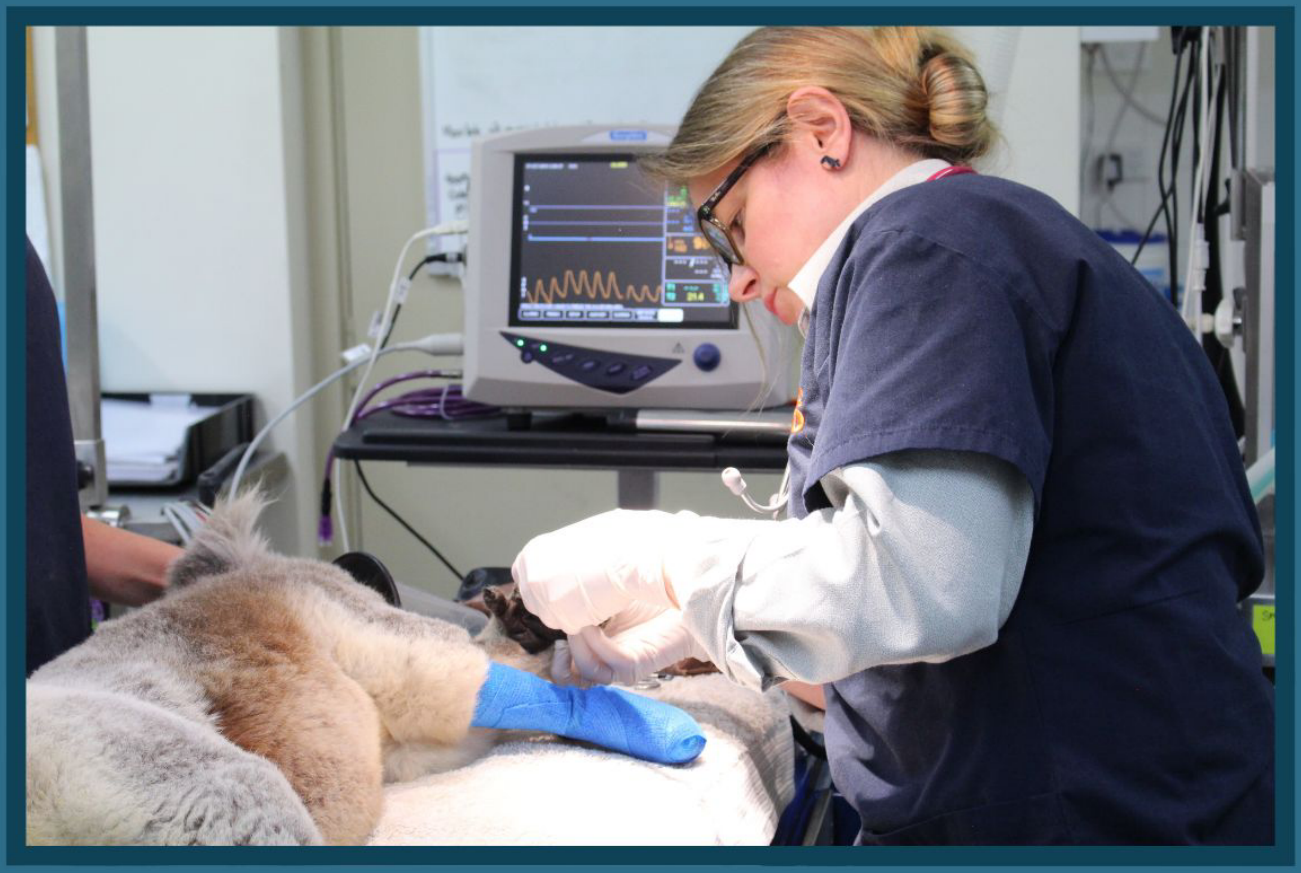
Guidelines for Antimicrobial Prescribing in Australian Wildlife



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First edition, 2025

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Antimicrobial stewardship in wildlife

1. Scope of guidelines

The guidelines are intended to highlight ways in which antimicrobial stewardship can be practiced in relation to free ranging and captive wildlife in Australia. These guidelines are not intended to replace detailed texts of wildlife medicine. Examples of conditions where antimicrobials are not needed, or are detrimental as part of treatment, are included, as well as a discussion of conditions in which antimicrobials may be required. These guidelines focus on the most common issues surrounding antimicrobial stewardship for wildlife, namely, husbandry, care of juveniles, and trauma presentations. In addition, a list of freely available online resources is included for more detailed information on the care and assessment of a variety of species.

The guidelines are not intended to or able to provide detailed information on antimicrobial prescribing in all wildlife species. If specific information is not included in the guidelines, the general antimicrobial stewardship principles described in this document should be followed, and specialist advice should be sought.

2. One Health considerations

The development of antimicrobial resistance in wildlife is associated with increasing proximity to humans and domestic animals (1). Wildlife that have been treated indiscriminately with antimicrobials are more likely to carry bacteria with antimicrobial resistance genes, which could be transmitted to other free-ranging or captive wild animals and into the environment (1). In addition, the use of antimicrobials causes alterations in the microbiome which may have various sequelae for wild animals after release. It is therefore important to consider the wide-reaching effects when using antimicrobials in wild animals.

2.1 Bacterial zoonoses

When handling wildlife, it is important to be aware of the risks of bacterial zoonoses, and the associated risk of transmission of antimicrobial-resistant bacteria. Many zoonotic pathogens are carried by apparently healthy animals, so good personal hygiene, including regular hand washing, should be practiced when handling wildlife.

For further information on zoonoses in wildlife, refer to the factsheets available on the Wildlife Health Australia website:

- Zoonoses and Australian bats
- Zoonoses and Australian native mammals
- Zoonoses and Australian wild birds
- Zoonoses and Australian wild reptiles

For additional information on biosecurity practices as they relate to wildlife, refer to the Wildlife Health Australia National Wildlife Biosecurity Guidelines and the AVA Veterinary Biosecurity Guidelines.

3. Triage of wildlife

When assessing wildlife, it is important to keep in mind the objective of rehabilitation and successful release into the wild (3). Early assessment of prognosis and potential for release avoids unnecessary patient suffering and stress (3). A summary of the approach to triage of wildlife presenting for veterinary care is provided in Figure 1. This figure should be used in conjunction with the wildlife triage resources and species-specific resources listed in 3.2.

3.1 Legislation

Once the species has been identified, it is essential that local legislation is consulted, as this differs between Australian jurisdictions. For example, the approach to release of non-native species differs and some jurisdictions have criteria for euthanasia published in Codes of Practice, as per the below list. This list is not exhaustive, and practitioners should familiarise themselves with their State or Territory's wildlife legislation and Codes of Practice.

- **Australian Capital Territory**
  - Code of Practice for the Welfare of Native Wildlife – Rescue, Rehabilitation & Release https://actwildlife.net/wp-content/uploads/2022/03/Wildlife-COP-2020.pdf
- **New South Wales**
  - Code of Practice for Injured, Sick and Orphaned Protected Fauna https://www.environment.nsw.gov.au/resources/wildlifelicences/110004faunarehab.pdf
  - There are numerous species specific Codes of practice for wildlife in NSW which can be found on the Department of Climate Change, Energy, the Environment and Water's website.
- **Northern Territory**
  - About caring for wildlife, including links to wildlife carer's permits and applications to release wildlife. https://nt.gov.au/environment/animals/caring-for-wildlife/about-caring-for-wildlife

- **Queensland**
  - Code of Practice. Care of Sick, Injured or Orphaned Protected Animals in Queensland. https://www.des.qld.gov.au/policies?a=272936:policy_registry/cp-wl-rehab.pdf
- **South Australia**
  - Wildlife permits, laws and guidelines, including links to species-specific guidelines for captive management https://www.environment.sa.gov.au/licences-and-permits/wildlife-permits/laws-guidelines
  - https://www.environment.sa.gov.au/topics/animals-and-plants/helping-protecting-wildlife/helping-wildlife
- **Tasmania**
  - Best Practice Guidelines for Wildlife Rehabilitation https://nre.tas.gov.au/Documents/Best%20Practice%20Guidelines%20for%20Wildlife%20Rehabilitation.pdf
- **Victoria**
  - Code of Practice for the Welfare of Wildlife During Rehabilitation https://agriculture.vic.gov.au/livestock-and-animals/animal-welfare-victoria/pocta-act-1986/victorian-codes-of-practice-for-animal-welfare
- **Western Australia**
  - Code of Practice for Wildlife Rehabilitation in Western Australia https://www.dbca.wa.gov.au/media/762/download

Are antibiotics indicated in the triage of wildlife?

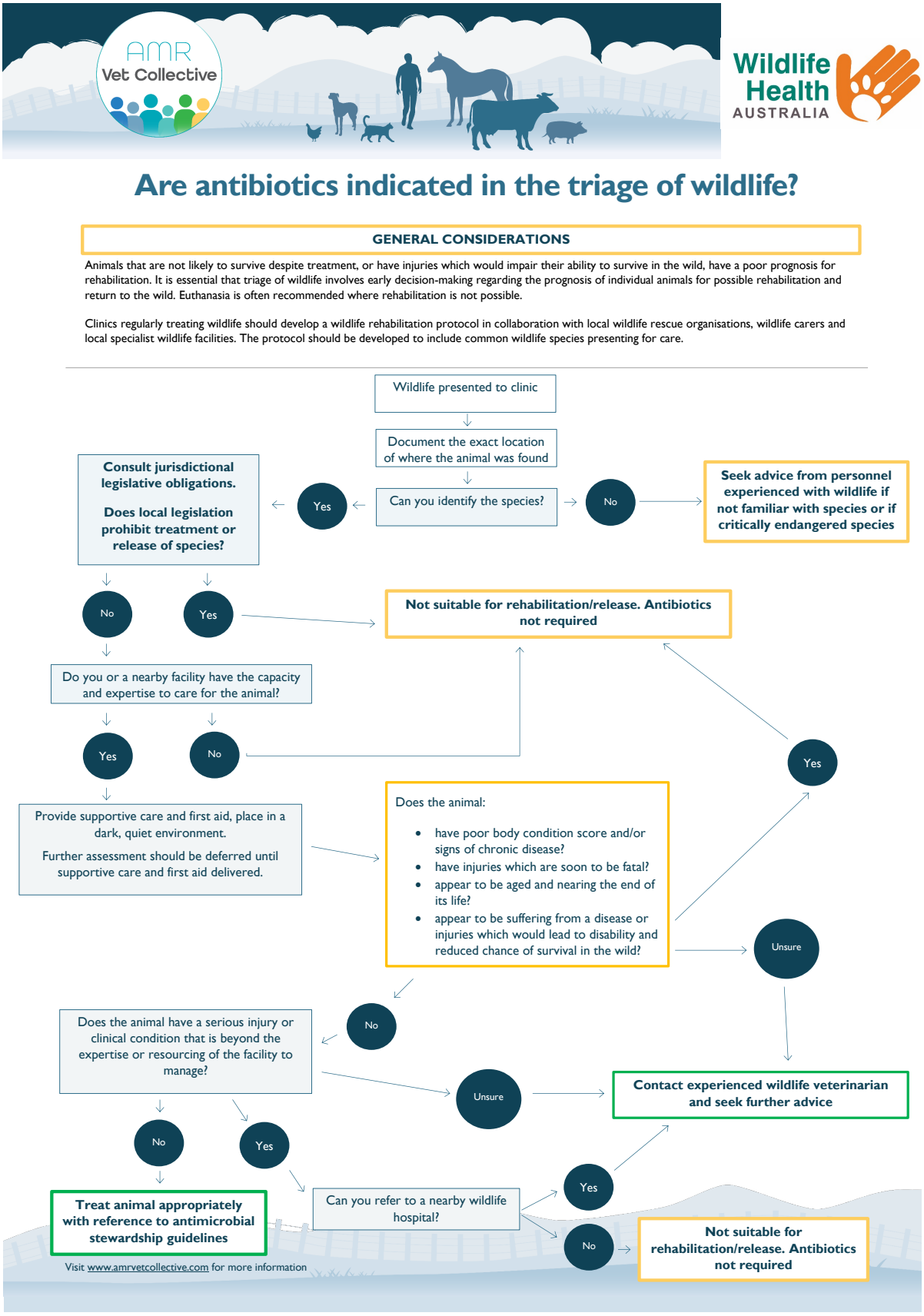

Figure 1. Decision tree for the use of antimicrobials in triage of wildlife presented to clinic. Adapted from (4)

3.2 Resources

Comprehensive discussion of the husbandry and care of native Australian wildlife is beyond the scope of these guidelines, but essential to enable appropriate stewardship.

A (non-exhaustive) list of resources is included below.

Initial assessment of Wildlife

The Wildlife Heroes website contains veterinary training videos which demonstrate clinical assessment techniques. Links below also contain printable single page resources for triage of a variety of species.

Birds

Species identification

- *Bird Life*
  https://birdlife.org.au/bird-profiles/

Triage and treatment

- *Initial treatment and care guidelines for rescued native birds*
  https://www2.environment.nsw.gov.au/sites/default/files/native-birds-initial-treatment-care-guidelines-210623.pdf

- *Birds Veterinary Triage & Assessment*
  https://wildlifeheroes.org.au/wp-content/uploads/2021/09/WFV_Poster_Birds.pdf.

- *Practical Handbook of Raptor Rehabilitation*
  https://wildlifeheroes.org.au/wp-content/uploads/2024/02/RRA-Raptor-Textbook.pdf

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Mammals

Bats

- *Initial treatment and care guidelines for rescued flying-foxes*
  https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Native-animals/flying-foxes-initial-treatment-care-guidelines-210417.pdf

- *Bats Veterinary Triage & Assessment*
  https://wildlifeheroes.org.au/wp-content/uploads/2022/10/Veterinary-Treatment-Information-A1_Wildlife-Rescue-Poster_FINAL_PRINT-1-1.pdf

Echidnas and platypus

- *Echidnas Veterinary Triage & Assessment*
  https://wildlifeheroes.org.au/wp-content/uploads/2022/01/WFV_Poster_Echidna_2021_PRINT.pdf

- *Initial treatment and care guidelines for rescued echidnas*
  https://www2.environment.nsw.gov.au/sites/default/files/rescued-echidnas-treatment-care-guidelines-210315.pdf

- *Rescue guidelines for platypus*
  https://platypus.asn.au/wp-content/uploads/2022/03/APC-Info-Note-Rescue-Guidelines-2022-Feb.pdf

Koalas

- *Guidelines for initial treatment and care of rescued koalas*
  https://www2.environment.nsw.gov.au/sites/default/files/treatment-care-rescued-koalas-guidelines-200202.pdf

- *Koalas Veterinary Triage & Assessment*
  https://wildlifeheroes.org.au/wp-content/uploads/2021/12/WFV_Poster_Koala_2021_20Dec2021_PRINT.pdf

Macropods

- *Guidelines for the initial treatment and care of rescued macropods*
  https://www2.environment.nsw.gov.au/sites/default/files/rescued-macropods-treatment-care-guidelines-210038.pdf

- *Macropods Veterinary Triage & Assessment*
  https://wildlifeheroes.org.au/wp-content/uploads/2021/09/WFV_Poster_Macropods.pdf.

Possums and gliders

- *Initial treatment and care guidelines for rescued possums and gliders*
  https://www2.environment.nsw.gov.au/sites/default/files/rescued-possums-gliders-treatment-care-guidelines-210312.pdf

- *Possums and Gliders Veterinary Triage & Assessment.*
  https://wildlifeheroes.org.au/wp-content/uploads/2021/09/WFV_Poster_Possums.pdf.

Small mammals

- *Small mammals Veterinary Triage & Assessment*
  https://wildlifeheroes.org.au/wp-content/uploads/2022/02/WFV_Poster_Small-Mammals_2022_PRINT.pdf

Wombats

- *Guidelines for the initial treatment and care of rescued wombats*
  https://www2.environment.nsw.gov.au/sites/default/files/rescued-wombats-treatment-care-guidelines-210230.pdf

- *Wombats Veterinary Triage & Assessment*
  https://wildlifeheroes.org.au/wp-content/uploads/2023/10/WFV_Booklet_Wombat_2023_low-res.pdf

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Reptiles

- *Initial treatment and care guidelines for rescued reptiles*
  https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Native-animals/reptiles-initial-treatment-care-guidelines-210566.pdf

- *Sea snake and sea turtle guidelines (referral for expert care recommended for these species)*
  https://www.environment.nsw.gov.au/sites/default/files/injured-sick-sea-turtles-sea-snakes-code-of-practice-210257.pdf

  https://www.environment.nsw.gov.au/sites/default/files/sea-turtle-sea-snake-rehabilitation-training-standards-210252.pdf

Amphibians

- *Amphibians Veterinary Triage & Assessment*
  https://wildlifeheroes.org.au/wp-content/uploads/2022/01/WFV_Poster_FROG_2022_FINAL.pdf

- *Chapter 3. Amphibians*
  https://www.wildlife.vic.gov.au/__data/assets/pdf_file/0025/671254/Part-B-Reptiles-Amphibians-Chapter-3.pdf

- *Chapter 4. Frogs*
  https://www.wildlife.vic.gov.au/__data/assets/pdf_file/0026/671255/Part-B-Reptiles-Amphibians-Chapter-4.pdf

Freshwater turtles

- *Freshwater Turtles Veterinary Triage & Assessment*
  https://wildlifeheroes.org.au/wp-content/uploads/2022/01/WFV_Poster_Tutle_2021_FINAL.pdf

- *Guidelines for the initial treatment and care of rescued sea turtles*
  https://www2.environment.nsw.gov.au/sites/default/files/rescued-sea-turtles-treatment-care-guidelines-210143.pdf

Lizards

- *Lizards Veterinary Triage & Assessment*

https://wildlifeheroes.org.au/wp-content/uploads/2021/09/WFV_Poster_LIZARD_2021_PRINT.pdf

Snakes

- *Snakes Veterinary Triage & Assessment*

  https://wildlifeheroes.org.au/wp-content/uploads/2021/12/WFV_Poster_Snake_2021_FINAL-7-Dec-2021.pdf

4. Principles of antimicrobial prescribing

1. **Use antimicrobials only when indicated (and consider species)**

   Antimicrobials should only be used when a bacterial disease is confirmed through examination and diagnostic investigation (2). If culture and susceptibility is not able to be performed, cytology and a Gram stain should be conducted before commencing treatment with antimicrobials (5). Note that some species are at high risk for adverse effects from antimicrobials.

2. **Review effectiveness at regular intervals and treat only as long as is needed to achieve a clinical response**

   Whenever antimicrobials are prescribed to wildlife, their effectiveness should be reviewed after a short period, e.g. 72 hours. Medication should be ceased after the desired response is achieved. If the expected effect is not seen, diagnostics, prognosis and treatment should be reassessed.

3. **Select the optimal antimicrobial (narrowest spectrum of activity possible), dose and duration of treatment for the pathogen and patient**

   Gram staining of samples can be used to identify the most appropriate first line antimicrobial (6).

4. **Choose an antimicrobial not classified as high importance for use in human health**

   All ASTAG red coded (high importance – refer to Section 6 for full explanation) antimicrobials should be reserved for use when indicated by culture and susceptibility, when lower importance antimicrobials are not suitable, and following discussion with an experienced wildlife veterinarian.

5. **Use topical antimicrobials instead of systemic where possible**

   Including creams, ophthalmic preparations, or antimicrobial impregnated materials (6).

6. **Consider alternatives to antimicrobials for wound treatment**

   For example, silver-impregnated wound dressings.

7. **Document indication, use and outcome for all patients**

   Real world data are essential for ongoing refinement of local prescribing and, more broadly, expansion of the evidence-base to support review and to inform regulatory decisions.

4.1 Husbandry

As with all animals, ensuring a high standard of husbandry is an important factor in preventing the development of bacterial infections. The provision of appropriate housing, diet, environmental conditions, and hygiene work together to promote good health, whereas substandard husbandry is a common factor contributing to the development of bacterial diseases. Please refer to the resources listed in section 3.2 for detailed species-specific advice on husbandry.

4.2 Care of juveniles

Large numbers of native wildlife presenting to veterinarians for assessment and care are paediatric, and many are orphaned.

For paediatric wildlife in care, hygiene is particularly important to minimise the development of infections (7). For hand-reared juveniles, hygiene incorporates sterilisation of feeding equipment, age appropriate nutrition, correct preparation of milk formula and the avoidance of stress and overcrowding (7).

It is important to be cautious with the use of antimicrobials in paediatric wildlife, due to their immature anatomy and physiology, which includes reduced renal blood flow and

renal drug clearance, and immature hepatic function (7). Antimicrobials that are metabolised by the kidneys and/or liver should only be used when absolutely necessary and once the animal has received appropriate supportive care and rehydration (7).

In addition, paediatric native wildlife are at a stage of development where they are establishing the microbiome of their gastrointestinal tract, an important component of their immunity to pathogens and digestive function (7). As any antimicrobial use will have a marked effect on the animal's microbiome, they should be used only when clinically indicated by a diagnosed infection and the animal should be monitored for clinical signs of dysbiosis (2). Antimicrobial use in juvenile mammals often leads to candidiasis, which can sometimes be fatal.

Marsupials are immature at birth and complete their development in their mother's pouch. Orphaned marsupials that are hand-reared have increased susceptibility to infectious disease as they have been removed from the protective environment of the pouch and are no longer receiving the protective factors from their mother's milk. Compared to other wildlife casualties, they generally require longer periods of time in rehabilitation before they are suitable for release (7).

4.3 Management of trauma in wildlife

Common causes of trauma in wildlife include predation, motor vehicle accidents, burns, and entanglement.

While the broad principles of wound management for wildlife are similar to domestic animals, prognosis for recovery and return to the wild can be highly specific to the species and body part affected. Please consult with experienced wildlife veterinarians and refer to triage and assessment documents such as those listed in section **3.2 Resources** for species-specific decision-making.

The general principles and considerations for wound management are presented in Figure 2.

Assessment of wounds

Any wounds should first be assessed to determine if they are likely to be caused by trauma, or if they are a manifestation of infection, from viruses, bacteria or fungi.

Antimicrobials are unlikely to be required for most fresh traumatic injuries in wildlife, except for those with a high likelihood of bacterial contamination such as cat or dog bites.

Wound management

Where wildlife have suffered from trauma and the animal is assessed as having a good prognosis for recovery and release into the wild, wound management is often a key component of treatment. As per general wound management principles, wounds should be thoroughly lavaged and debrided, and where possible and appropriate, primary closure should be undertaken.

If primary closure cannot be achieved, wounds can be left to heal by secondary intention or treated by delayed primary closure. The use of topical antimicrobials (e.g. silver sulfadiazine) or impregnated wound dressings, such as Acticoat®, should be considered rather than parenteral antimicrobial preparations. The approach to application of dressings varies with species and anatomical location and is beyond the scope of these guidelines.

When using secondary intention and bandaging to treat wounds, ensure regular bandage changes and wound cleaning. Some burns patients may need daily dressing changes, while other constrictive traumas may require dressing changes every three to four days.

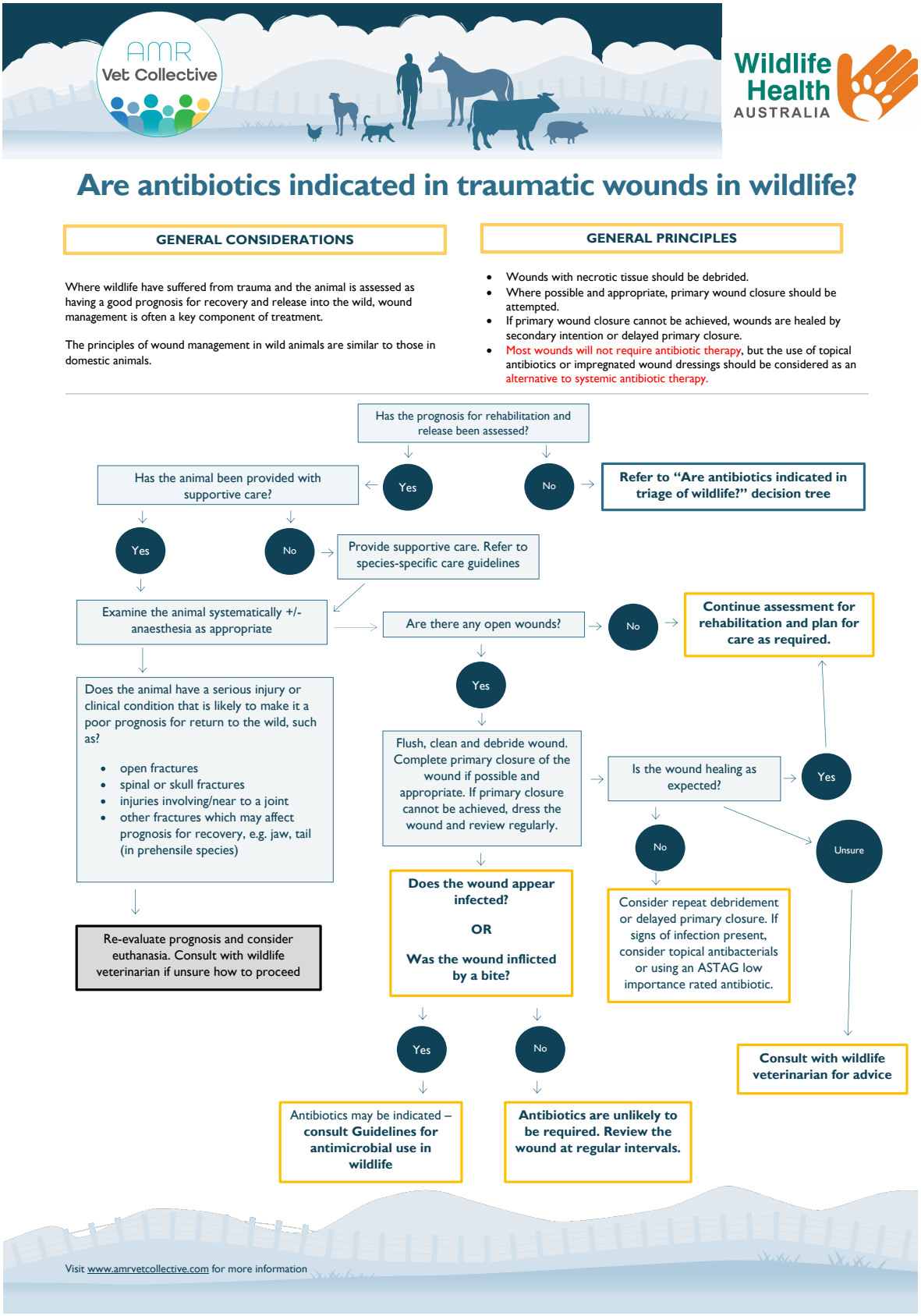

Figure 2. Decision tree for the use of antimicrobials in traumatic wounds in wildlife

5. Improving antimicrobial stewardship for wildlife in veterinary practice

Box 1. Actions to improve antimicrobial stewardship

Consult your jurisdictional biodiversity authority for information on the legislative requirements for the taking, handling, treatment and rehabilitation of wildlife. This avoids unnecessary treatment including potential antimicrobial use.

Establish working relationships with wildlife rehabilitators and veterinarians in your local area. This enables a streamlined rehabilitation process for any wildlife admitted to your clinic and ensures you can access advice if unsure how to proceed.

Complete additional training in wildlife triage and treatment to build on your knowledge and skills in wildlife medicine**.**

- Veterinary professional training in Wildlife Treatment and Care includes an online component and an optional practical workshop: https://taronga.org.au/education/veterinary-professional-training**.**
- Wildlife Medicine for Veterinary Professionals online course (Western Australia focus): https://wawildlife-training.thinkific.com/
- Assessment, Triage and Treatment of Bushfire Affected Wildlife https://taronga.org.au/externalpartners/assessment-triage-and-treatment-of-bushfire-affected-wildlife/index.html

Be aware of and have access to key triage and treatment resources for native wildlife.

- Wildlife Heroes printable one-page posters https://wildlifeheroes.org.au/veterinary-treatment-information/
- FaunaOz books https://faunaozeducation.com.au/collections/all
- Medicine of Australian Mammals textbook https://ebooks.publish.csiro.au/content/medicine-australian-mammals
- Carpenter's Exotic Animal Formulary https://www.elsevierhealth.com.au/carpenters-exotic-animal-formulary-9780323833929.html
- AMR Vet Collective guidelines on gram stain / cytology / microscope use https://www.amrvetcollective.com/home/continuing-education/

Box 1 summarises some key actions clinics can take to improve antimicrobial stewardship in wildlife. Improving knowledge and skills in the assessment and treatment of wildlife is important, in addition to building relationships with local wildlife carers and veterinarians, having access to resources, and maintaining an awareness of local legislative requirements.

5.1 Case studies demonstrating application of antimicrobial stewardship

Case study 1. Approach to antimicrobial stewardship in a kangaroo joey with diarrhoea

Antimicrobial stewardship principle: use antimicrobials only when indicated

Hand-reared joeys are often presented to veterinarians due to diarrhoea. It is important to differentiate between husbandry related (more common) and infectious causes.

A thorough history is required to determine the stage of development, as joeys do not usually produce solid faeces prior to emergence from the pouch (8). Factors in the development of diarrhoea include the type of diet being fed, whether this is appropriate for the species, feeding practices and hygiene. Stress can also contribute to diarrhoea, with causes of stress including inhabiting areas in proximity to domestic animals and noise, and excessive handling.

A thorough physical examination, including faecal examination (smear and cytology), of the joey should be performed, with a focus on hydration status, weight and body condition.

If a husbandry or dietary factor is identified, antimicrobials are not required. Instead, treatment will revolve around the resolution of the issue, focusing on hydration, dietary correction and supportive care.

If husbandry and dietary factors have been eliminated as causes of diarrhoea and severe clinical signs are present (e.g. haemorrhagic diarrhoea), infectious causes (e.g. candidiasis, coccidiosis, bacterial enteritis) need to be considered and investigated. Experienced advice and referral are preferred, as use of antimicrobials alone are unlikely to resolve the disease.

Paediatric medicine can be complex, please utilise the resources referenced and refer readily.

Case study 2: Reptile wound management

Antimicrobial stewardship principles:

- Choose an antimicrobial not classified as highly important for use in human health
- Review effectiveness at regular intervals and treat only as long as needed to achieve clinical response
- Antimicrobial stewardship principle: consider alternatives to antimicrobials for wound treatment

Reptiles have significantly slower wound healing compared to other species, often taking weeks to months depending on the injury. Primary wound closure may take six weeks to be complete. In reptiles, it is particularly important to optimise husbandry, including provision of the optimum temperature zone for the species, to provide the ideal conditions for wound healing.

Silver sulfadiazine or Iodosorb® can be used topically to assist with healing for five to seven days, however once the wound has a healthy granulation bed, this should be stopped, as excessive use can delay healing. Hydrocolloid dressings can be used for large wounds and tail injuries.

In contaminated wounds where antimicrobials are deemed necessary for healing, it is important to ensure that body temperature and hydration have been corrected at the same time as starting treatment (5). In reptiles, body temperature and hydration status will affect the pharmacokinetics and effectiveness of antimicrobials, therefore effective antimicrobial treatment requires the reptile to be at the preferred range of body temperature for the species (5).

Medication courses often need to be longer in reptiles than in mammals (9). Recent antimicrobial use guidelines advise that ceftazidime and enrofloxacin are reserved as 'Tier 2' (high importance) antimicrobials in reptiles, which are only to be used if 'Tier 1' (low importance) drugs are not effective or the patient is not responding (6).

First line antimicrobials that can be used to treat contaminated wounds include amoxicillin and doxycycline (5,6).

6. Guidance on antimicrobial selection and dosing

Australian wildlife are adapted to unique diets and environments. In the small number of studies investigating drug metabolism in Australian wildlife species, pharmacokinetics has been found to differ significantly from domestic animals (7). Nevertheless, most drug doses have been extrapolated from domestic animal doses (1). As a result, drugs administered can be ineffective and/or some medications can have serious adverse effects, particularly in native mammals (7).

Doses in these guidelines have been sourced from *Carpenter's Exotic Animal Formulary* (6th edition, 2023) except where indicated, in combination with the experience and expertise of Australian wildlife and zoo veterinarians. The doses listed below should be used as a guide in combination with clinical judgement. Recommendations may include off-label use. Suspected adverse reactions should always be noted in clinical records and collated for refinement of future prescribing.

Tables of antimicrobials have been annotated as follows to indicate the level of pharmacokinetic and clinical evidence available:

- * unknown dose origin, no peer reviewed studies or only 1 peer reviewed study
- ** <2 peer reviewed studies
- *** 2-4 peer reviewed studies
- **** >4 studies published

The Australian Strategic and Technical Advisory Group on Antimicrobial Resistance (ASTAG) published ratings of antimicrobials of **low importance** (colour coded green), **medium importance** (orange) and **high importance** (red). **Antimicrobials of high importance are essential antibacterials for the treatment of infections in humans where there are few alternatives, and these antimicrobials should be reserved as last line treatments** (10).

6.1 Mammals

Mammalian dose and drug information has been sourced from *Current Therapy in Medicine of Australian Mammals* (2). While there are some published pharmacokinetic studies on antimicrobials in marsupials (common brush-tailed possum, tammar wallaby, koala), there are no studies in monotremes or Australian rodents (3).

Antimicrobials should only be used when absolutely necessary due to the risk of resistance and of adverse effects including dysbiosis, where antimicrobials can affect the normal intestinal bacteria. This can cause inappetence, leading to emaciation and subsequent death (3). Weaning animals that are transitioning from milk or formula to solid foods are more at risk of adverse gastrointestinal effects. Antimicrobial use at any stage of development can also lead to candida overgrowth, which can be fatal if not managed.

For herbivorous species, oral administration of antimicrobials is not likely to be effective as some medications may be metabolised or bind to herbivorous ingesta rather than crossing into the animal's circulation (7). In these animals, parenteral antimicrobials may have better absorption when given by an injectable route (3).

Herbivorous native animals are more susceptible to dysbiosis due to their specialised gut function and complex populations of gastrointestinal flora. Antimicrobials should therefore only be used only when indicated and with caution in these species.

Table 1. Antimicrobials which can be used in native mammals (7) **by ASTAG ratings of low, medium and high importance - prescribers should aim to use antimicrobials from the green category and avoid using those from the red category wherever possible.**

Antimicrobial	Indications	Species	Route	Dose	Comments and reported adverse effects	Evidence rating
Silver sulfadiazine	Wounds	All	Topical	Apply q12-24h		
Amoxicillin	Staphylococcal, streptococcal infections	Sugar gliders Macropods Koala Bats Wombats	PO SC IM IV IM SC PO SC	30 mg/kg PO, SC q12-24h 10 mg/kg q8-12h 25 mg/kg q8h 10 mg/kg q12h 10 mg/kg q12h 11mg/kg 30mg/kg		*
Chloramphenicol	Chlamydia	Macropods Koalas	IM SC	50 mg/kg q412h 60 mg/kg q24h	Injectable drug is not commercially available but can be compounded	*
Doxycycline	Chlamydia	Koalas	SC	5 mg/kg q7d	Dilute 50:50 with water to reduce reaction at injection site Tolerated well by koalas in Queensland, but has been associated with death in koalas in NSW and Victoria	*
Florfenicol	Progressive periodontal disease in macropods	Macropods	IM	25 mg/kg q3d		*

Oxytetracycline long-acting		Macropods	IM	40 mg/kg q48h	Long-acting preparation has questionable efficacy	*
Procaine/benzathine penicillin	Mandibular osteomyelitis (with concurrent clindamycin)	Macropods Brush-tailed possums Wombats	IM SC IM IM	30mg/kg q48h 80,000 IU/kg q12h 40,000 IU/kg 1 mL/10 kg q48h 40,000 IU/kg q12h	Long-acting preparations have questionable efficacy	*
Tulathromycin		Macropods	SC IM	2.5 mg/kg q7d 2.5 mg/kg q7d		*
Amoxicillin with clavulanic acid	Wounds Pneumonia	Gliders Monotremes Wombats Koalas Bats Brushtail possums	PO SC IM	12.5-20 mg/kg q12-24h 12.5-20 mg/kg q12-24h 12.5-20 mg/kg q12-24h	Higher dose in joeys, lower dose in adult koalas **In some species (e.g. juvenile and sub-adult eastern ring-tailed possums), can cause gastrointestinal dysbiosis** **Avoid in eastern ring-tailed possums**	*
Cefalexin		Gliders Echidna	PO PO	30 mg/kg divided q12-24h 30mg/kg q12h	Not often used in practice	*
Cefazolin	Perioperative use Dog attack wounds, open fractures, burns	Koalas	IV	22 mg/kg q8h		*
Clindamycin	Periodontal disease, sinusitis Toxoplasmosis, mandibular osteomyelitis	Gliders Macropods Wombats	PO PO IV PO IM	5.5-10mg/kg q12h 11 mg/kg q12h 20 mg/kg IV q12h 15-25 mg/kg q8-12h 15-25 mg/kg q8-12h	Can also be used in the form of impregnated beads Unpalatable	*

Gentamicin	Used in combination with amoxicillin for severe bacterial pneumonia in pouch young	Gliders Macropods Koalas Wombats	SC IM IM IV SC IM	1.5-2.5 mg/kg q12h 1.5-2.5 mg/kg q12h 4-7 mg/kg q12h with 10mg/kg q8h IM amoxicillin 6-10 mg/kg q12-24h 4.4 mg/kg q24h 4.4 mg/kg q24h	Nephrotoxicity, administer with SC fluids	*
Metronidazole	Anaerobic infection, progressive periodontal disease (in combination with clindamycin)	Gliders Echidna Macropods Koalas Bats	PO PO SC IV PO IV PO	25 mg/kg q12-24h 20 mg/kg q24h 20 mg/kg q24h 20 mg/kg q24h 20 mg/kg q12h 20-25 mg/kg q 12 h 25 mg/kg q 24 h	Risk of CNS toxicity at high doses or with underlying liver disease	*
Trimethoprim-sulfadiazine	Toxoplasmosis Enteric salmonellosis Pneumonia	Macropods Wombats Koalas	PO	15-30 mg/kg q12h		*
Trimethoprim / sulfamethoxazole	As needed for bacterial infection, coccidiosis	Gliders Echidna Koalas Bats	PO PO PO PO SC IM	10-20 mg/kg q12-24h or 50mg/kg q24h 15-30 mg/kg q12-24h 15 mg/kg q12h 30 mg/kg q12h 30 mg/kg q12h 30 mg/kg q12h	Avoid IM administration due to risk of haematoma formation	*

Amikacin	Severe gram-negative infections, pneumonia Severe burns, cellulitis, septicaemia	Gliders Bats	SC IM SC IM IV	3 mg/kg q12h 3 mg/kg q12h 5-10 mg/kg q8-12h 5-10 mg/kg q8-12h 5-10 mg/kg q8-12h		*
Ceftiofur	Salmonellosis Campylobacteriosis (1)	Macropods	IM IV	1-2 mg/kg q24h 1-2 mg/kg q24h		*
Ceftazidime	Severe bacterial pneumonia in joeys Dog attack injuries, open fractures Burns	Macropods Koalas	IV IV	20mg/kg q8h 20mg/kg q8h		*
Enrofloxacin	Soft tissue injury, dog attack injuries Pneumonia	Gliders Echidna Macropods Bats Koalas Wombats Possums	PO SC IM PO SC IV SC PO PO	2.5-5mg/kg q12-24h 2.5-5mg/kg q12-24h 2.5-5mg/kg q12-24h 5 mg/kg q24h 5 mg/kg q24h 8-10mg/kg q12-24h 8-10mg/kg q12-24h 5-20 mg/kg q24h 10 mg/kg q24h	Tissue necrosis when given by injection. Dilute for injection to reduce pain In koalas, lower SC and oral bioavailability compared to dogs, not well understood in koalas SC dosing ineffective in eastern ring-tailed possums	*
Marbofloxacin		Gliders	PO SC IM	2-5 mg/kg q24h 2-5 mg/kg q24h 2-5 mg/kg q24h		*

NB The exclusion of a species does not necessarily mean that it isn't applicable, just that there are no published data

6.2 Reptiles

In reptiles, bacterial infections are often present secondary to a viral, parasitic or fungal infection, malnutrition, or poor husbandry (6). Therefore, the underlying cause needs to be diagnosed and treated in addition to the appropriate use of antimicrobials (6). Antimicrobial use in lethargic or anorexic reptiles without a specific diagnosis may cause adverse effects, including renal injury (5). In addition, there are no robust published studies that show the untargeted use of antimicrobials improves the outcomes for any reptiles affected by disease (5).

In reptiles, drug metabolism does vary with body temperature, the site of administration, and the current health status of the animal (5,11). The gut transit time of reptiles is variable with the environmental temperature having a significant effect on pharmacokinetics. Keeping reptiles at their preferred body temperature will make drug absorption, distribution, metabolism and elimination as reliable as possible (9).

The injectable route is commonly used in reptiles, often due to difficulties with oral administration. Many reptile species do not eat every day, meaning that effective oral antimicrobial administration through food is difficult.

The reptile kidneys have a dual blood supply (renal-portal system) which means that theoretically, medications which are removed by first-pass renal blood flow, may have lower serum concentrations, and increased potential for renal toxicity for nephrotoxic drugs, when injected in the caudal half of the body (2). The renal portal system does not impact blood flow to the glomerulus, therefore drugs excreted by glomerular filtration, such as gentamicin, are unaffected by renal first-pass metabolism. Current knowledge indicates that the clinical implications of the renal portal system are unclear, as plasma drug concentrations are unaffected by IM injection site in pythons, iguanas and chelonians (12).

Recent publications propose the use of a two-tier system as summarised and included in the tables below. In accordance with these publications, amoxicillin and doxycycline are possible first-line antimicrobial choices, and clindamycin, amoxicillin-clavulanic acid,

sulphonamides and metronidazole are practical second-line choices (due to their orange ASTAG rating). Ceftazidime and enrofloxacin are second-line antimicrobials which should only be used if a) culture and antimicrobial susceptibility testing indicates first-line options are ineffective (5) and b) the case has been discussed with an experienced wildlife veterinarian or AMS champion.

Table 2. Antimicrobials which can be used in native reptiles (7) **by ASTAG ratings of low, medium and high importance - prescribers should aim to use antimicrobials from the green category and avoid using those from the red category wherever possible.**

Antimicrobial	Indications	Route	Dose	Comments and reported adverse effects	Evidence rating	ARAV Antimicrobial Stewardship Policy 2023	Hedley et al 2021
Silver sulfadiazine	Wounds, burns	Topical	Apply q24-72h		*		
Amoxicillin	Gram-positive infections including *Staphylococcus* species. Contaminated wounds	IM PO	10 mg/kg q24h 22mg/kg q12-24h		*	Tier 1	First line
Azithromycin	*Mycoplasma* *Pasteurella* *Bordetella* *Campylobacter* *Clostridia*	PO	10 mg/kg q3-7days	Potentially hepatotoxic, can cause reversible anaemia in some reptiles	**	Tier 1	Second line
Clarithromycin	*Susceptible upper respiratory tract infections and osteomyelitis* *Gram-positives, anaerobes* *Gram-negative bacteria aerobes are resistant*	PO	15 mg/kg q24-72h	**Not commonly used in practice**	*		
Chloramphenicol	*Chlamydia, Mycoplasma,* Gram-positive and Gram-negative bacteria	Ophthalmic			*		

Doxycycline	Gram-positive infections *Chlamydia* *Mycoplasma*	PO IM	5-10mg/kg q24h 50 mg/kg once then 25 mg/kg q72h	Anorexia, vomiting, diarrhoea Local tissue reactions to injection Altered gut flora, yeast overgrowth		Tier 1	First line
Oxytetracycline	Gram-positive infections	IM Poorly absorbed when given orally	10-80 mg/kg q4h	**Not commonly used in practice** May cause inflammation at injection site Anorexia, vomiting, diarrhoea Local tissue reactions to injection Altered gut flora, yeast overgrowth	**	Tier 1	First line
Procaine/Benzathine penicillin		IM	6.25-12.5 mg/kg q48-96h	**Not commonly used in practice**			
Amoxicillin with clavulanic acid	Bite wounds	IM PO	15 mg/kg q24h 30 mg/kg q12 -24h		*	Tier 1	First line
Cefalexin	Gram-positive cocci, Gram-negative infections	PO	20-40 mg/kg q12h	**Not used in clinical practice**		Tier 1	First line
Cefazolin	Perioperative use	IM	22 mg/kg q24h	**Not used in clinical practice**	*	Tier 1	First line
Clindamycin	Mycoplasma, *Pasteurella, Bordetella, Campylobacter, Clostridia* Susceptible upper respiratory tract infections and osteomyelitis	PO IM IV	5 mg/kg q12h 5 mg/kg q12h 5 mg/kg q12h	Do not use in turtles	*	Tier 1	First line

	Gram-positives, anaerobes Gram-negative bacteria aerobes are resistant						
Gentamicin		IM	2.5 mg/kg q72h	**Not often used due to narrow safety margin** Nephrotoxic	***	Tier 1	First line
Metronidazole	Anaerobic infections, motile protozoa	PO	20 mg/kg q24-48h		**	Tier 1	First line
Trimethoprim sulfamethoxazole	Most Gram-positive and negative infections Coccidia Maxillary osteomyelitis	IM PO	30 mg/kg q24h 30 mg/kg q24h then q48h		*	Tier 1	First line
Amikacin	Gram-positive and negative infections	IM	5mg/kg IM then 2.5mg/kg q72h	**Not used in Australia due to availability and cost** Potentially nephrotoxic Poor penetration into CNS and eye	**		
Cefovecin		SC	10 mg/kg q12h		*		
Ceftiofur	*Pasteurella, E.coli, Streptococcus, Staphylococcus, Salmonella* species	SC IM	5 mg/kg q24h 5 mg/kg q24h	**Not often used in practice**	*	Tier 2	Second line
Ceftazidime	Gram positive infections	IM SC	20-40 mg/kg IM q72h 20-40 mg/kg IM q72h	Penetrates CSF	**	Tier 2	Second line

				Reduce dose in renal impairment Consider dilution with lignocaine (3 mg/kg) to reduce pain on injection			
Enrofloxacin	*Mycoplasma,* some Gram-positive and most Gram-negative infections	PO IM	5-10 mg/kg q24 -48h 5-10 mg/kg q24 -48h	IM injection is painful and can cause tissue necrosis and sterile abscesses. Dilute with saline for injection	***	Tier 2	Second line
Marbofloxacin		IM IV PO	2 mg/kg q24h 2 mg/kg q24h 10 mg/kg q48h		***		

6.3 Birds

Administration of antimicrobials in drinking water is not generally recommended, as this is unlikely to achieve adequate therapeutic concentrations (14). This method can also cause birds to stop drinking the treated water and risk dehydration.

Oral administration in the form of liquid or tablets is the preferred route of antimicrobials in birds, however initial doses of antimicrobials are often administered parenterally so that therapeutic levels can be rapidly achieved. In species where oral administration is difficult or can cause regurgitation, alternate administration routes should be considered.

If an intramuscular route needs to be used, the injection site should be chosen in an area less likely to cause functional adverse effects, for example, in birds that walk rather than fly, intramuscular injections are given into the pectoral muscles (14). In larger birds such as swans and pelicans, the quadriceps muscle can be used to administer antimicrobials.

Table 3. Antimicrobials which can be used in native birds by ASTAG ratings of low, medium and high importance - prescribers should aim to use antimicrobials from the green category and avoid using those from the red category wherever possible.

Antibiotic	Indications	Route	Dose	Comments and adverse effects	Evidence rating
Amoxicillin	Gram-positive infections	IM PO	50-150 mg/kg q12-24h 15-175 mg/kg q8-24h		*
Azithromycin	Aerobic and anaerobic gram-positive bacteria *Mycoplasma* *Chlamydia*	PO	10-80 mg/kg q24-48h	Should not be used off label except in exceptional circumstances	
Chloramphenicol	Injectable formulation not commercially available but can be compounded	IM SC	30-200mg/kg q8-12h 30-200mg/kg q8-12h		*
Clarithromycin	Aerobic and anaerobic Gram-positive bacteria *Mycobacterium* *Chlamydia* *Mycoplasma*	PO	10-85 mg/kg q24h	Should not be used off label except in exceptional circumstances	*
Doxycycline	*Chlamydia* *Mycoplasma*	PO IM	2-40 mg/kg PO q12-24h 25-100 mg/kg q5-7d	Can cause elevations in AST and hepatocellular damage in lorikeets	*
Neomycin	Superficial wounds	Ophthalmic	Topical q6-12 h	Can be absorbed systemically with potential for ototoxicity and nephrotoxicity	*
Oxytetracycline		IM SC	5-100 mg/kg q12-72h 5-100 mg/kg q12-72h	**Not often used in wild birds** IM injection can cause muscle inflammation or necrosis	*
Procaine/Benzathine penicillin		IM	200mg/kg q24h	**Risk of toxicity in birds <1kg so not recommended**	*
Silver sulfadiazine	Wounds Burns	Topical	Apply q12-24h		*
Amoxicillin with clavulanic acid		IM PO	7-105 mg/kg q12-24h 10-125 mg/kg q6-12h	May cause regurgitation in raptors if used PO	*

Cefalexin		PO	15-100 mg/kg q6-12h	**Not often used**	*
Cefazolin		IM IV	25-50 mg/kg q12h 25-50 mg/kg q12h	**Not often used in practice**	*
Clindamycin	Aerobic pathogens, bone infections	PO	5.5-150 mg/kg q8-24h		*
Gentamicin		IM PO	1-10 mg/kg q4-12h 40 mg/kg q8-24h	Potentially nephrotoxic	* *
Metronidazole	Anaerobes CNS infections	IM PO	10 mg/kg q24h 10-50 mg/kg q12-24h		
Piperacillin/tazobactam	*Pseudomonas* *Proteus*	IM IV	25-200 mg/kg q4-8h 25-200 mg/kg q4-8h	**Not registered for use in animals**	*
Trimethoprim sulfamethoxazole		IM PO	8-75 mg/kg q8-12h 10-144 mg/kg q8-12h		*
Trimethoprim sulfadiazine		IM SC PO	8-20 mg/kg q8-12h 8-20 mg/kg q8-12h 30-60 mg/kg q8-12h		
Amikacin		IV IM SC	15-20 mg/kg q8-24h 15-20 mg/kg q8-24h 15-20 mg/kg q8-24h	Potentially nephrotoxic and ototoxic Poorly absorbed from gastrointestinal tract	* *
Cefovecin				Not recommended to use in birds due to short-half life	
Ceftazidime	Gram-negative infections	IM	50-100 mg/kg q4-8h	**Not registered for use in animals**	
Ceftiofur	*Pasteurella*	IM	10-50 mg/kg q12h		*
Enrofloxacin	Gram-negative and positive bacteria *Chlamydia*, *Mycoplasma*	PO SC	1.5-5 mg/kg q12-24h 5-15 mg/kg q12-24h	Can cause vomiting IM injection is painful and can cause tissue necrosis and sterile abscesses - dilute with sterile saline and give SC Can cause blindness at high doses	*
Marbofloxacin		IM PO	5 mg/kg q24h 2.5-15 mg/kg q24h	**Not used in practice**	**

References

1. Wildlife Health Australia. (n.d.). *Antimicrobial resistance and Australian wildlife* [PDF]. Wildlife Health Australia. Retrieved March 7, 2025, from https://wildlifehealthaustralia.com.au/Portals/0/ResourceCentre/FactSheets/Multiple/Antimicrobial_resistance_and_Australian_wildlife.pdf

2. Vogelnest, L., & Portas, T. (2019). *Current therapy in medicine of Australian mammals.* CSIRO Publishing.

3. Vogelnest, L., & Woods, R. (2008). *Medicine of Australian mammals.* CSIRO Publishing.

4. Mullineaux, E., & Keeble, E. (2017). *BSAVA manual of wildlife casualties* (2nd ed.). Wiley.

5. Hedley, J., Whitehead, M. L., Munns, C., Pellett, S., Abou-Zahr, T., Calvo Carrasco, D., & Wissink-Argilaga, N. (2021). Antibiotic stewardship for reptiles. *Journal of Small Animal Practice, 62*(9), 789–799. https://doi.org/10.1111/jsap.13402

6. Divers, S. J., & Burgess, B. A. (2023). ARAV antimicrobial stewardship policy. *Journal of Herpetological Medicine and Surgery, 33*(1), 61–64. https://doi.org/10.5818/JHMS.33.1.61

7. Vogelnest, L., & Portas, T. (Eds.). (2025). *Current therapy in medicine of Australian mammals* (Revised ed.). CSIRO Publishing. https://doi.org/10.1071/9781486317943

8. Fowler, A. (2018). *Joey diarrhoea: Diagnosis and management* [PDF]. Australian Wildlife Rehabilitation Conference. Retrieved March 7, 2025, from https://www.awrc.org.au/uploads/5/8/6/6/5866843/04_fowler_-_2018_joey_diarrhoea_final.pdf

9. Doneley, B., Monks, D., Johnson, R., & Carmel, B. (Eds.). (2018). *Reptile medicine and surgery in clinical practice.* John Wiley & Sons. https://doi.org/10.1002/9781118977705

10. Australian Government, Department of Health and Aged Care. (2022, October). *Importance ratings and summary of antibacterial uses in human and animal health in Australia* [PDF]. https://www.amr.gov.au/sites/default/files/2022-10/importance-ratings-and-summary-of-antibacterial-uses-in-human-and-animal-health-in-australia.pdf

11. Girling, S. J., & Raiti, P. (Eds.). (2019). *BSAVA manual of reptiles* (3rd ed.). British Small Animal Veterinary Association (BSAVA).

12. Holz, P. H. (2020). Anatomy and physiology of the reptile renal system. *Veterinary Clinics of North America: Exotic Animal Practice, 23*(1), 103–114. https://doi.org/10.1016/j.cvex.2019.09.004

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13. Carpenter, J. W., & Harms, C. (Eds.). (2023). *Carpenter's exotic animal formulary* (6th ed.). Saunders. https://doi.org/10.1016/C2019-0-00378-0

14. Chitty, J., & Monks, D. (Eds.). (2018). *BSAVA manual of avian practice: A foundation manual.* British Small Animal Veterinary Association (BSAVA).