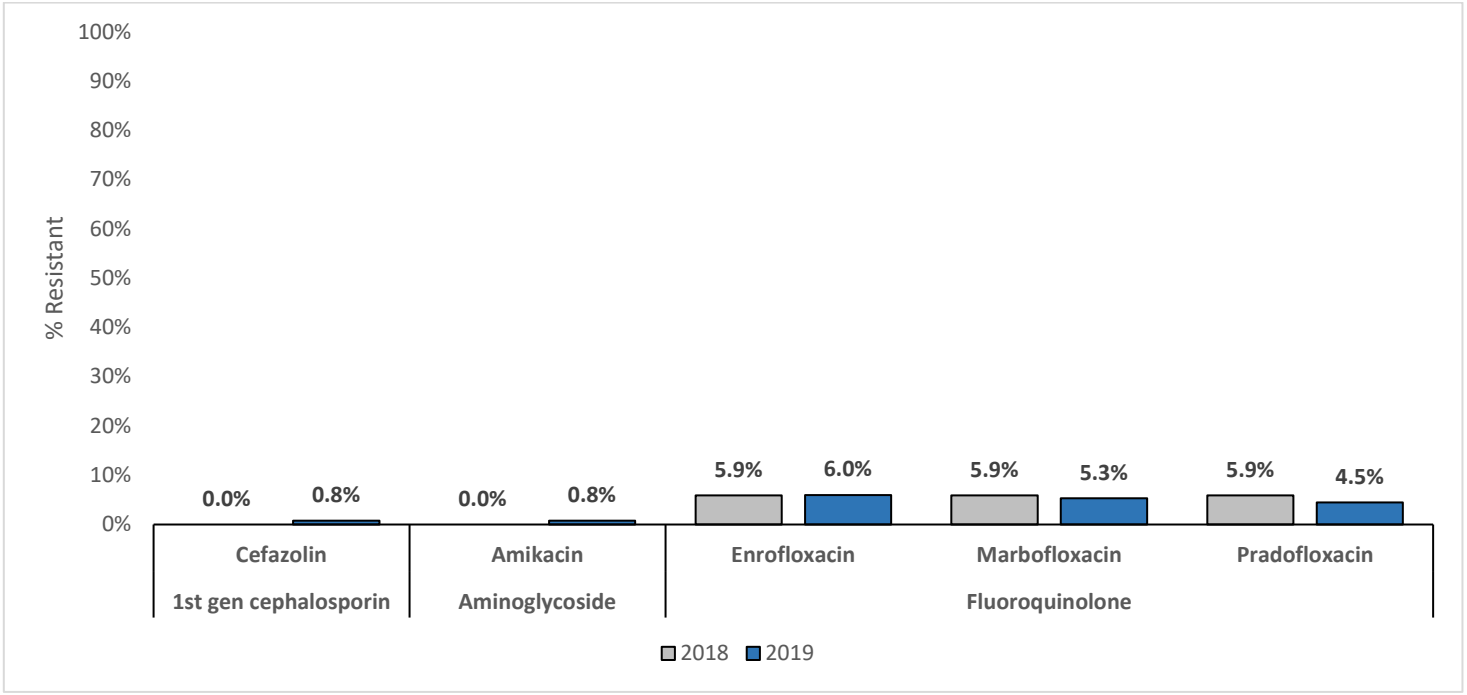


Table 33. Antimicrobial resistance analysis for canine OX[S] *S. intermedius* UTI isolates.

		Number of resistant isolates by antimicrobial class and individual antibiotic					
		AMINOGLYCOSIDE	CEPHALOSPORIN	FLUOROQUINOLONE			β LACTAM COMBO
No. of antibiotic resistant phenotypes per isolate	No. isolates	Amikacin No. resistant	Cefazolin No. resistant	Enrofloxacin No. resistant	Marbofloxacin No. resistant	Pradofloxacin No. resistant	Amoxicillin/ Clavulanic acid No. resistant
3	6	0	0	6	6	6	0
2	2	1	0	2	1	0 (1 intermediate susceptibility)	0
1	2	0	1	0	0	0	1
0	123	0	0 (2 intermediate susceptibility)	0 (10 intermediate susceptibility)	0 (1 intermediate susceptibility)	0 (2 intermediate susceptibility)	0
Total	133	1	1	8	7	6	1

DOGS – *S. INTERMEDIUS* GROUP – URINARY TRACT INFECTIONS-OX^{R}

Table 34. MIC distribution for canine OX^{R} *S. intermedius* group isolates recovered from urinary tract infections.

Antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.06	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	>0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	<=16	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	**Cefazolin****				**0**					**0**			**30**	**0**			**4**	**6**											40	
1st gen cephalosporin	**Cephalothin****									**0**			**33**				**3**	**4**											40	
3rd gen cephalosporin	**Cefovecin****	**0**	**0**	**1**		**2**		**0**			**2**			**6**			**6**			**3**	**20**							40	
3rd gen cephalosporin	**Cefpodoxime****									**0**			**11**				**6**		**0**	**7**	**16**							40	
aminoglycoside	**Amikacin**																		0			39			1	0			40	2.5%
aminoglycoside	**Gentamicin**												0			14				10			12	4					40	
ansamycin	**Rifampin**						0			38				0	2														40	
β lactam/β-lactamase inhibitor combo	**Amoxicillin/ Clavulanic acid**†**		0		8	0		9			11		0	4			2			3	3								40	
carbapenem	**Imipenem****						0			38				1			0	1											40	
fluoroquinolone	**Enrofloxacin**				12	0		0			4			0			0	24											40	60.0%
fluoroquinolone	**Marbofloxacin**						0			16	0			0			0	24											40	60.0%
fluoroquinolone	**Pradofloxacin§**		0		16			0			0			13	11													40	60.0%
folate pathway antagonist	**Trimethoprim/sulfamethoxazole‡**									0			13				6	21											40	
glycopeptide	**Vancomycin**						0			40				0			0			0			0	0					40	
lincosamide	**Clindamycin**				0		10				1			0			0	29											40	
macrolide	**Erythromycin**		0		8	0		2			1			0			0	29											40	
nitrofuran	**Nitrofurantoin**																		0			38	0		2		0	0	40	
penicillin	**Ampicillin****		0		3		0	1			2			0			2			4	28								40	
penicillin	**Oxacillin§**				0	0	0	4			12			8	16														40	
penicillin	**Penicillin****	2		0	0	0		0			1			1			0			2	34								40	
phenicol	**Chloramphenicol**															0			30				3		4	3			40	
tetracycline	**Doxycycline**	0	9			0		2	29				0																40	
tetracycline	**Minocycline**				0		10				2			2	26														40	
tetracycline	**Tetracycline**		0		9			1			1	29		0			0	0											40	

Canine-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values based on CLSI Vet08, 4th ed. (2018).

*Percentage of resistant isolates.

**Antimicrobials that would be reported as resistant based on oxacillin resistance.

§Pradofloxacin is not approved for use in dogs in the U.S.

§Human-derived breakpoints for oxacillin [S ≤0.25, R ≥0.5] were used to categorize oxacillin sensitive isolates.

†Amoxicillin/clavulanic acid concentrations on plate are 0.25/0.12, 0.5/0.25, 1/0.5, 2/1, 4/2 and 8/4 µg/mL.

‡Trimethoprim/sulfamethoxazole concentrations on plate are 2/38 and 4/76 µg/mL.

Figure 10. Antimicrobial resistance trends in canine *S. intermedius* group OX^{R} UTI isolates, 2018-2019.

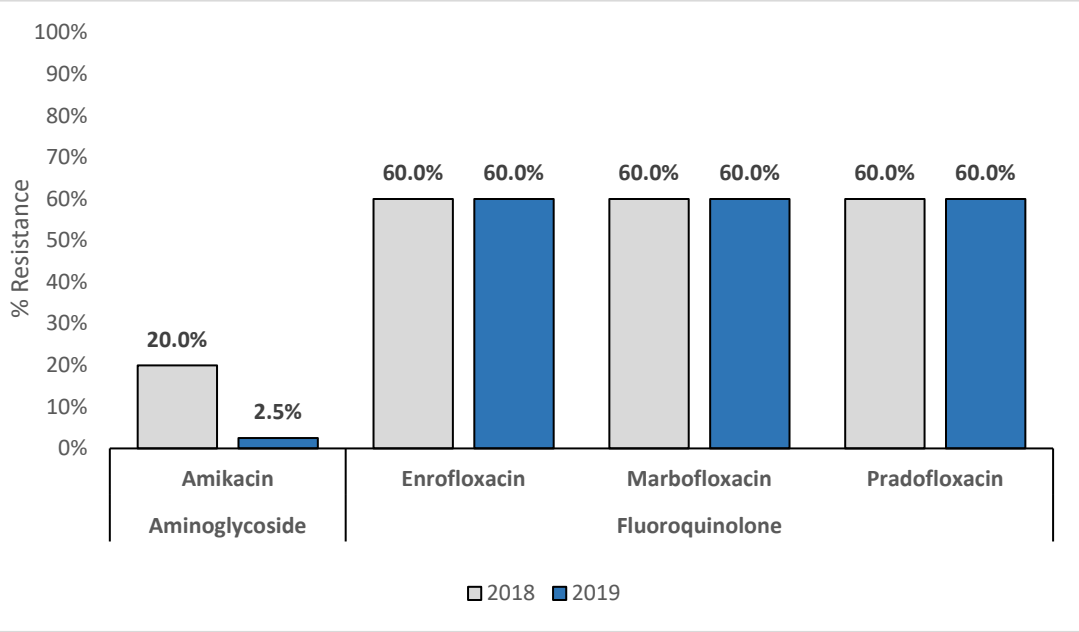


Table 35. Antimicrobial resistance analysis for canine OX^{R} *S.intermedius* UTI isolates.

		Number of resistant isolates by antimicrobial class and individual antibiotic			
		AMINOGLYCOSIDE	FLUOROQUINOLONE		
No. of antibiotic resistant phenotypes per isolate	No. isolates	Amikacin No. resistant	Enrofloxacin No. resistant	Marbofloxacin No. resistant	Pradofloxacin No. resistant
4	1	1	1	1	1
3	23	0	23	23	23
2	0	0	0	0	0
1	0	0	0	0	0
0	16	0	0 (4 Intermediate Susceptibility)	0	0
Total	40	1	24	24	24

DOGS - STAPHYLOCOCCUS INTERMEDIUS GROUP – NON- URINARY TRACT INFECTIONS

Table 36. Clinical signs and diagnoses associated with canine *S. intermedius* group non-UTI isolates.

Clinical signs/indications	2018 COUNT	2018 %	2019 COUNT	2019 %
ABSCESS/WOUND/SKIN INFECTION*	147	54.9%	461	59.3%
OTITIS/EAR INFECTION	61	22.8%	188	24.2%
PNEUMONIA/RESPIRATORY INFECTION**	7	2.6%	42	5.4%
EYE INFECTION	5	1.9%	22	2.8%
REPRODUCTIVE TRACT INFECTIONS	12	4.5%	17	2.2%
OTHER†	7	2.6%	13	1.7%
ARTHRITIS, BONE/JOINT INFECTION	6	2.2%	13	1.7%
UNDETERMINED	11	4.1%	12	1.5%
PERITONITIS/PARENCHYMAL ORGAN INFECTIONS	7	2.6%	6	0.8%
MASTITIS	2	0.7%	2	0.3%
SEPSIS/SEPTICEMIA	3	1.1%	1	0.1%
TOTAL	268		777	

*2019 total for abscess/wound/skin infections includes the following diagnoses: pyoderma (124), wounds, surgical site infections (110), skin infections-not otherwise specified (99), dermatitis (90), abscesses (25), and cellulitis (13).

**2019 pneumonia/respiratory infection diagnoses includes the following: sinus infections (24), upper respiratory infections (10, and pneumonia (8).

†Other diagnoses 2018 = hepatic lipidosis (1), pleuritis (1), cardiomyopathy (1), canine herpesvirus (1), heartworm (1), and epiglottitis (2).

Other diagnoses 2019 = tooth/oral abscess (5), abscessed lymph node (1), lymph node tumor (1), canine distemper (1), canine herpesvirus (1), proctitis (2), anal sacculitis (1),

DOGS – *S. INTERMEDIUS* GROUP – NON-URINARY TRACT INFECTIONS-OX[S]

Table 37. MIC distribution for canine OX[S] *S. intermedius* group isolates recovered from body sites other than urinary tract infections.

Antimicrobial class	Antimicrobial / MIC value (µg/mL)	<=0.06	0.06	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	>0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	<=16	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	Cefazolin					0					0			483	0			1	1											485	0.2%
1st gen cephalosporin	Cephalothin										0			483				1	1											485	0.2%
3rd gen cephalosporin	Cefovecin	6	0	0	251		206		18			3			0			1			0	0							485	0.2%
3rd gen cephalosporin	Cefpodoxime**										0			483				1			1	0							485	0.2%
aminoglycoside	Amikacin†																						484			0	1			485	0.2%
aminoglycoside	Gentamicin													0			425				24			22	14					485	
ansamycin	Rifampin							0			484				1	0														485	
B lactam/B-lactamase inhibitor	Amoxicillin/ Clavulanic acid‡			0		481	0		1			1		0	0			1			0	1							485	0.6%
carbapenem	Imipenem							0			484				0			0	1											485	
fluoroquinolone	Enrofloxacin					404	0		17			24			3			4	33											485	7.6%
fluoroquinolone	Marbofloxacin							0			441	0			7			1	35											484	7.4%
fluoroquinolone	Pradofloxacin§			0		444			4			2			18	17														485	7.2%
folate pathway antagonist	Trimethoprim/sulfamethoxazole^										0			420				11	54											485	
glycopeptide	Vancomycin							0			477				7			0			0			0	1					485	
lincosamide	Clindamycin					0		403				2			3			1	76											485	15.9%
macrolide	Erythromycin			0		316	0		80			6			1			2	80											485	
nitrofuran	Nitrofurantoin																			0			484	0		1		0	0	485	
penicillin	Ampicillin			0		290		0	49			38			34			27			16	31								485	40.2%
penicillin	Oxacillin°					485	0	0	0			0			0	0														485	
penicillin	Penicillin	162	1		17	0	33		44			30			22			17			51	108								485	
phenicol	Chloramphenicol																0			433				7		7	38			485	
tetracycline	Doxycycline	0		324			22		2	137				0																485	28.7%
tetracycline	Minocycline					0		342				12			27	104														485	27.0%
tetracycline	Tetracycline			0		325			17			4	139		0			0	0											485	29.5%

Canine-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values based on CLSI Vet08, 4th ed. (2018).

*Percentage of resistant isolates.

** Cefpodoxime breakpoints are established for wounds, abscesses and urinary tract infections only in dogs.

† Antimicrobial sensitivity plate dilutions for amikacin are 16 and 32 µg/mL. Canine amikacin breakpoints are ≤4 µg/mL [sensitive], 8 µg/mL [intermediate] and ≥16 µg/mL [resistant]. Isolates classified as resistant are in red.

‡Amoxicillin/clavulanic acid concentrations on plate are 0.25/0.12, 0.5/0.25, 1/0.5, 2/1, 4/2 and 8/4 µg/mL.

§Pradofloxacin is not approved for use in dogs in the U.S.

^Trimethoprim/sulfamethoxazole concentrations on plate are 2/38 and 4/76 µg/mL.

° Human-derived breakpoints for oxacillin [S ≤0.25, R ≥0.5] were used to categorize oxacillin sensitive isolates. Dark blue shaded cells = sensitive based on human breakpoints.

Figure 11. Antimicrobial resistance trends in canine *S. intermedius* group OX^S non-UTI isolates, 2018-2019.

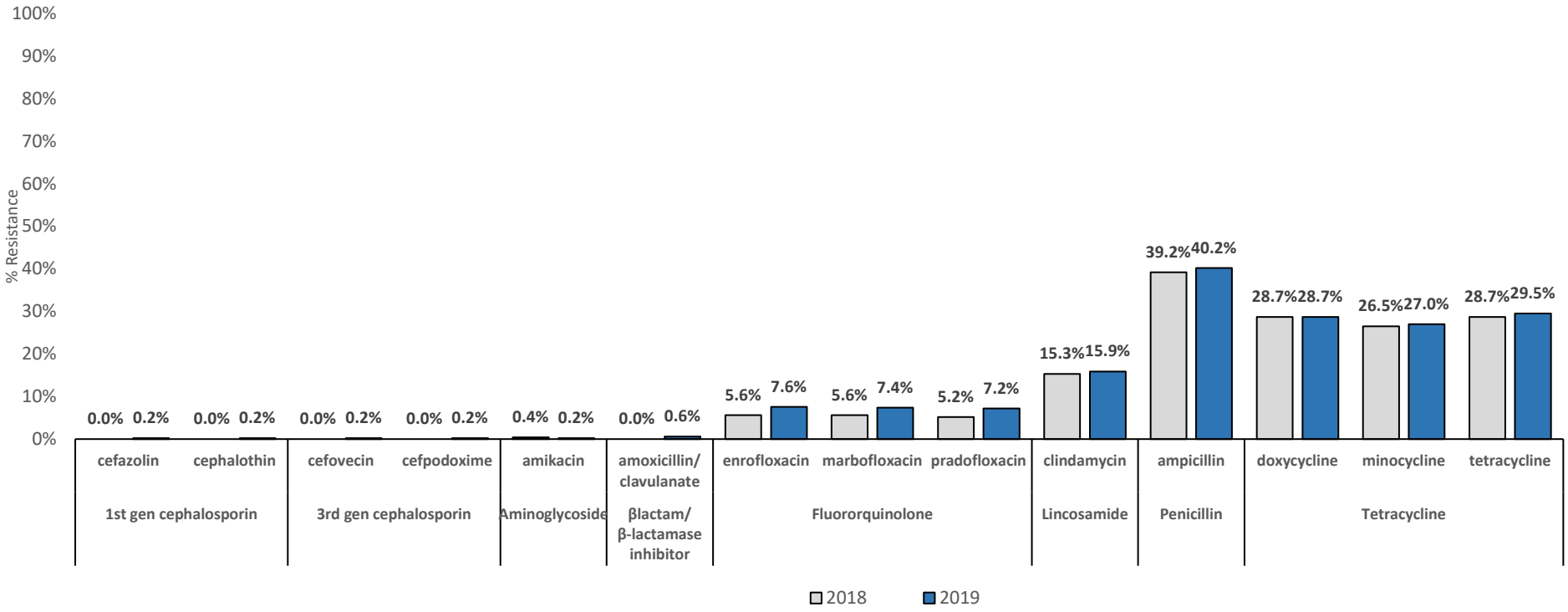


Table 38. Antimicrobial resistance analysis for canine OX[S] *S. intermedius* group non-UTI isolates.

		Number of resistant isolates by antimicrobial class and individual antibiotic													
		AMINO-GLYCOSIDE	β LACTAM COMBO	CEPHALOSPORIN				FLUOROQUINOLONE			LINCOSAMIDE	PENI-CILLIN	TETRACYCLINE		
No. of antibiotic resistant pheno-types per isolate	No. isolates (% total)	Amikacin* No. resistant	Amoxicillin/ clavulanic acid No. resistant	Cefazolin No. resistant	Cefovecin No. resistant	Cefpodoxime No. resistant	Cephalothin No. resistant	Enrofloxacin No. resistant	Marbofloxacin No. resistant	Pradofloxacin No. resistant	Clindamycin No. resistant	Ampicillin No. resistant	Doxycycline No. resistant	Minocycline No. resistant	Tetracycline No. resistant
10	1	0	1	1	0	0	1	0	1	1	1	1	1	1	1
9	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	11	0	0	0	0	0	0	11	11	11	11	11	11	11	11
7	15	0	0	0	0	0	0	15	15	15	9	6	15	15	15
6	4	0	0	0	0	0	0	3	4	3	2	2	3 (1 intermediate susceptibility)	3 (1 intermediate susceptibility)	4
5	16	0	0 (1 intermediate susceptibility)	0 (1 intermediate susceptibility)	0 (1 intermediate susceptibility)	0	0	0 (2 intermediate susceptibility)	0	0	16	16	16	16	16
4	47	1	2	0	0 (1 intermediate susceptibility)	0 (1 intermediate susceptibility)	0	2 (8 intermediate susceptibility)	1 (1 intermediate susceptibility)	2 (2 intermediate susceptibility)	13 (1 intermediate susceptibility)	35	45	43 (1 intermediate susceptibility)	44
3	50	0	0	0	0	0	0	5	4 (1 intermediate susceptibility)	3 (2 intermediate susceptibility)	5	3	45 (1 intermediate susceptibility)	40 (4 intermediate susceptibility)	45 (1 intermediate susceptibility)
2	15	0	0	0	0	0	0	0 (1 intermediate susceptibility)	0 (1 intermediate susceptibility)	0	10	10	3 (2 intermediate susceptibility)	1 (3 intermediate susceptibility)	6
1	126	0	0	0	1 (1 intermediate susceptibility)	1	0	1 (9 intermediate susceptibility)	0 (2 intermediate susceptibility)	0 (1 intermediate susceptibility)	10 (1 intermediate susceptibility)	111	0 (13 intermediate susceptibility)	1 (3 intermediate susceptibility)	1 (12 intermediate susceptibility)
0	200	0	0	0	0	0	0 (1 intermediate susceptibility)	0 (7 intermediate susceptibility)	0 (2 intermediate susceptibility)	0 (1 intermediate susceptibility)	0 (3 intermediate susceptibility)	0	0 (5 intermediate susceptibility)	0	0 (4 intermediate susceptibility)
TOTAL	485	1	3	1	1	1	1	37	36	35	77	195	139	131	143

DOGS – *S. INTERMEDIUS* GROUP - NON-URINARY TRACT INFECTIONS-OX^{R}

Table 39. MIC distribution for canine OX^{R} *S. intermedius* group isolates recovered from body sites other than urinary tract infections.

Antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.06	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	>0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	<=16	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	Cefazolin**				0					0			194	0			9	89											292	
1st gen cephalosporin	Cephalothin**									0			214				11	67											292	
3rd gen cephalosporin	Cefovecin**	0	0	0		4		8			25			28			36			29	162								292	
3rd gen cephalosporin	Cefpodoxime**									0			69				32		0	32	159								292	
aminoglycoside	Amikacin§																		0			287			1	4			292	1.7%
aminoglycoside	Gentamicin												0			120				59			60	53					292	
ansamycin	Rifampin						0			279				4	9														292	
β lactam/β-lactamase inhibitor combo	Amoxicillin/ Clavulanic acid**†		0		26	0		88			46		0	32			34			22	44								292	
carbapenem	Imipenem**						0			284				2			3	3											292	
fluoroquinolone	Enrofloxacin				42	0		5			24			2			5	214											292	75.0%
fluoroquinolone	Marbofloxacin						0			69	0			5			5	213											292	74.7%
fluoroquinolone	Pradofloxacin		0		71			6			8			116	91														292	70.9%
folate pathway antagonist	Trimethoprim/sulfamethoxazole‡									0			72				36	184											292	
glycopeptide	Vancomycin						0			279				8			0			0			1	4					292	
lincosamide	Clindamycin				0		60				1			2			3	226											292	78.4%
macrolide	Erythromycin		0		46	0		15			0			0			3	228											292	
nitrofuran	Nitrofurantoin																		0			285	0		2		1	4	292	
penicillin	Ampicillin**		0		2		0	7			11			19			21			38	194								292	
penicillin	Oxacillin°				0	0	0	42			49			33	168														292	
penicillin	Penicillin**	0		0	0	1		3			4			5			5			23	251								292	
phenicol	Chloramphenicol															0			194				38		8	52			292	
tetracycline	Doxycycline	0	46			6		3	237				0																292	82.2%
tetracycline	Minocycline				0		58				8			24	202														292	77.4%
tetracycline	Tetracycline		0		47			5			3	237		0			0	0											292	82.2%

Canine-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values based on CLSI Vet08, 4th ed. (2018).

*Percentage of resistant isolates.

**Antimicrobials that would be reported as resistant based on oxacillin resistance.

§Antimicrobial sensitivity plate dilutions for amikacin are 16 and 32 µg/mL. Canine amikacin breakpoints are ≤4 µg/mL [sensitive], 8 µg/mL [intermediate] and ≥16 µg/mL [resistant]. Isolates classified as resistant are in red.

† Amoxicillin/clavulanic acid concentrations on plate are 0.25/0.12, 0.5/0.25, 1/0.5, 2/1, 4/2 and 8/4 µg/mL.

‡Trimethoprim/sulfamethoxazole concentrations on plate are 2/38 and 4/76 µg/mL.

°Human-derived breakpoints for oxacillin [S ≤0.25, R ≥0.5] were used to categorize oxacillin resistant isolates. Dark blue shaded cells = resistant based on human breakpoints.

Figure 12. Antimicrobial resistance trends in canine *S. intermedius* group OX^R, non-UTI isolates, 2018-2019

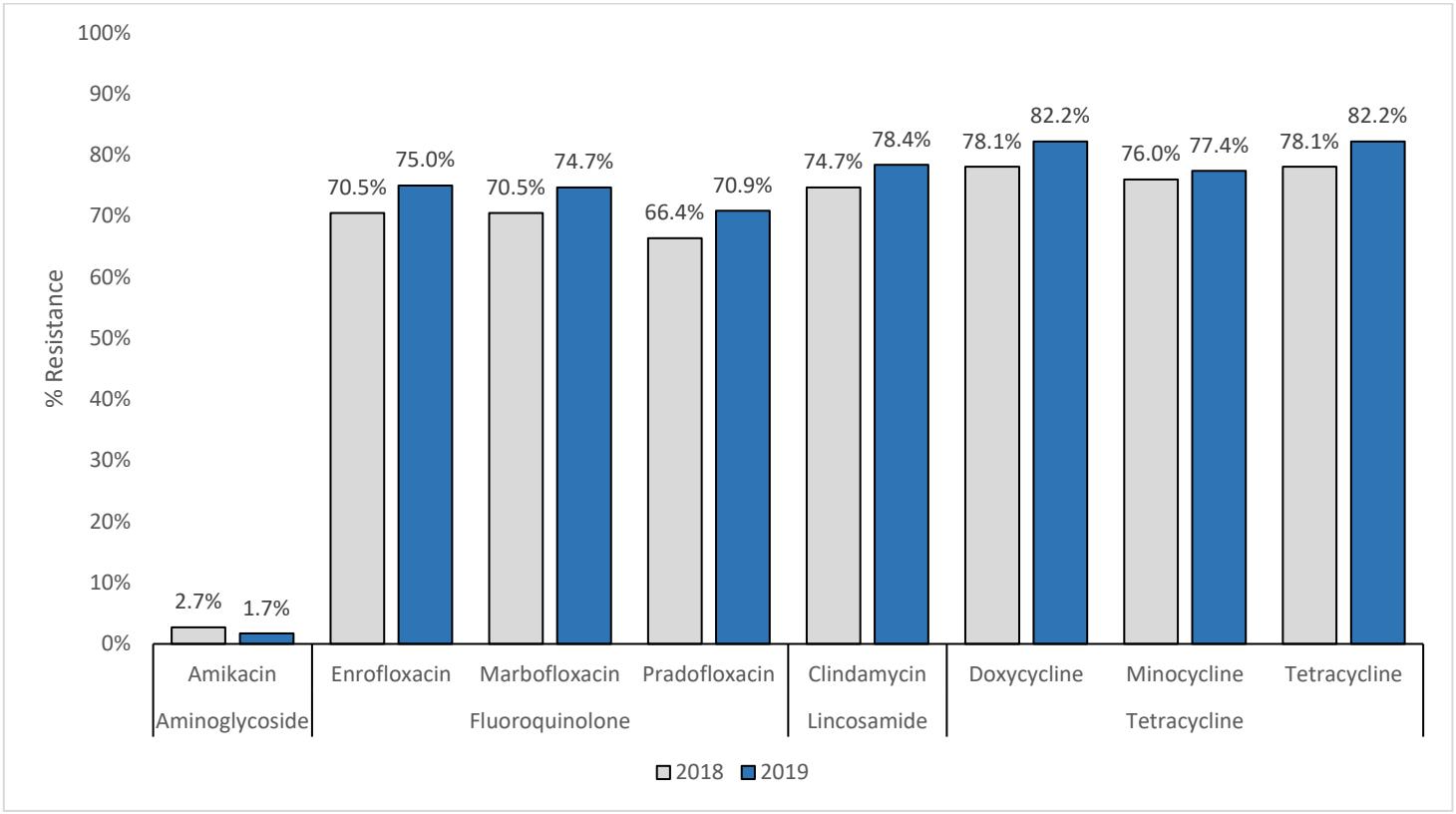


Table 40. Antimicrobial resistance analysis for canine OX^R *S. intermedius* group non-UTI isolates.

		Number of resistant isolates by antimicrobial class and individual antibiotic*							
		AMINOGLYCOSIDE	LINCOSAMIDE	FLUOROQUINOLONE			TETRACYCLINE		
No. of antibiotic resistant phenotypes per isolate	No. isolates (% total)	Amikacin** No. resistant	Clindamycin No. resistant	Enrofloxacin No. resistant	Marbofloxacin No. resistant	Pradofloxacin No. resistant	Doxycycline No. resistant	Minocycline No. resistant	Tetracycline No. resistant
8	3	3	3	3	3	3	3	3	3
7	167	0	167	167	167	167	167	167	167
6	22	0	12	22	22	15 (6 intermediate susceptibility)	22	17 (3 intermediate susceptibility)	22
5	4	0	3	4	3 (1 intermediate susceptibility)	1 (2 intermediate susceptibility)	4	1 (1 intermediate susceptibility)	4
4	36	0	35	16 (12 intermediate susceptibility)	16 (1 intermediate susceptibility)	15 (2 intermediate susceptibility)	21 (1 intermediate susceptibility)	20	21 (1 intermediate susceptibility)
3	26	0	2 (1 intermediate susceptibility)	6 (4 intermediate susceptibility)	6 (1 intermediate susceptibility)	6	20	18 (2 intermediate susceptibility)	20
2	6	2	2	1 (2 intermediate susceptibility)	1 (2 intermediate susceptibility)	0 (3 intermediate susceptibility)	3 (2 intermediate susceptibility)	0 (2 intermediate susceptibility)	3 (2 intermediate susceptibility)
1	5	0	5	0 (3 intermediate susceptibility)	0	0	0	0	0
0	23	0	0 (2 intermediate susceptibility)	0 (5 intermediate susceptibility)	0	0 (1 intermediate susceptibility)	0 (3 intermediate susceptibility)	0	0 (2 intermediate susceptibility)
TOTAL	292	5	229	219	218	207	240	226	240

Table 41. Clinical signs and diagnoses associated with canine OX^R *S. intermedius* group non-UTI isolates.

Clinical signs/indications	2018 COUNT	2018 %	2019 COUNT	2019 %
ABSCESS/WOUND/SKIN INFECTIONS	76	52.1%	195	66.8%
OTITIS/EAR INFECTION	42	28.8%	48	14.4%
PNEUMONIA/RESPIRATORY INFECTION	7	4.8%	17	5.8%
EYE INFECTION	0	0%	11	3.7%
OTHER*	4	2.7%	8	2.7%
ARTHRITIS/JOINT INFECTION	10	6.8%	7	2.4%
UNDETERMINED	4	2.7%	3	1.0%
REPRODUCTIVE TRACT INFECTIONS	2	1.4%	2	0.7%
SEPSIS/SEPTICEMIA	1	0.7%	1	0.3%
TOTAL	146		292	

* Other diagnoses 2018: cornea infection (1), gastritis (1), stomatitis (1), urinary obstruction (1), and no diagnosis given (1).
Other diagnoses 2019: peritonitis (1), gingivitis (1), canine herpesvirus 1 (1), canine distemper (1), mastitis (2), peritoneal injury (1), pyothorax (1)

APPENDIX F: MIC Distributions and Clinical Signs for *E. coli* and *S. intermedius* group in Cats

CATS - *E. COLI*

Table 42. MIC distribution for *E. coli* UTI isolates recovered from cats.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	<=2	2	>2	<=4	4	>4	<=8	8	>8	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	Cefazolin						33			203			60			3		7		4	30			340	
1st gen cephalosporin	Cephalexin				0			1		4			165			119		10	41					340	
3rd gen cephalosporin	Cefovecin**		34	0		175		80		12			4			5	30							340	10.3%
3rd gen cephalosporin	Cefpodoxime§						298	0		1			3			7	31							340	
3rd gen cephalosporin	Ceftazidime§											316	0			6		9	9					340	
aminoglycoside	Amikacin											330				9		0		0	1			340	
aminoglycoside	Gentamicin		8	0		190		119		14			1			2	6							340	
β lactam/β-lactamase inhibitor combo	Amoxicillin/ Clavulanic acid†		0			0		9		63			169			60	39							340	100%
β lactam/β-lactamase inhibitor combo	Piperacillin/tazobactam														333			1		3		3	0	340	
fluoroquinolone	Enrofloxacin						337	0		3			0			0	0							340	
fluoroquinolone	Marbofloxacin	310		3		6		2		0			1	18										340	
fluoroquinolone	Orbifloxacin	311		2		7		0		2			0	18										340	
fluoroquinolone	Pradofloxacin						316			1			5			0	18							340	
folate pathway antagonist	Trimethoprim/sulfamethoxazole‡		318	0		3		1		3	15													340	
penem	Imipenem				323			2		1			0	14										340	
penicillin	Ampicillin		0			1		13		137			95			4	90							340	100%
phenicol	Chloramphenicol								11				121			176		21		2	9			340	
tetracycline	Doxycycline		2			33		149		105			19			8	24							340	
tetracycline	Tetracycline											308				0		1	31					340	

Feline-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018).

*Percentage of resistant isolates.

** Cefovecin only has feline *E. coli* breakpoints for urinary tract infections.

§ Extended spectrum β lactamase (ESBL) testing is indicated for isolates with cefpodoxime MIC ≥ 8 µg/ml, or >2 µg/ml for ceftazidime (highlighted in blue)

† Amoxicillin/clavulanic acid concentrations on plate are 0.25/0.12, 0.5/0.25, 1/0.5, 2/1, 4/2 and 8/4 µg/mL.

‡Trimethoprim/sulfamethoxazole concentrations on plate are 2/38 and 4/76 µg/mL.

Figure 13. Antimicrobial resistance trends in feline *E. coli* UTI isolates, 2018-2019.

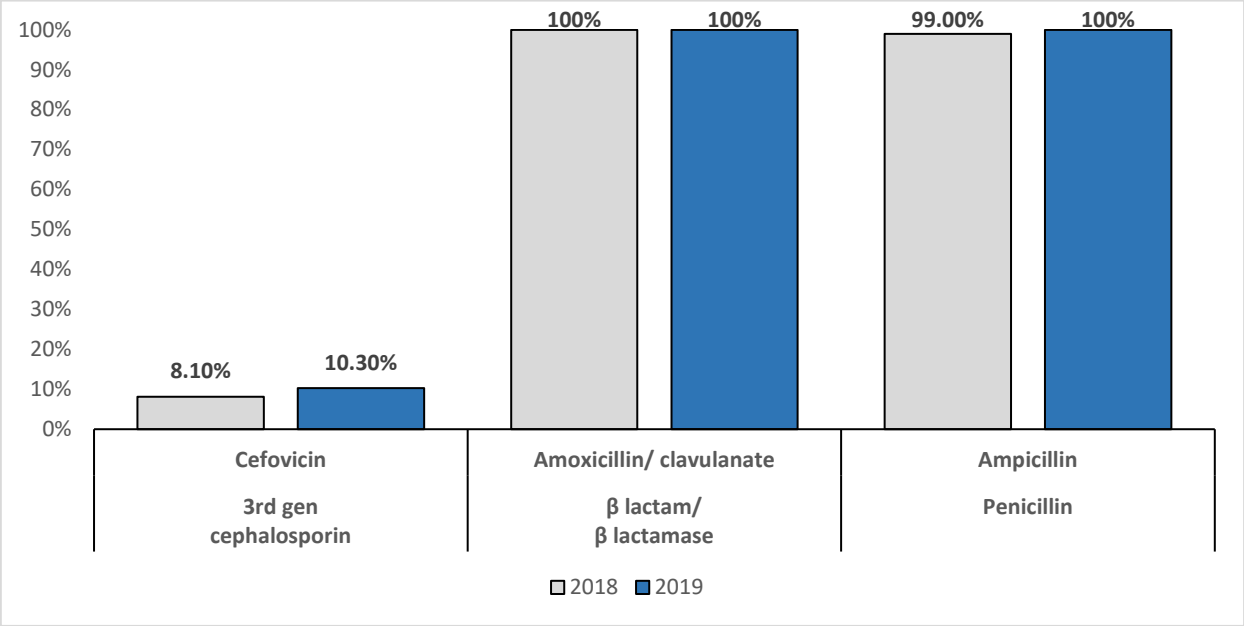


Table 43. MIC distribution for *E. coli* non-UTI isolates recovered from cats.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.12	<=0.25	0.25	<=0.5	0.5	<=1	1	<=2	2	>2	<=4	4	>4	<=8	8	>8	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	Cefazolin						9			57			18			5		1		1	4			95	
1st gen cephalosporin	Cephalexin				0			1		2			47			36		2	7					95	
3rd gen cephalosporin	Cefovecin		18	0		45		22		3			3			0	4							95	
3rd gen cephalosporin	Cefpodoxime**						88	0		0			1			2	4							95	
3rd gen cephalosporin	Ceftazidime**											92	0			1		1	1					95	
aminoglycoside	Amikacin											89				5		1		0	0			95	
aminoglycoside	Gentamicin		1	0		58		25		6			0			0	5							95	
β lactam/β-lactamase inhibitor combo	Amoxicillin/ Clavulanic acid †		1			0		3		16			40			20	15							95	98.9%
β lactam/β-lactamase inhibitor combo	Piperacillin/tazobactam														94			0		0		0	1	95	
fluoroquinolone	Enrofloxacin						95	0		0			0			0	0							95	
fluoroquinolone	Marbofloxacin	85		3		1		0		1			0	5										95	5.3%
fluoroquinolone	Orbifloxacin	84		2		3		0		1			0	5										95	5.3%
fluoroquinolone	Pradofloxacin						89			0			1			0	5							95	6.3%
folate pathway antagonist	Trimethoprim/sulfamethoxazole‡		90	0		0		0		1	4													95	5.3%
penem	Imipenem				89			1		0			0	5										95	
penicillin	Ampicillin		1			0		6		32			21			0	35							95	98.9%
phenicol	Chloramphenicol								2				44			44		2		0	3			95	
tetracycline	Doxycycline		1			11		46		31			0			1	5							95	
tetracycline	Tetracycline											89				0		0	6					95	

Feline-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018).

*Percentage of resistant isolates.

** Extended spectrum β lactamase (ESBL) testing is indicated for isolates with cefpodoxime MIC ≥ 8 µg/ml, or >2 µg/ml for ceftazidime (highlighted in blue).

† Amoxicillin/clavulanic acid concentrations on plate are 0.25/0.12, 0.5/0.25, 1/0.5, 2/1, 4/2 and 8/4 µg/mL.

‡Trimethoprim/sulfamethoxazole concentrations on plate are 2/38 and 4/76 µg/mL.

Figure 14. Antimicrobial resistance trends in feline *E. coli* non-UTI isolates, 2018-2019.

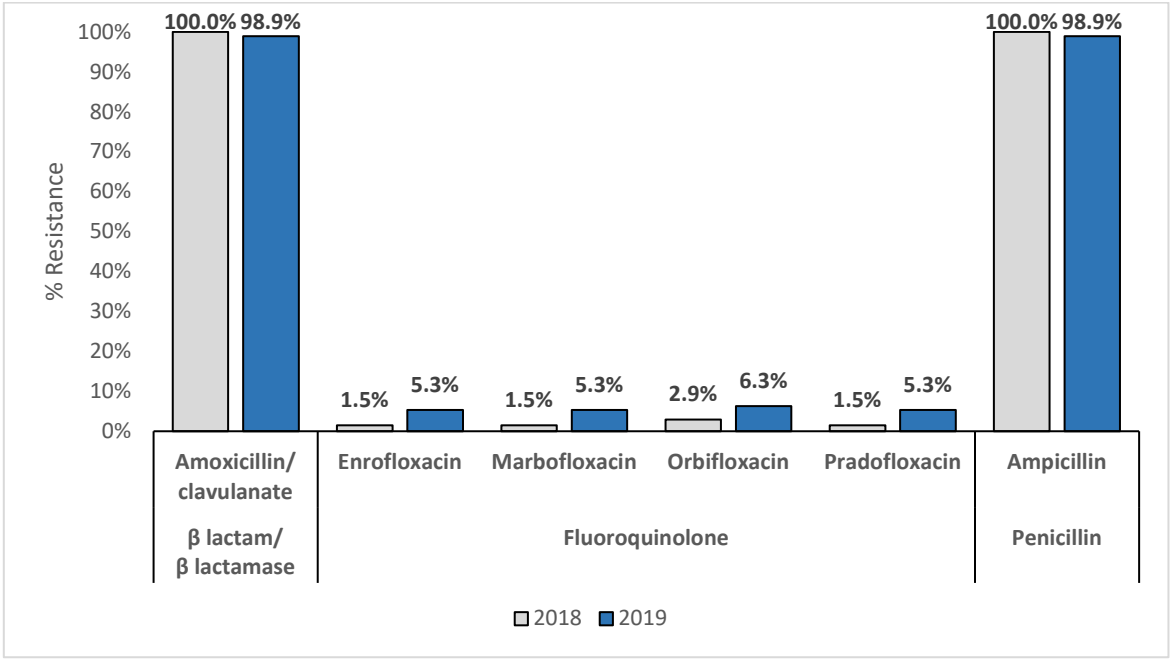


Table 44. Clinical signs and diagnoses associated with feline *E. coli* non-UTI isolates in 2018 and 2019.

Clinical signs/indications	2018 COUNT	2018 %	2019 COUNT	2019 %
ENTERITIS/ENTERIC INFECTIONS	7	10.3%	21	22.1%
SKIN/WOUND INFECTIONS	14	20.6%	20	21.1%
PERITONITIS/PERYNCHAMOUS ORGAN INFECTIONS	11	16.2%	14	14.7%
PNEUMONIA/RESPIRATORY INFECTION	12	17.6%	11	11.6%
OTHER*	11	16.2%	9	9.5%
UNDETERMINED	4	5.9%	9	9.5%
OTITIS/EAR INFECTIONS	3	4.4%	6	6.3%
REPRODUCTIVE TRACT INFECTIONS	4	5.9%	4	4.2%
SEPSIS/SEPTICEMIA	2	2.9%	1	1.1%
TOTAL	68		95	

*Other diagnoses Y1 = cancer (2), feline panleukopenia (4), mastitis (1) lymphadenopathy (1), parvovirus (1), corneal sequestrum (1), and IBD (1).
Other diagnoses Y2 = cerebral abscess (1), empyema (1), esophageal perforation (1), panleukopenia (1), hyperthyroid (1), mastitis (2), endoscopic gastronomy site infection (1), calcivirus infection (1)

Cats - S. intermedius group

CATS – *S. INTERMEDIUS* GROUP - URINARY TRACT INFECTIONS-OX^{S}

Table 45. MIC distribution for feline OX^{S} *S. intermedius* group isolates recovered from urinary tract infections.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.06	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	>0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	<=16	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	Cefazolin				0								21	0			0	0		0									21	
1st gen cephalosporin	Cephalothin												21				0	0											21	
3rd gen cephalosporin	Cefovecin	0		7		9		4			1			0			0			0	0								21	
3rd gen cephalosporin	Cefpodoxime												21				0		0	0	0								21	
aminoglycoside	Amikacin																					21			0	0			21	
aminoglycoside	Gentamicin															19				1			1	0					21	
ansamycin	Rifampin									20				0	1														21	
β lactam/β-lactamase inhibitor	Amoxicillin/ Clavulanate				20			0			0			1			0			0	0								21	4.8%
carbapenem	Imipenem									21				0			0	0											21	
fluoroquinolone	Enrofloxacin				17			1			0			0			1	2											21	
fluoroquinolone	Marbofloxacin									18				0			0	3											21	
fluoroquinolone	Pradofloxacin				14			0			0			4	3														21	
folate pathway antagonist	Trimethoprim/ sulfamethoxazole												14				4	3											21	
glycopeptide	Vancomycin									20				1			0			0			0	0					21	
lincosamide	Clindamycin				0		19				0			0			0	2											21	
macrolide	Erythromycin				16			3			0			0			0	2											21	
nitrofuran	Nitrofurantoin																					21			0		0	0	21	
penicillin	Ampicillin				14			1			4			1			1			0	0								21	33.3%
penicillin	Oxacillin°				21			0			0			0	0														21	
penicillin	Penicillin	8		0	0	0		0			1			4			2			1	5								21	
phenicol	Chloramphenicol																		19				1		0	1			21	
tetracycline	Doxycycline		17			0		0	4																				21	
tetracycline	Minocycline						17				0			0	4														21	
tetracycline	Tetracycline				11			2			0	8		0			0	0											21	

Feline-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018).

*Percentage of resistant isolates.

°Human-derived breakpoints for oxacillin [S ≤0.25, R ≥0.5] were used to categorize oxacillin sensitive isolates. Dark blue shaded cells = sensitive based on human breakpoints.

Table 46. MIC distribution for feline OX^{R} *S. intermedius* group isolates recovered from urinary tract infections.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.06	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	>0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	<=16	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	Cefazolin**				0								6	0			2	3		0								11	
1st gen cephalosporin	Cephalothin**												8				1	2										11	
3rd gen cephalosporin	Cefovecin**	0		0		0		0			1			1			1			1	7							11	
3rd gen cephalosporin	Cefpodoxime**												2				2		0	0	7							11	
aminoglycoside	Amikacin§																					11			0	0			11	
aminoglycoside	Gentamicin															4				2			4	1					11	
ansamycin	Rifampin									11				0	0														11	
β lactam/β-lactamase inhibitor	Amoxicillin/ Clavulanic acid**†				1			3			2			2			1			1	1								11	
carbapenem	Imipenem**									10				0			0	1											11	
fluoroquinolone	Enrofloxacin				1			0			0			1			0	9											11	
fluoroquinolone	Marbofloxacin									2				0			0	9											11	
fluoroquinolone	Pradofloxacin				7			0			0			2	2														11	
folate pathway antagonist	Trimethoprim/sulfamethoxazole‡												7				2	2											11	
glycopeptide	Vancomycin									10				1			0			0			0	0					11	
lincosamide	Clindamycin				0		2				0			0			0	9											11	
macrolide	Erythromycin				1			0			0			0			0	10											11	
nitrofuran	Nitrofurantoin																					11			0		0	0	11	
penicillin	Ampicillin**				0			0			2			2			0			2	5								11	
penicillin	Oxacillin°				0			2			0			2	7														11	
penicillin	Penicillin**	2		0	0	0		0			1			2			1			0	5								11	
phenicol	Chloramphenicol																		10				0		1	0			11	
tetracycline	Doxycycline		2			0		0	9																				11	
tetracycline	Minocycline						2				0			2	7														11	
tetracycline	Tetracycline				6			0			0	5		0			0	0											11	

Feline-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018).

*Percentage of resistant isolates.

**Antimicrobials that would be reported as resistant based on oxacillin resistance.

°Human-derived breakpoints for oxacillin [S ≤0.25, R ≥0.5] were used to categorize oxacillin sensitive isolates. Dark blue shaded cells = resistant based on human breakpoints.

† Amoxicillin/clavulanic acid concentrations on plate are 0.25/0.12, 0.5/0.25, 1/0.5, 2/1, 4/2 and 8/4 µg/mL.

‡Trimethoprim/sulfamethoxazole concentrations on plate are 2/38 and 4/76 µg/mL.

CATS – *S. INTERMEDIUS* GROUP – NON-URINARY TRACT INFECTIONS-OX^{S}

Table 47. MIC distribution for feline OX^{S} *S. intermedius* group isolates recovered from non-urinary tract infections.

antimicrobial class	MIC value (µg/mL) / Antimicrobial	<=0.06	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	>0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	<=16	16	>16	32	>32	64	>64	Total Isolates	%R*
1st gen cephalosporin	Cefazolin				0								21	0			0	1		0									22	
1st gen cephalosporin	Cephalothin												22				0	0											22	
3rd gen cephalosporin	Cefovecin	1		9		8		2			1			0			0			1	0							22	
3rd gen cephalosporin	Cefpodoxime												21				0		0	0	1								22	
aminoglycoside	Amikacin																					22			0	0			22	
aminoglycoside	Gentamicin															18				1			2	1					22	
ansamycin	Rifampin									21				0	1														22	
β lactam/β-lactamase inhibitor	Amoxicillin/ Clavulanate				20			1			0			0			1			0	0								22	4.5%
carbapenem	Imipenem									22				0			0	0											22	
fluoroquinolone	Enrofloxacin				18			1			2			0			0	1											22	
fluoroquinolone	Marbofloxacin									21				0			0	1											22	
fluoroquinolone	Pradofloxacin				17			0			0			3	2														22	
folate pathway antagonist	Trimethoprim/ sulfamethoxazole												14				1	7											22	
glycopeptide	Vancomycin									19				1			0			0			0	2					22	
lincosamide	Clindamycin				0		18				1			0			0	3											22	
macrolide	Erythromycin				13			5			0			0			0	4											22	
nitrofuran	Nitrofurantoin																					22			0		0	0	22	
penicillin	Ampicillin				15			1			1			3			0			0	2								22	31.8%
penicillin	Oxacillin°				22			0			0			0	0														22	
penicillin	Penicillin	7		0	0	0		1			1			0			0			2	11								22	
phenicol	Chloramphenicol																		20				0		0	2			22	
tetracycline	Doxycycline		18			1		0	3																				22	
tetracycline	Minocycline						19				1			1	1														22	
tetracycline	Tetracycline				11			3			1	7		0			0	0											22	

Feline-specific interpretive criteria are indicated for selected antimicrobials. Green shaded cells = sensitive, yellow shaded cells = intermediate and red shaded cells = resistant. Interpretive values are based on CLSI Vet08, 4th ed. (2018).

*Percentage of resistant isolates.

°Human-derived breakpoints for oxacillin [S ≤0.25, R ≥0.5] were used to categorize oxacillin sensitive isolates. Dark blue shaded cells = sensitive based on human breakpoints.

CATS – *S. INTERMEDIUS* GROUP – NON-URINARY TRACT INFECTIONS-OX^{R}

Table 48. MIC distribution for feline OX^{R} *S. intermedius* group isolates recovered from non-urinary tract infections.

antimicrobial class	Antimicrobial / MIC value (µg/mL)	<=0.06	<=0.12	0.12	<=0.25	0.25	<=0.5	0.5	>0.5	<=1	1	>1	<=2	2	>2	<=4	4	>4	<=8	8	>8	<=16	16	>16	32	>32	64	>64	Total Isolates
1st gen cephalosporin	Cefazolin**				0								14	0			1	6		1									22
1st gen cephalosporin	Cephalothin**												16				0	6											22
3rd gen cephalosporin	Cefovecin**	0		0		0		1			5			0			0			2	14							22
3rd gen cephalosporin	Cefpodoxime**												5				1		0	3	13								22
aminoglycoside	Amikacin§																					21			1	0			22
aminoglycoside	Gentamicin															6				3			7	6					22
ansamycin	Rifampin									21				0	1														22
β lactam/β-lactamase inhibitor	Amoxicillin/ Clavulanic acid**†				4			3			4			2			3			2	3								21
carbapenem	Imipenem**									20				0			1	1											22
fluoroquinolone	Enrofloxacin				2			2			3			0			2	13											22
fluoroquinolone	Marbofloxacin									9				0			0	13											22
fluoroquinolone	Pradofloxacin				17			0			0			3	2														22
folate pathway antagonist	Trimethoprim/sulfamethoxazole‡												14				1	7											22
glycopeptide	Vancomycin									19				1			0			0			0	2					22
lincosamide	Clindamycin				0		5				0			0			1	16											22
macrolide	Erythromycin				1			1			1			1			1	17											22
nitrofuran	Nitrofurantoin																					22			0		0	0	22
penicillin	Ampicillin**				1			1			1			0			1			3	15								22
penicillin	Oxacillin°				0			**3**			**4**			**3**	**12**														22
penicillin	Penicillin**	7		0	0	0		1			1			0			0			2	11								22
phenicol	Chloramphenicol																		14				7		1	0			22
tetracycline	Doxycycline		3			3		1	15																				22
tetracycline	Minocycline						7				0			3	12														22
tetracycline	Tetracycline				11			3			1	7		0			0	0											22

**Antimicrobials that would be reported as resistant based on oxacillin resistance.

°Human-derived breakpoints for oxacillin [S ≤0.25, R ≥0.5] were used to categorize oxacillin sensitive isolates.

† Amoxicillin/clavulanic acid concentrations on plate are 0.25/0.12, 0.5/0.25, 1/0.5, 2/1, 4/2 and 8/4 µg/mL.

‡Trimethoprim/sulfamethoxazole concentrations on plate are 2/38 and 4/76 µg/mL.

Table 49. Clinical signs and diagnoses associated with feline S. intermedius group isolates from non-urinary tract infections.

Clinical sign/indications	COUNT OX^{S}	%	COUNT OX^{R}	%
ABSCESS/SKIN/WOUND INFECTION	10	45.5%	10	45.5%
OTITIS/EAR INFECTION	7	31.8%	3	13.5%
RESPIRATORY INFECTION/PNEUMONIA	4 (sinusitis/nasal infections)	18.2%	2	9.1%
OTHER*	1	4.5%	4	18.2%
UNDETERMINED	0	0%	3	13.5%
TOTAL	**22**		**22**	

*Other OX^{S} clinical diagnoses: pyometria (1)
Other OX^{R} clinical diagnoses: pyometria (1), esophagostomy site infection (1), eye infection (1), septic peritonitis (1)

APPENDIX G. Acknowledgments

The following laboratories contributed data and isolates to the 2019 Year 2 NAHLN Pilot Project:

AL - Bacteriology & Mycology Diagnostic Laboratory; Auburn, AL

CA - California Animal Health & Food Safety Laboratory System; Davis, CA

CO - Colorado State University Veterinary Diagnostic Laboratory; Fort Collins, CO

FL - Bronson Animal Disease Diagnostic Laboratory; Kissimmee, FL

GA - Athens Veterinary Diagnostic Laboratory: Athens, GA

IN - Indiana Animal Disease Diagnostic Laboratory; West Lafayette, IN

KS - Kansas State Veterinary Diagnostic Lab; Manhattan, KS

KY - University of Kentucky, Veterinary Diagnostic Laboratory; Lexington, KY

LA - Louisiana Animal Disease Diagnostic Laboratory (LADDL); Baton Rouge, LA

MI - Michigan State University Veterinary Diagnostic Laboratory; Lansing, MI

MN - University of Minnesota Veterinary Diagnostic Laboratory; St. Paul, MN

MO - Columbia, University of Missouri Veterinary Medical Diagnostic Laboratory; Columbia, MO

MS - Mississippi State University Veterinary Research & Diagnostic Laboratory System; Pearl, MS

NE - Nebraska Veterinary Diagnostic Center; Lincoln, NE

NY - Cornell University Animal Health Diagnostic Center; Ithaca, NY

ND - North Dakota Veterinary Diagnostic Lab; Fargo, ND

OH - Ohio Animal Disease Diagnostic Laboratory; Reynoldsburg, OH

PA - University of Pennsylvania PADLS Harrisburg Veterinary Laboratory; Harrisburg, PA

PA - Pennsylvania State University, Animal Diagnostic Laboratory; University Park, PA

PA - University of Pennsylvania PADLS New Bolton Center Veterinary Laboratory; Kennett Square, PA

SD - South Dakota Animal Disease Research & Diagnostics Laboratory; Brookings, SD

TX - Texas A&M Veterinary Medical Diagnostic Laboratory; College Station, TX

WA - Washington Animal Disease Diagnostic Laboratory; Pullman, WA

WI - Wisconsin Veterinary Diagnostic Laboratory; Madison, WI