Influence of Wildlife Emergencies (heat stress and bushfires) on the dynamics of Antimicrobial Resistance in Flying Fox

MICHELLE POWER

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I acknowledge the First Peoples and Traditional Custodians of the land where Macquarie University is located, the Wallumattagal Clan of the Dharug nation. I pay my respect to Elders and knowledge holders who have, and continue to share their wisdom and knowledge, nurturing and sustaining our environments, cultures and education, and healing country.

Acknowledgements

Plethora of wildlife rehabilitators across the country

- Fiona McDougall – Post doc MW
- Juliane Schaer - Humboldt
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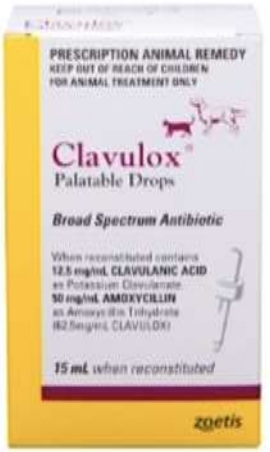
- Wayne Boardman - U Adl
- Paul Thompson - Taronga
- Roy Robbins-Brown - Doherty Centre
- Jenny McLean - Tolga Bat Hopsital
- David Gordon - ANU
- Sabine Schiller – Mres Student
- Ian Smith – Zoos SA

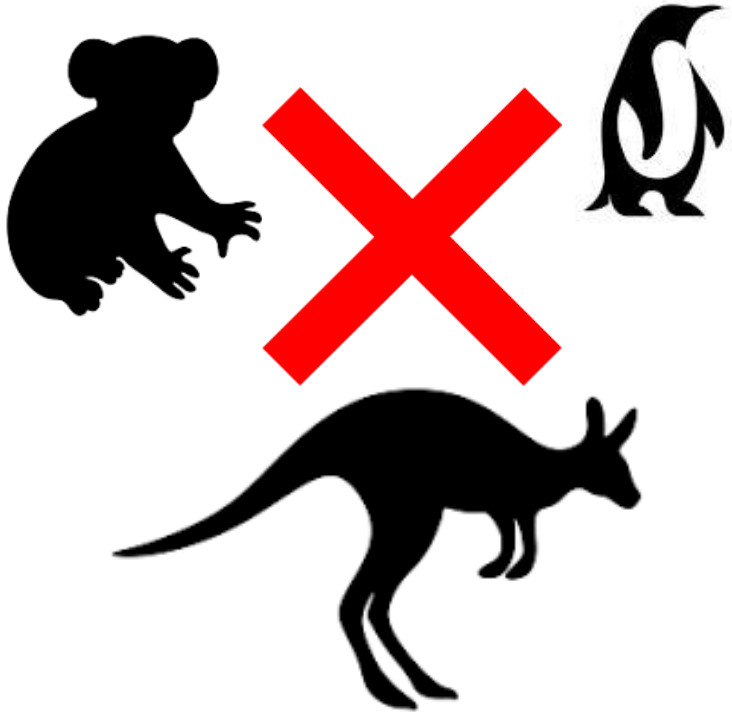
What are antibiotics?



Chemicals that kill or inactivate bacteria

What is antibiotic resistance?

Ability of bacteria to overcome the action of antibiotics

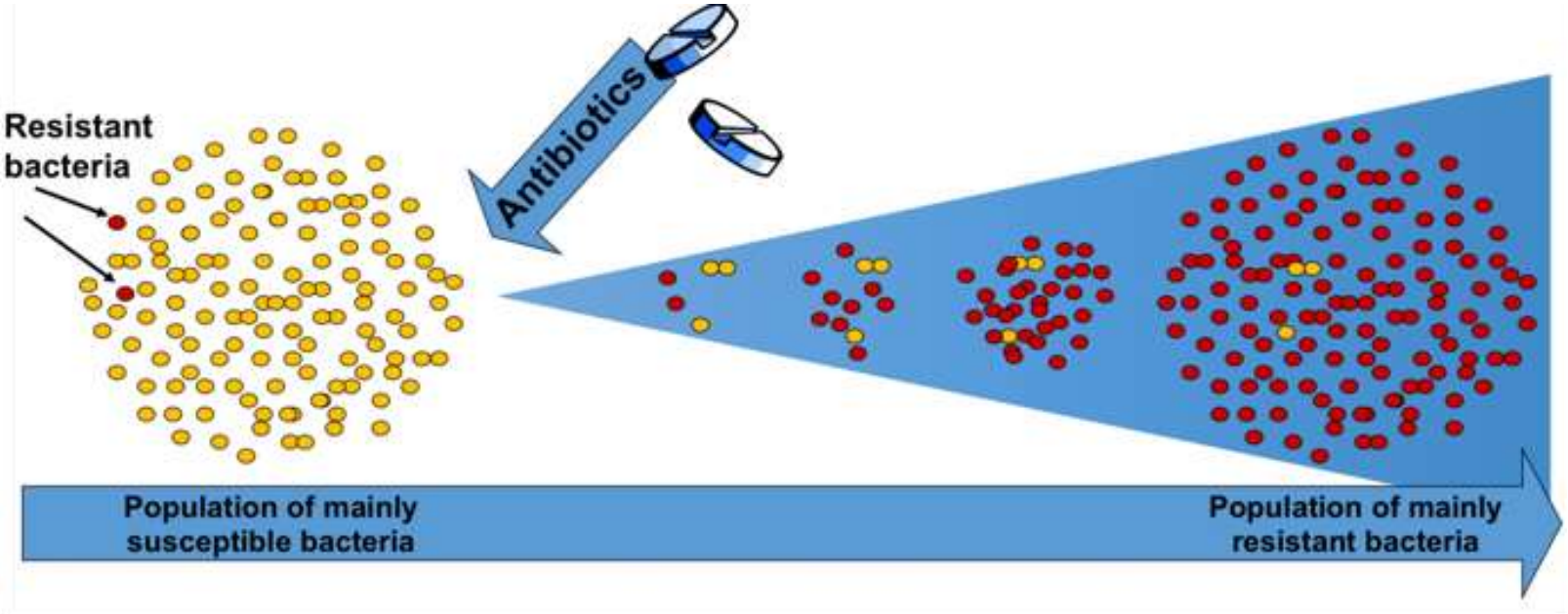


- **Not the animal or person that is resistant**
- **Not an immune response**

Images Clipart & Wikimedia commons

Antibiotic resistance

Antibiotics and bacteria have been acquainted for millions of years



Antibiotic use continues to select for resistant bacteria and drive their spread and evolution

Image source: reactgroup.org

Antibiotic resistance

Timeline of antibiotic use and emergence of resistance

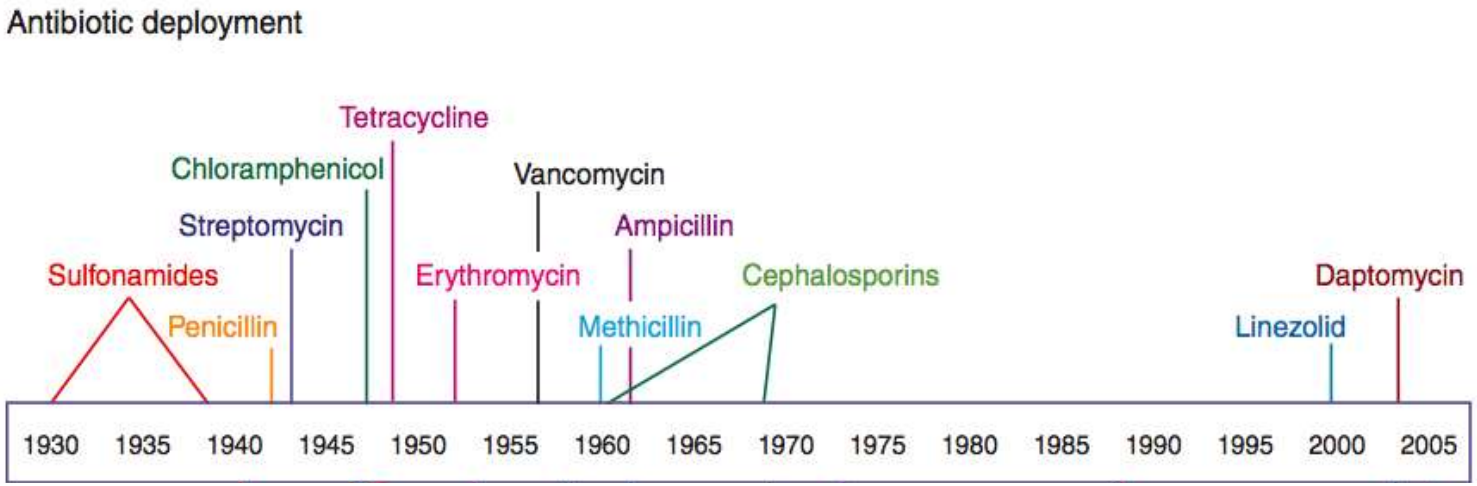
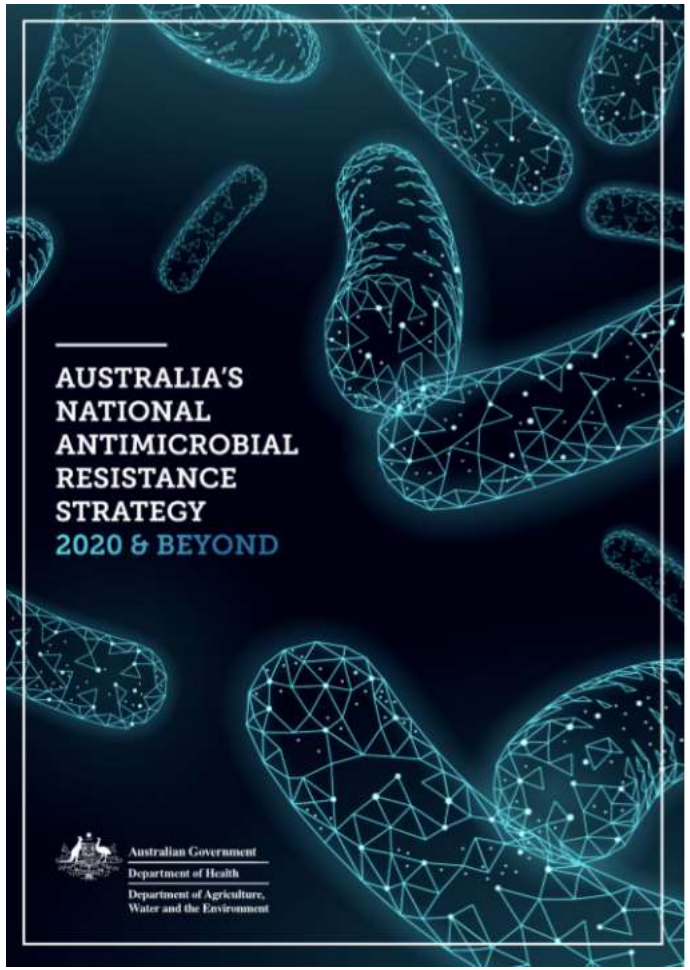


Image: iGEM Sheffield

Antibiotic stewardship – applies to those who prescribe, administer, and use antibiotics

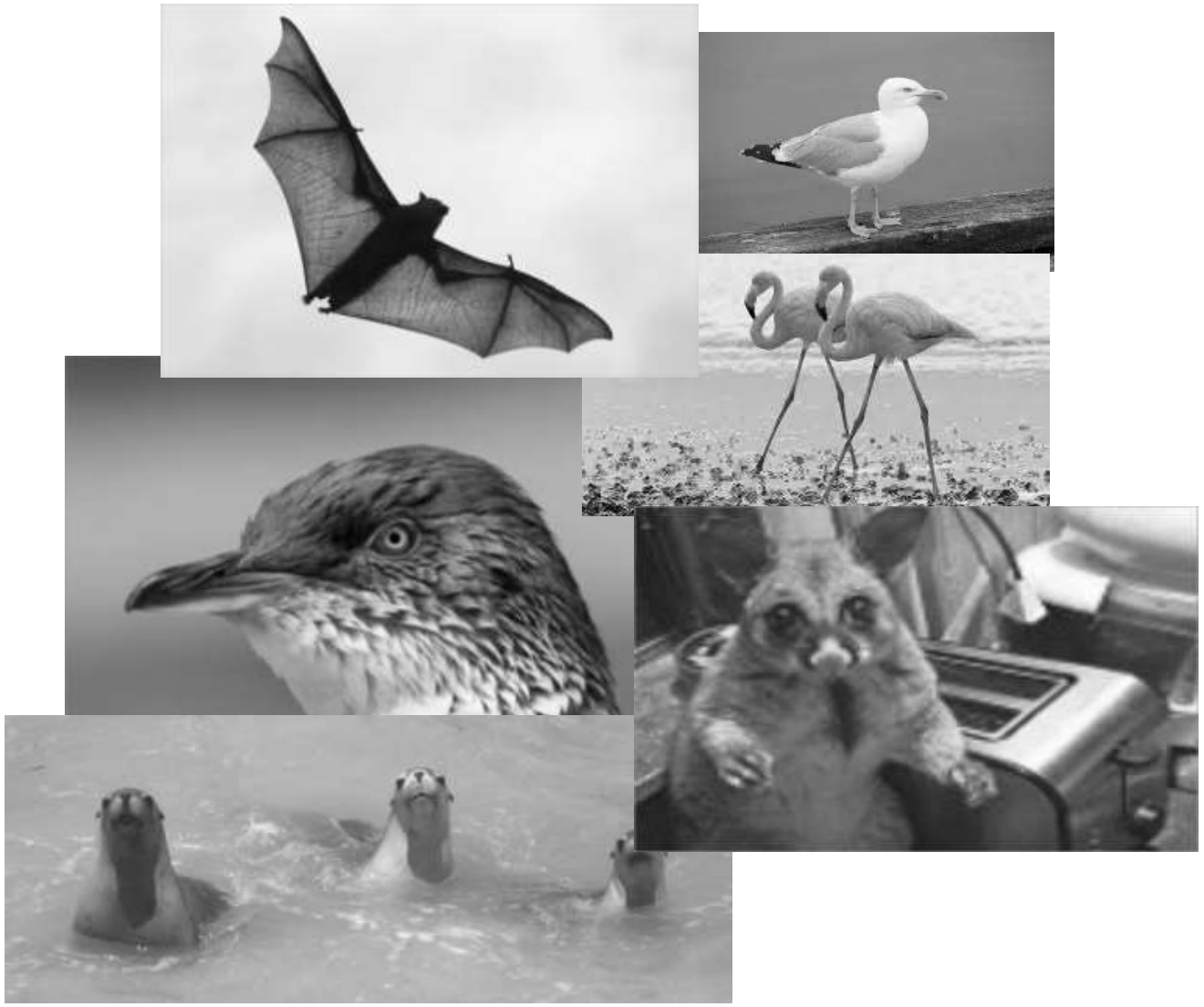


Aims

- Enhance outcomes for the patient (whatever species)
- Protect the patient's (whatever species) microbiome
- Reduce antibiotic use
- Preserve efficacy of current antibiotics

- Pressure on antibiotic prescribers to abide by Stewardship principles

Antibiotic resistance has no boundaries



The One Health Concept / pathogen continuum

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The One Health Triad

Translocation

- Encroachment
- Introduction
- Spill-over and 'spill-back'

Zooanthroponosis

- Encroachment
- Ecological change

Wildlife

Domestic animal

Human

- Agricultural intensification

- Technology
- Production
- Disease

Daszak *et al*, Science 2000

From commensals to ‘superbugs’

Commensal bacteria have acquired pathogenic traits and antibiotic resistance to multiple drugs

Beta lactams

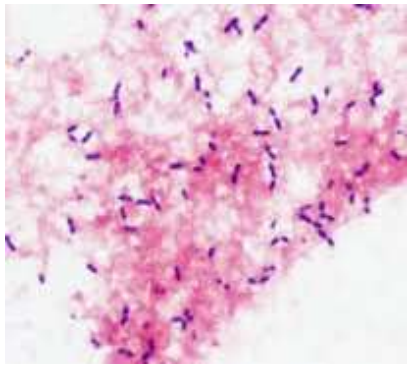
Penicillin and related drugs

- *Escherichia coli*
- *Klebsiella pneumoniae*
- Carbapenem-resistant Enterobacteriaceae

Methicillin resistant

Staphylococcus aureus

Vancomycin



- *Enterococcus faecium*
- *Enterococcus faecalis*

Investigating AMR in wildlife with variable connectivity to humans

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URBAN SETTINGS

Flying fox

Possum

Macropods

CONSERVATION

Tasmanian devil

Platypus

Koala

Echidna

MARINE

Australian sea lion

Little penguin

Images: Echidna and Platypus Doug Gimesy; Sea lion - R Harcourt; Possum Stilgherrian Flickr creative commons 16251601655 ; Bat iStock; Others M Power

Lab methodology for detecting antibiotic resistance

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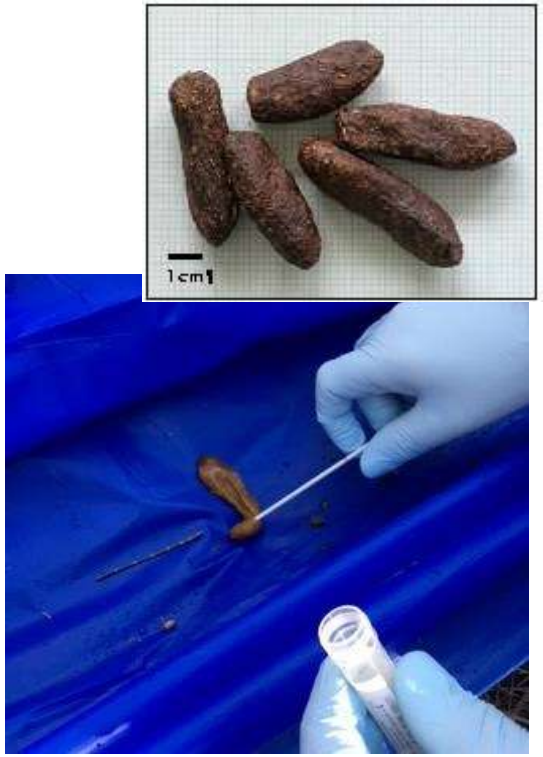
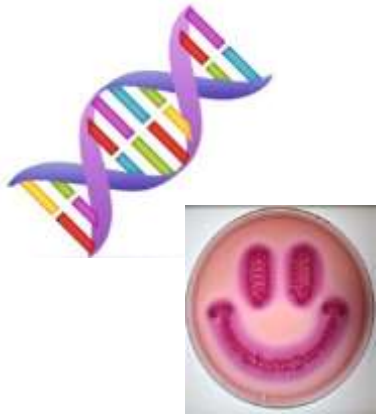
Faecal samples

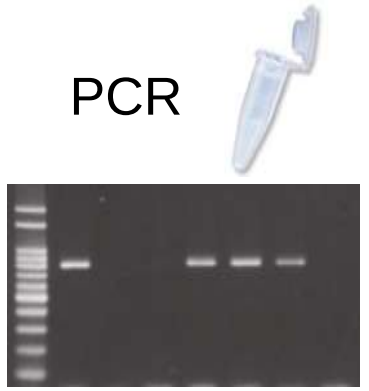


DNA Extraction

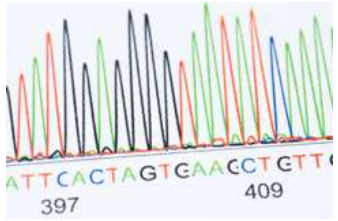


Test for resistance genes

PCR



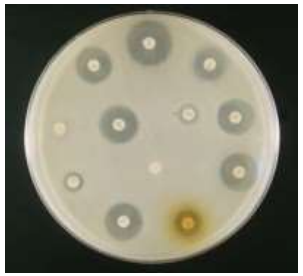
Detection of ARGs



DNA sequencing

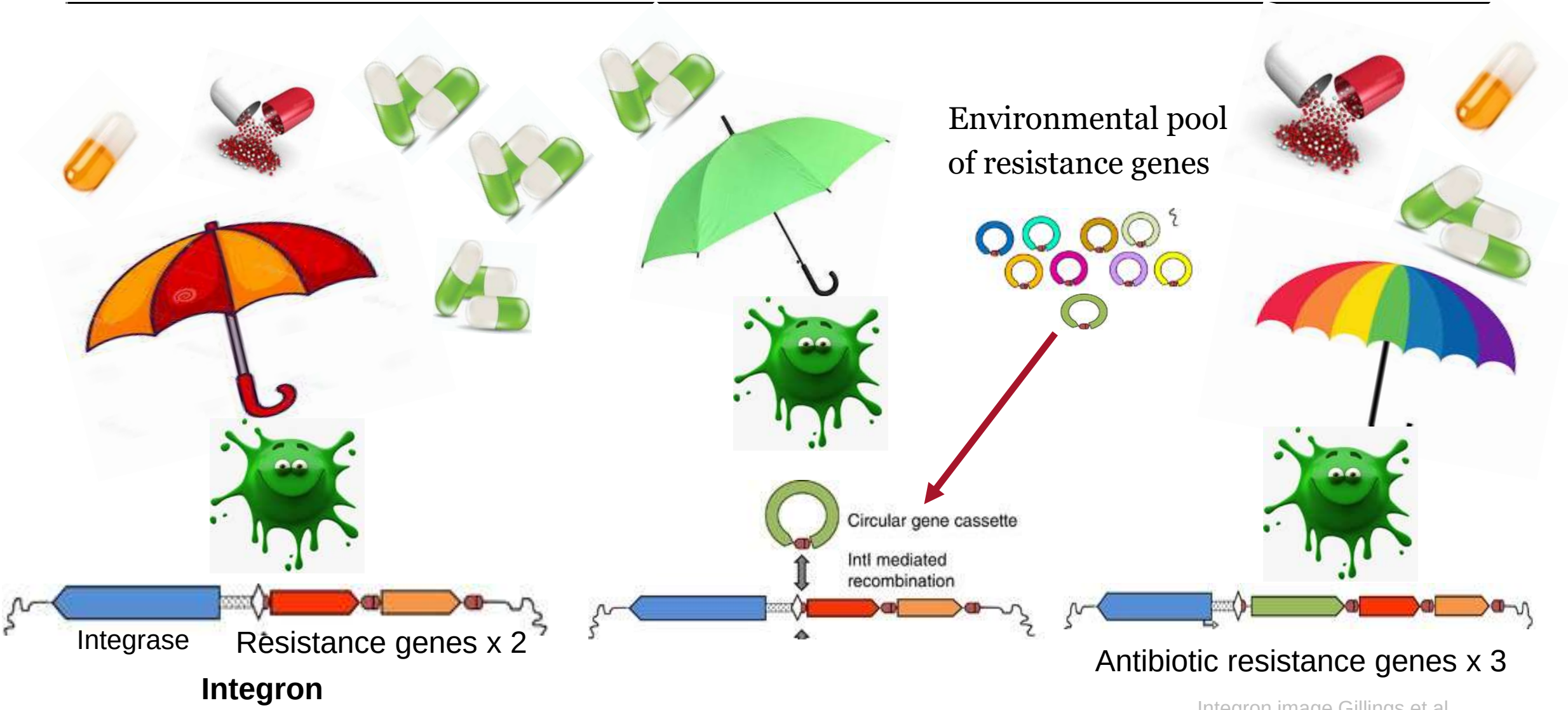
Whole genome sequencing
Strain typing and ARGs

Phenotype analysis



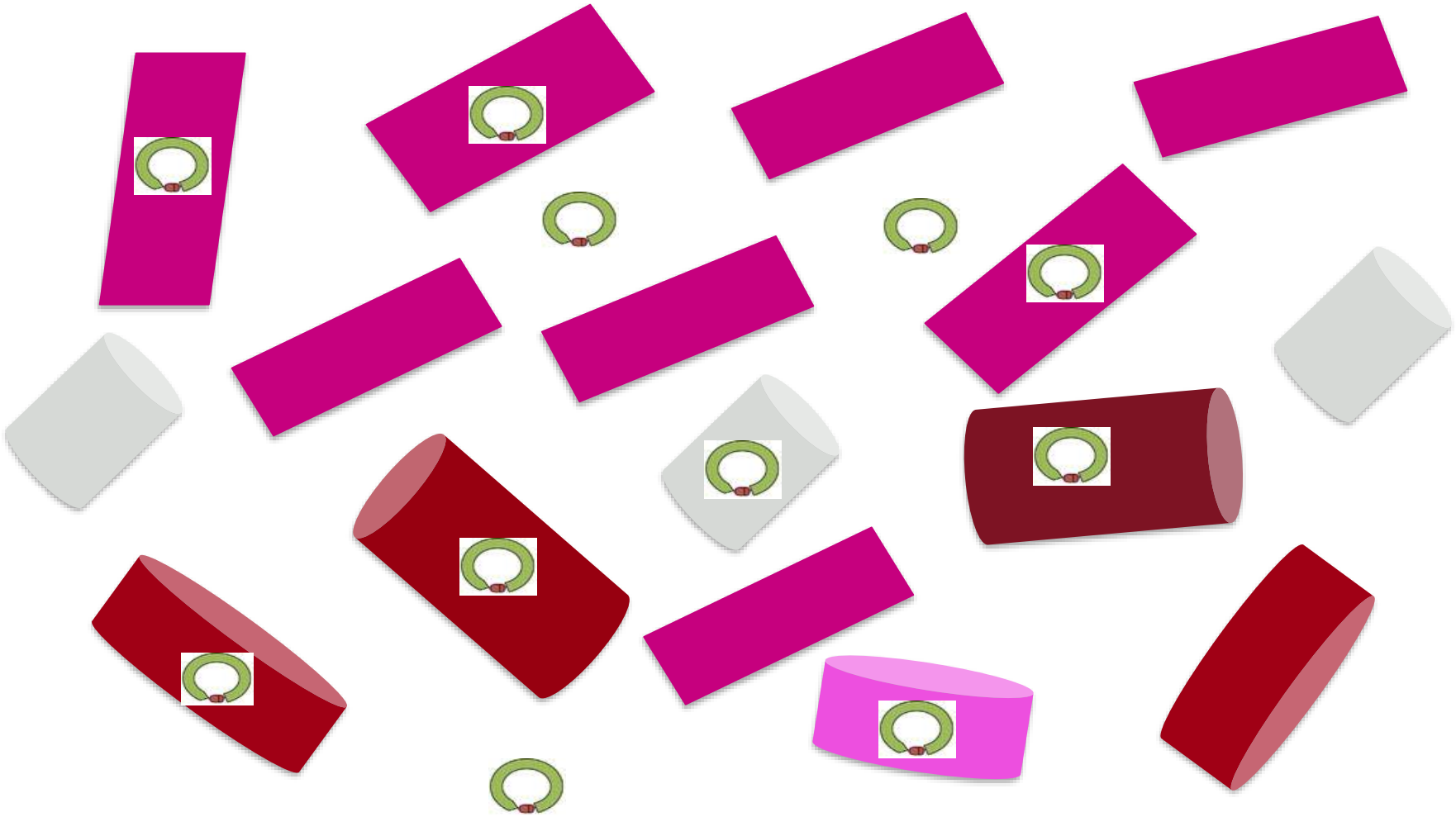
Genetic determinant of resistance

Class 1 integron



Integron image Gillings et al

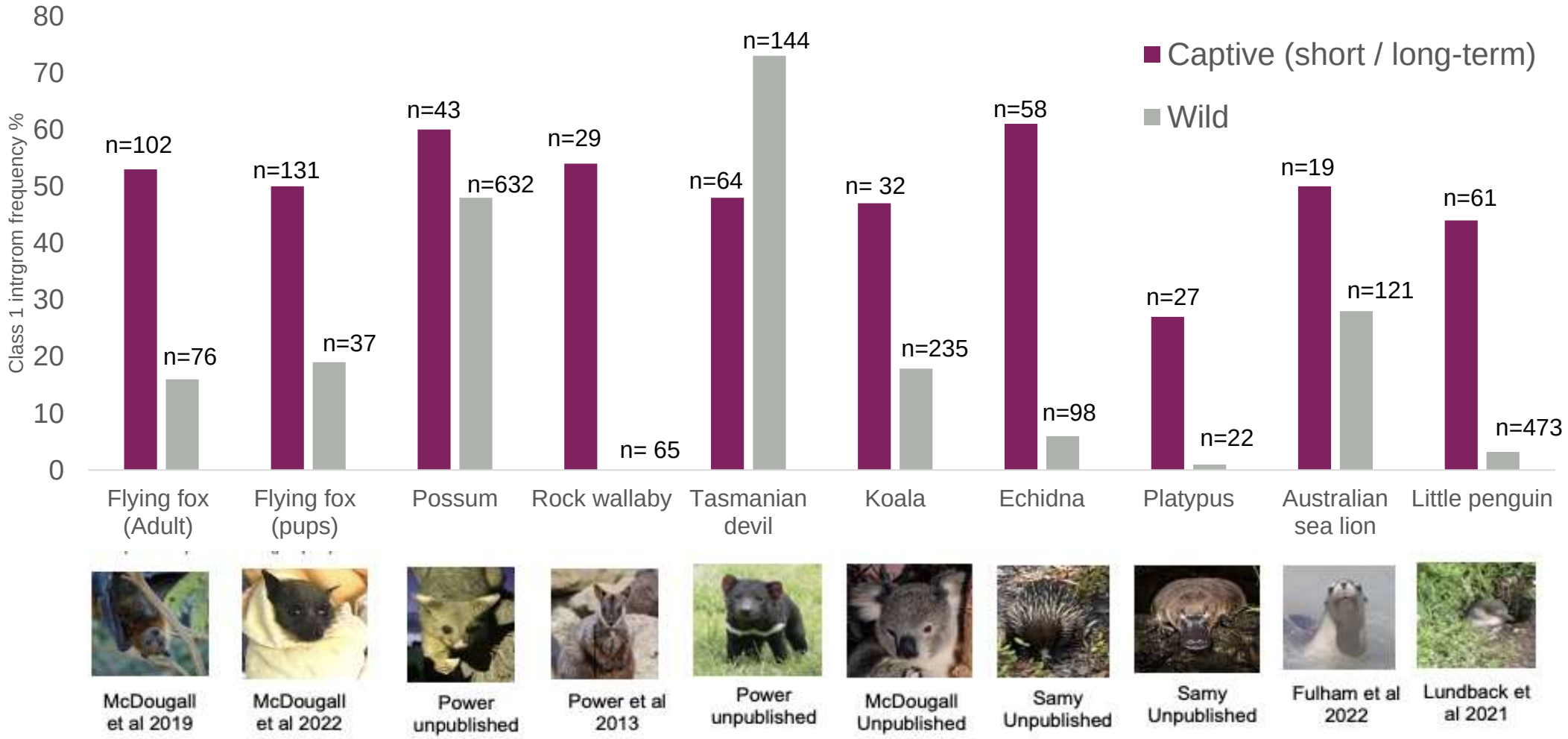
Resistance determinants can be exchanged within and between bacterial species



AMR is widespread among Australian wildlife

➢ CLASS 1 INTEGRONS IN AUSTRALIAN WILDLIFE

AMR is more frequent in animals in rehabilitation / close-contact to people



AMR in Grey headed flying fox *Pteropus poliocephalus*

Infection, Genetics and Evolution 70 (2019) 107–113

Contents lists available at ScienceDirect

Infection, Genetics and Evolution

journal homepage: www.elsevier.com/locate/meegid

Research paper

Bats as reservoirs of antibiotic resistance determinants: A survey of class 1 integrons in Grey-headed Flying Foxes (*Pteropus poliocephalus*)

Fiona McDougall[a,*], Wayne Boardman[b], Michael Gillings[a], Michelle Power[a]

[a] Department of Biological Sciences, Macquarie University, NSW 2109, Australia
[b] School of Animal and Veterinary Sciences, University of Adelaide, SA 5371, Australia

MICROBIAL GENOMICS

RESEARCH ARTICLE

McDougall *et al.*, *Microbial Genomics* 2021;7:000571

DOI 10.1099/mgen.0.000571

MICROBIOLOGY SOCIETY

OPEN DATA OPEN ACCESS

Characterization of beta-lactam-resistant *Escherichia coli* from Australian fruit bats indicates anthropogenic origins

Fiona K. McDougall[1,*], Wayne S. J. Boardman[2] and Michelle L. Power[1]

Image: Adam Mckeown

Enteric pathogens in grey-headed flying foxes

Culture-based detection and antibiotic sensitivity testing

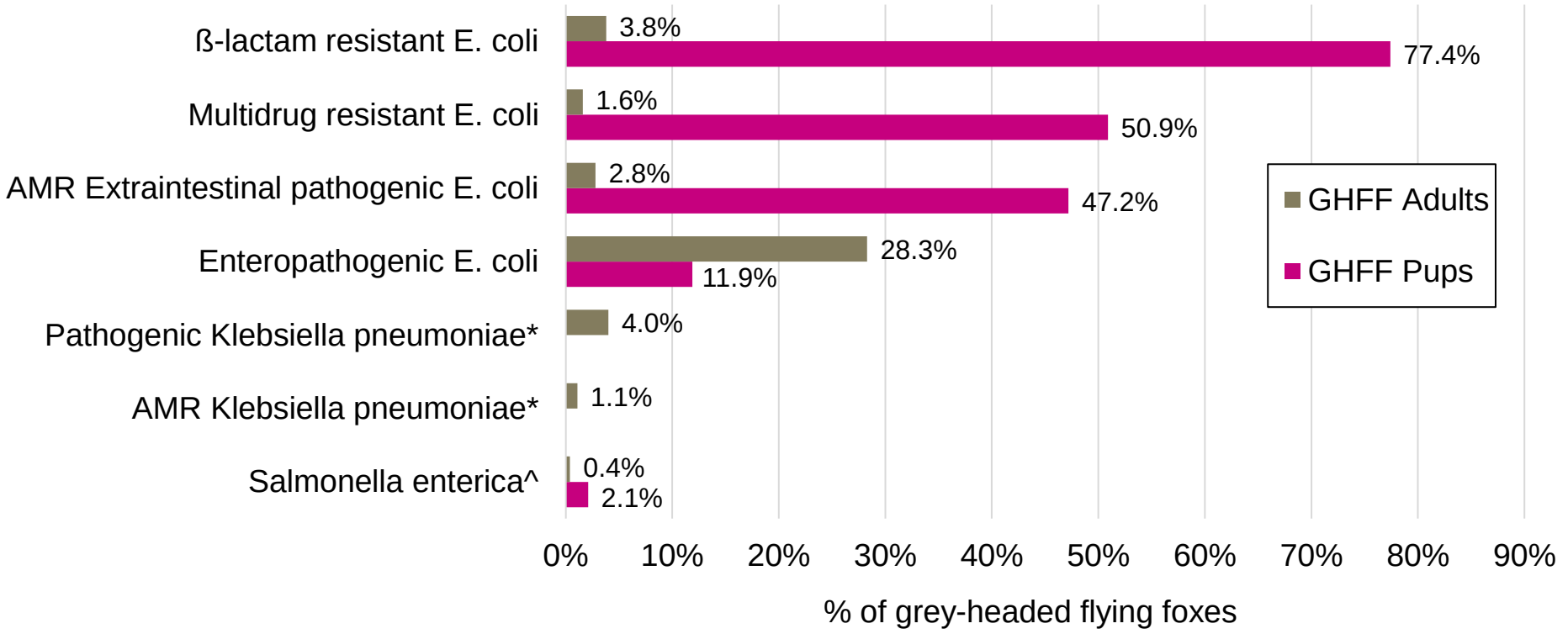


Image: Adam Mckeown

* Preliminary data. # Data not available.

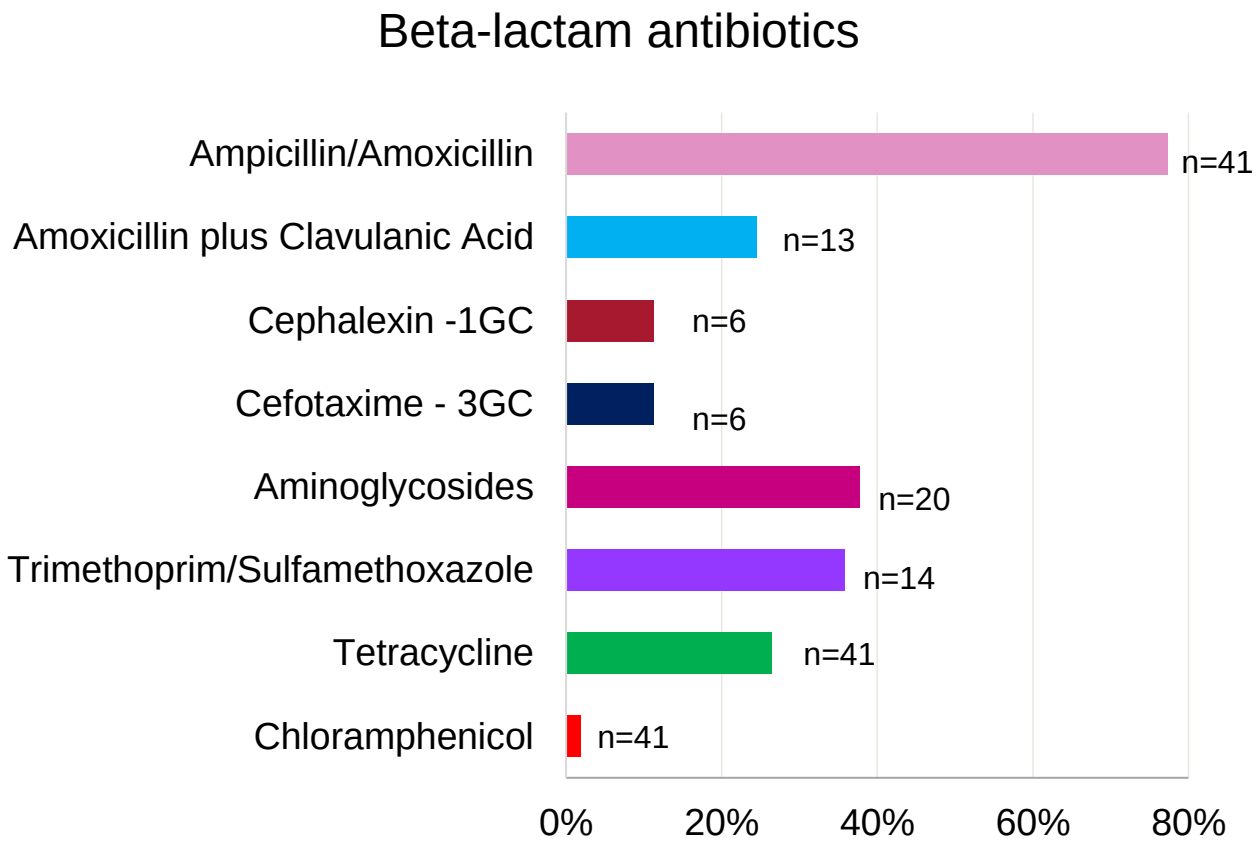
Beta-lactam resistant *E. coli* in GHFF pups

Culture-based sensitivity

50.9% of pups carried multidrug resistant *E. coli*

Beta-lactam resistant *E. coli* in GHFF pups:

- 77.4% Amoxicillin
- 24.5% Amoxicillin + clavulanic acid
- 11.3% Cephalosporin



38 different antibiotic resistance gene in Grey-headed flying fox

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Beta lactams = 10

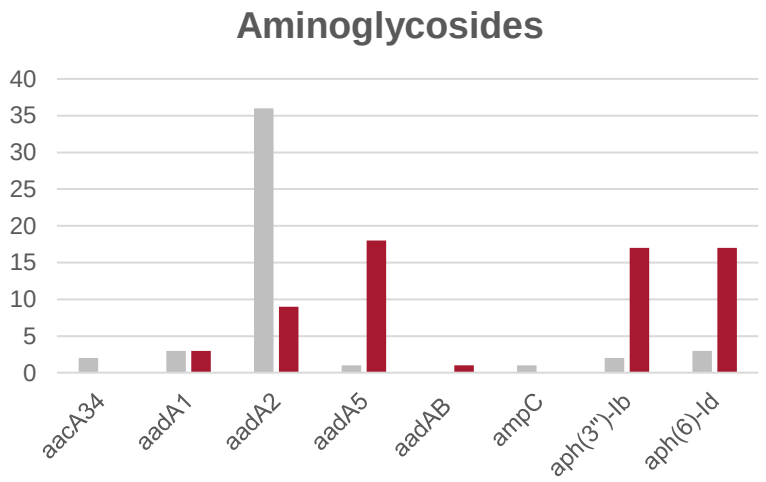
Aminoglycosides = 12

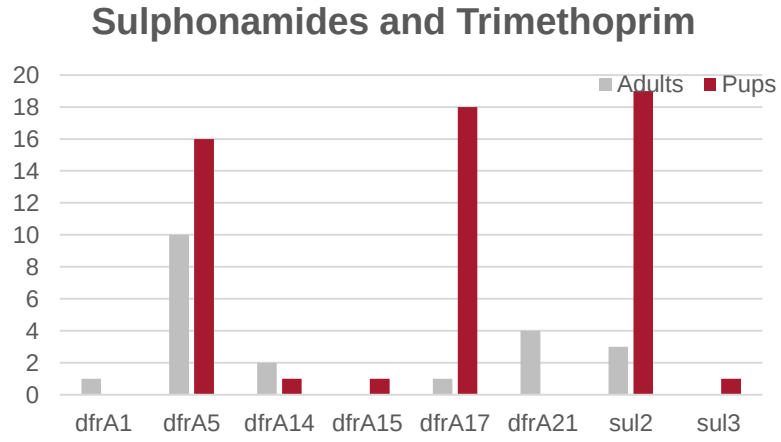
Chloramphenicol = 2

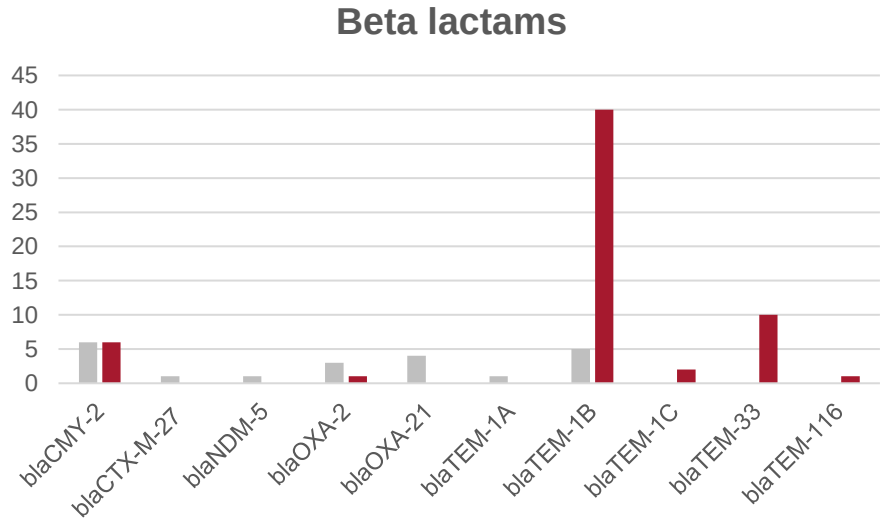
Tetracyclines = 2

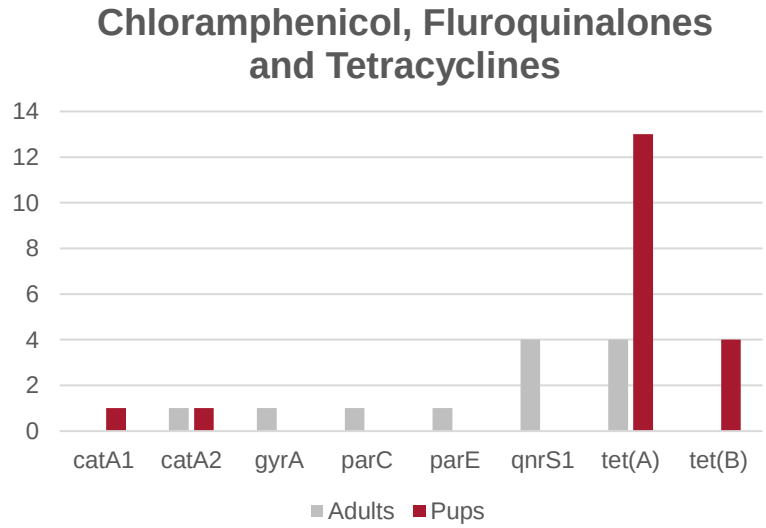
Fluoroquinalones = 4

Sulfonamides / trimethoprim = 8









Significance and impact of antibiotic resistance for wildlife health

- Treatment implications for wildlife hospitals / rehabilitation when animals enter care carrying resistant bacteria
- Resistant bacteria represent invasive organisms in wildlife microbiomes – microbial level disturbance and impact
- Resistant strains are typically pathogenic and may influence optimal rehabilitation outcomes or risk disease in free-range animals

Implications – Potential negative health outcomes of carrying ARGs

- Antibiotic can induce or exacerbate gut dysbiosis – under stress bacteria will sequester resistant genes

- Antibiotics select and amplify resistant bacteria
  - → Secondary bacterial infections
  - → Increased risk for disease
  - → Poor rehabilitation outcomes

Implications – Potential negative health outcomes of carrying ARGs

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Good gut bacteria

ARG

Resistant bacteria

Resistant secondary infections

Recent paper

Gammaretroviruses, novel viruses and pathogenic bacteria in Australian bats with neurological signs, pneumonia and skin lesions

Kate Van Brussel[a], Jackie E. Mahar[a], Jane Hall[b], Hannah Bender[b], Ayda Susana Ortiz-Baez[a], Wei-Shan Chang[a], Edward C. Holmes[a,*], Karrie Rose[b,**]

[a] Sydney Institute for Infectious Diseases, School of Medical Sciences, The University of Sydney, NSW, 2006, Australia
[b] Australian Registry of Wildlife Health, Taronga Conservation Society Australia, Mosman, New South Wales, Australia

Nadine Samy, Mres Thesis

- Data mining from wildlife pathogen database
- 55% of the *Pseudomonas aeruginosa* strains were resistant to enrofloxacin
- We do not know if the bats received enrofloxacin.

Impact of wildlife emergencies on AMR dynamics

Image: Adam Mckeown

Wildlife emergencies and AMR dynamics

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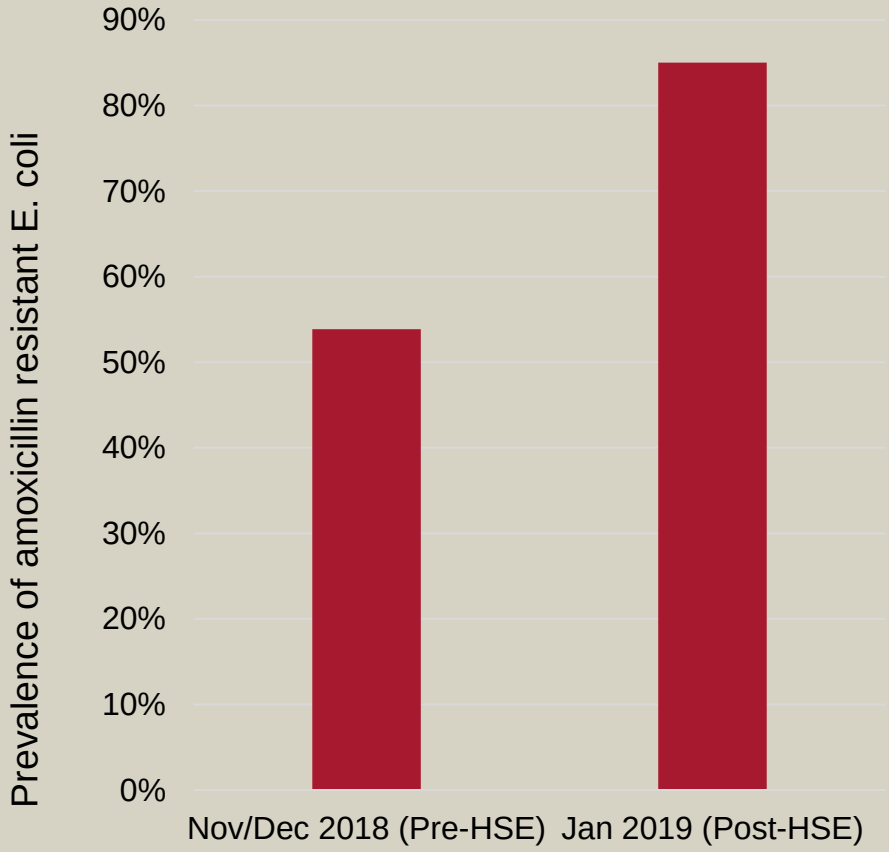
Observed increase in frequency of resistant *E. coli* and strain diversity in heat stressed bats



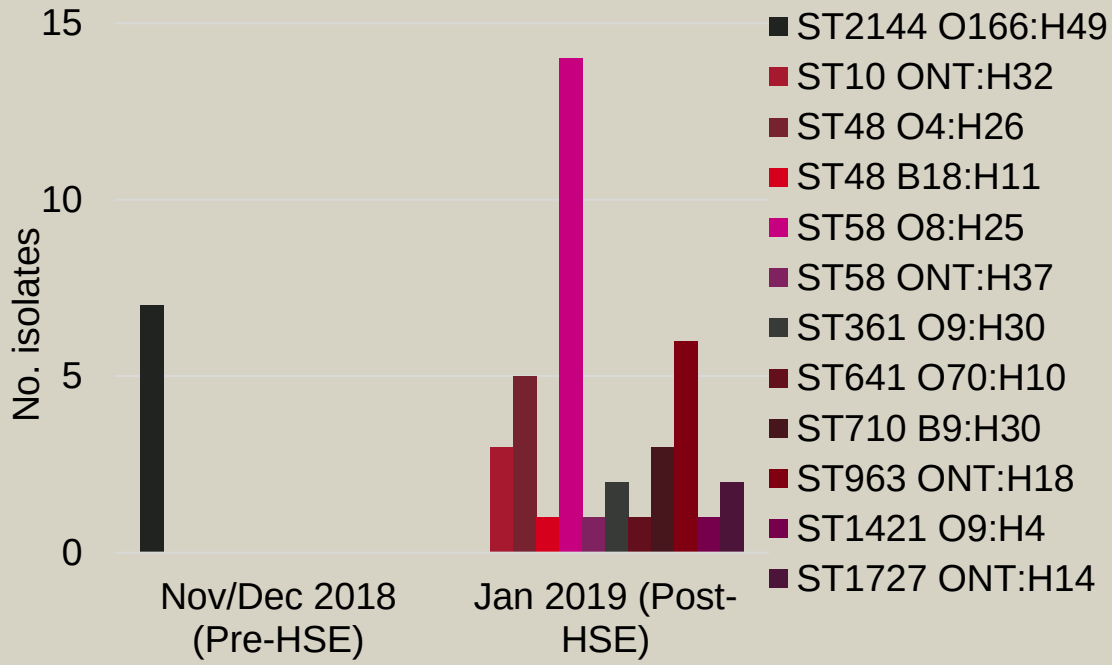


Image: Adam Mckeown

Wildlife emergencies – 2019/2020 bushfires

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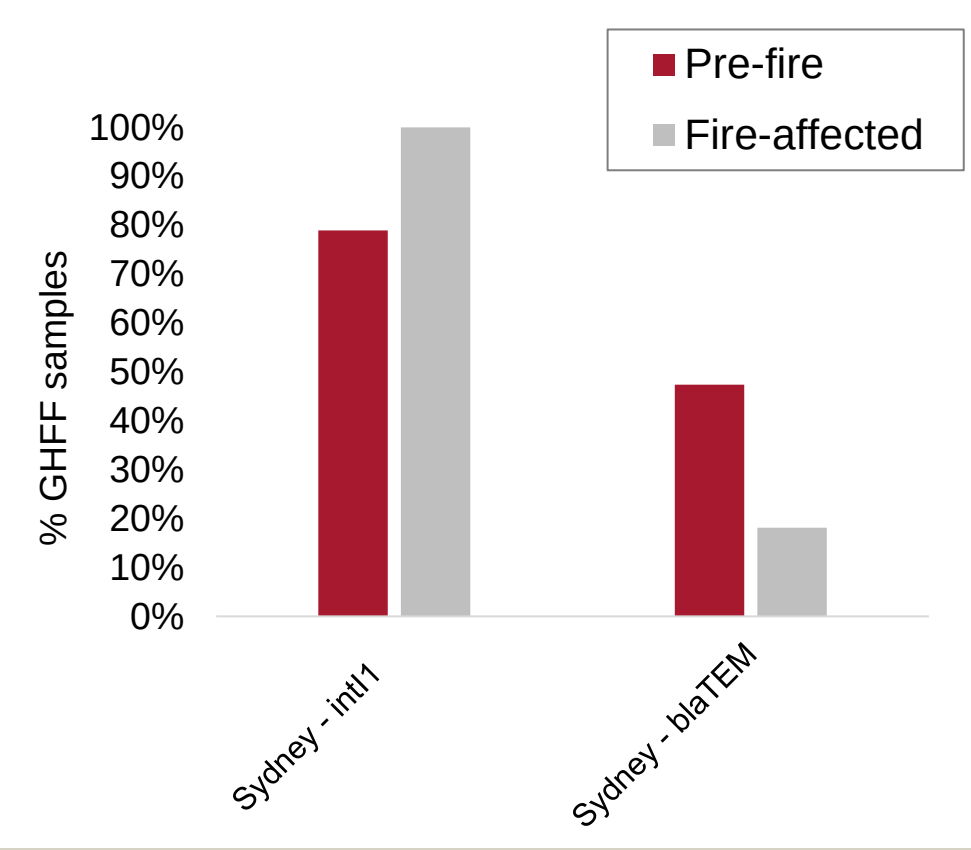
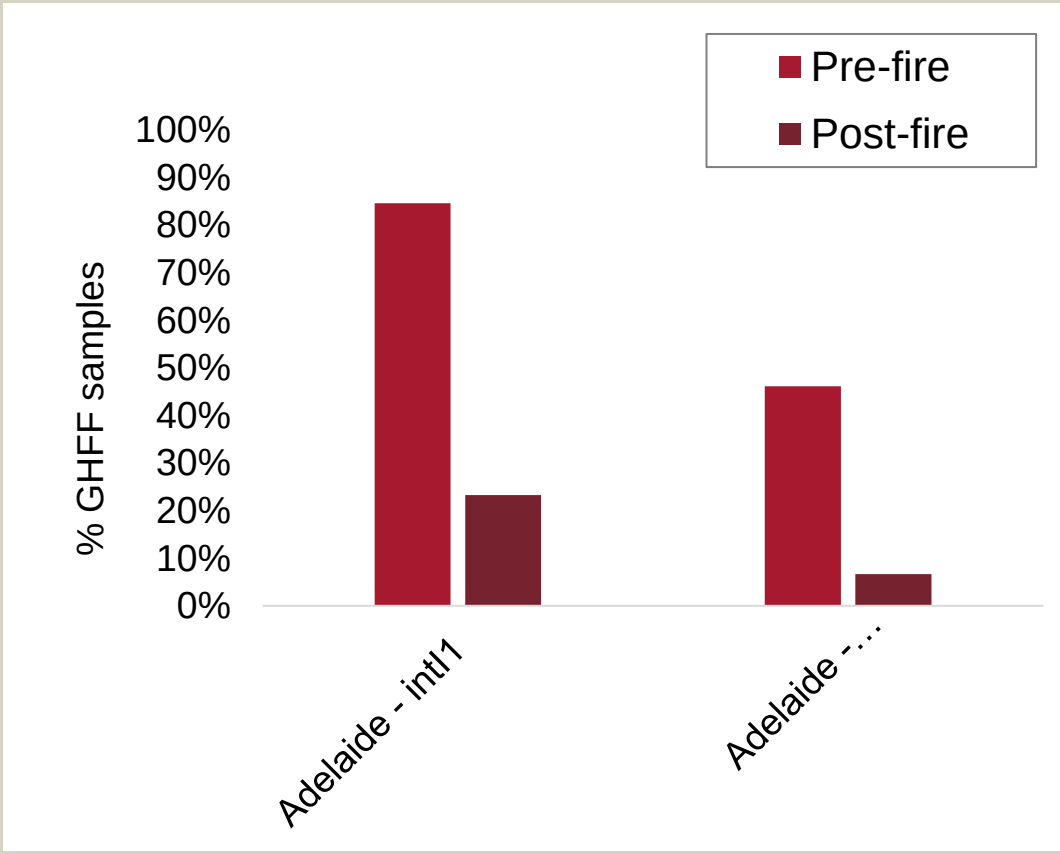
Variable outcomes pending antibiotic resistance determinant and location





Potential cycling of antibiotic resistant bacteria in wildlife in rehabilitation

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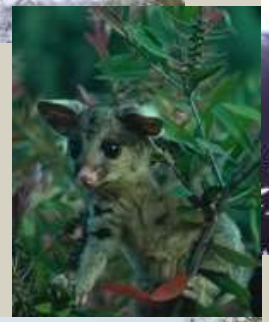
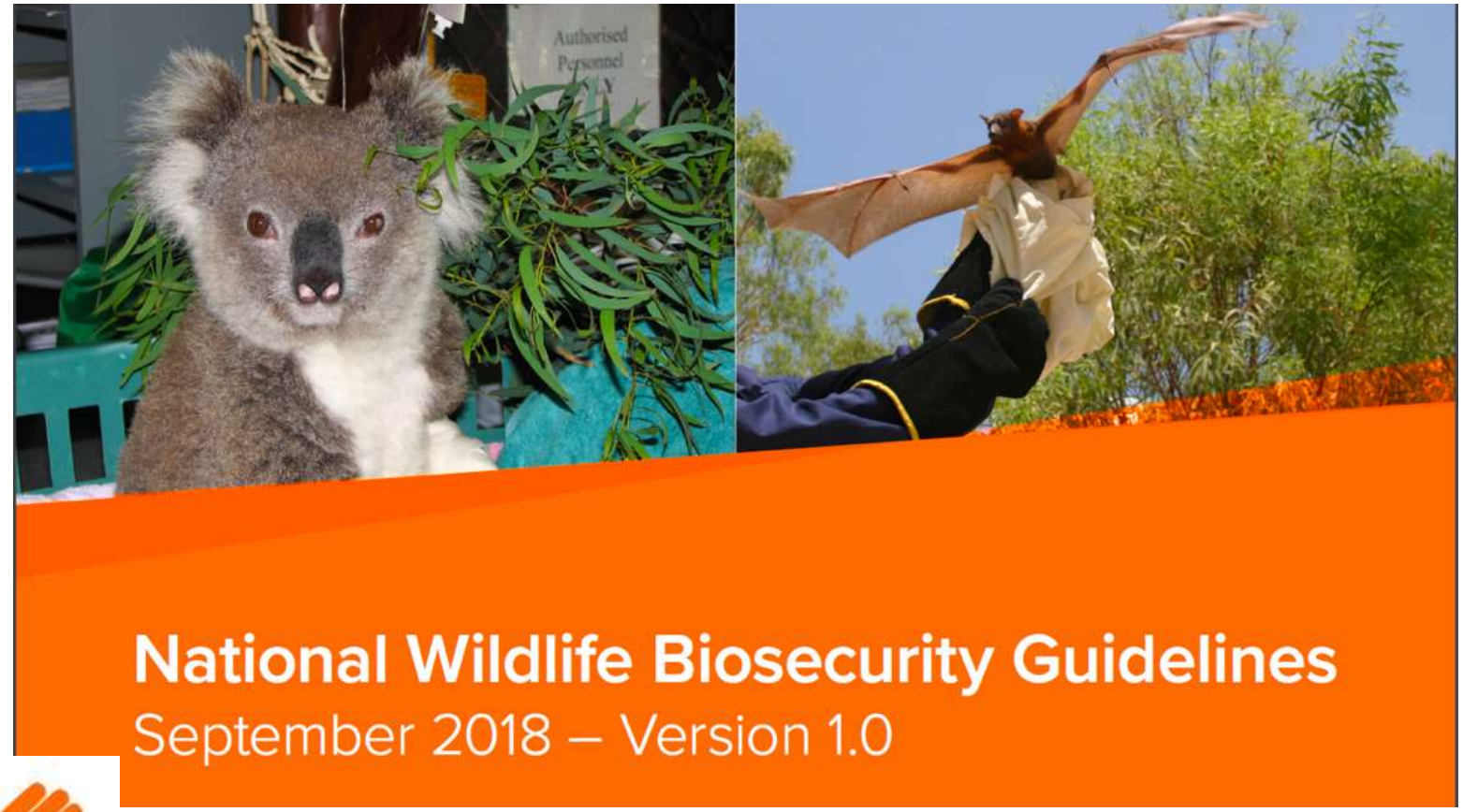


What can you do to reduce the risk and preserve antibiotics?

ACTION	Veterinarian	Rehabilitator
Prescribe antibiotics only when necessary	✓	
Select the optimal antibiotic, dose and duration for the animal/condition	✓	
Treat at correct doses and complete the course as prescribed	✓	✓
Consult a veterinarian before using antibiotics in wildlife		✓
Don’t use antibiotics that have been prescribed for specific conditions in one species/individual for another species/individual		✓
Recognise that veterinarians are being educated on good antimicrobial stewardship (including not prescribing antibiotics as prophylaxes or without confirmation of a bacterial infection)		✓
Adhere to established protocols for the treatment of burns in wildlife	✓	✓
Consider alternatives to antibiotics for wounds e.g.Manuka honey, Saline	✓	
Use measures to prevent infection (good hygiene, appropriate environment, One Health and sources of infectious agents)	✓	✓

Managing the threat of antibiotic resistance and negative outcomes of charges



RESOURCES

- Code of practice for different species (NSW)
- Treatment and Care Guidelines (NSW)
- WHA Fact sheets
- Recorded talks – Wildlife Heroes
- Medicine of Australian Mammals
- Planning an online micro-credential / short course to support the wildlife rehabilitation industry
- Continue our research

Antibiotic resistance in wildlife rehabilitation survey

We invite you to help us understand the knowledge and practice associated with the use of antibiotics in wildlife among people who contribute in various capacities to wildlife rescue, care, and rehabilitation by completing a short survey

Macquarie University Human Ethics committee, project ID 14343

Antibiotic resistance in fire affected koalas

Michelle Power
Fiona McDougall
Wayne Boardman
Merran Govendir
Melanie Taylor

Photo: Doug Gimesy

Antibiotic resistance dynamics are influenced during wildlife emergencies

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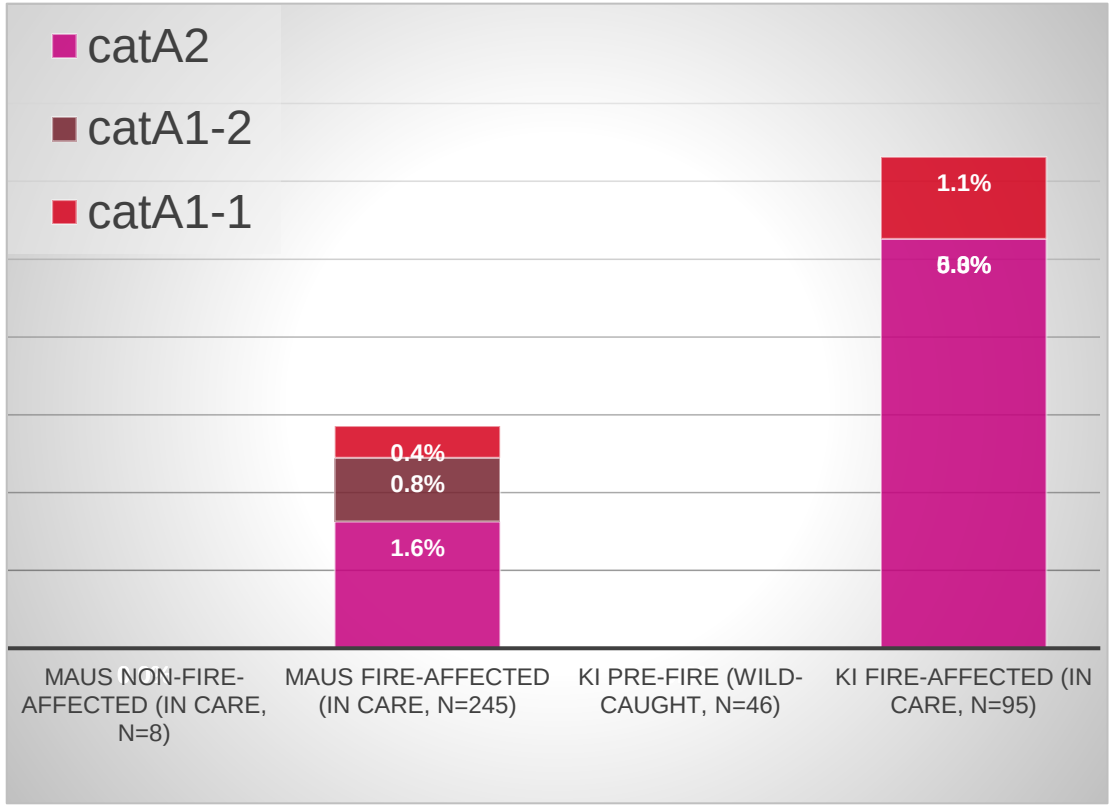
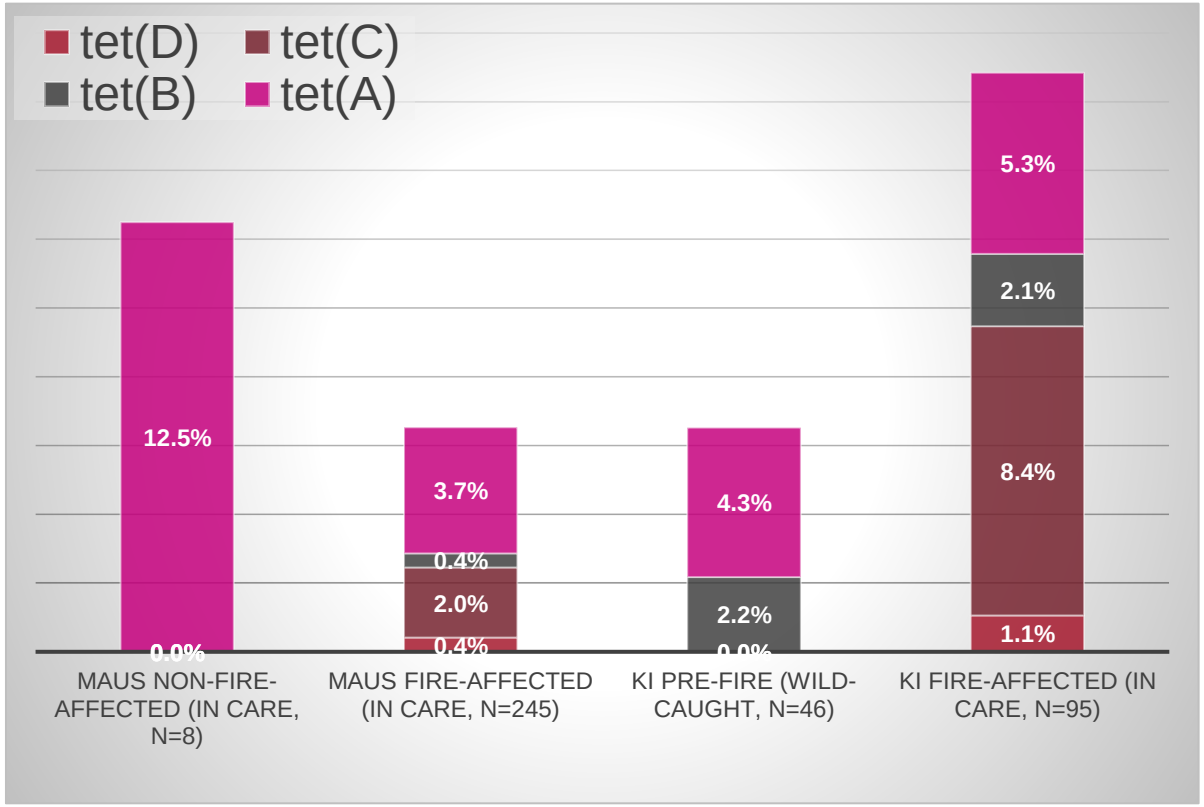
Chloramphenicol resistance genes



Doxytetracycline resistance genes



↑ ARG Prevalence

↑ ARG diversity

Implications – Potential negative health outcomes carrying ARGs

- Induce or exacerbate gut dysbiosis – under stress bacteria will sequester resistant genes
- Select and amplify resistant bacteria

→ Secondary bacterial infections
→ Increased risk for disease
→ Poor rehabilitation outcomes