Common causes for veterinary visits among Australian wildlife

Reasons for admission and care in the acute phase for different types of animals

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Independent project in Veterinary Nursing • 15 credits
Swedish University of Agricultural Sciences, SLU
Faculty of Veterinary Medicine and Animal Science
Veterinary Nursing programme
Uppsala, Sweden 2023

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Vanliga orsaker till veterinärbesök bland vilda djur i Australien

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Credits:	15 credits
Level:	First cycle, G2E
Course title:	Independent project in Veterinary Nursing
Course code:	EX0994
Programme/education:	Veterinary Nursing programme
Course coordinating dept:	Department of Clinical Sciences
Place of publication:	Uppsala, Sweden
Year of publication:	2023
Cover picture:	Photo taken by Agnes Gårdebäck
Copyright:	All featured images are used with permission from the copyright owner.
Keywords:	Amphibians, Birds, Mammals, Native Animals, Reptiles, Veterinary Nursing, Veterinary Nurse, Veterinary Technician, Veterinary Hospital.

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Abstract

Australia has a unique wildlife, the increasing rate of species going extinct or being threatened to go extinct is thus a worry to many. Veterinary hospitals can play one part in increasing survival of wildlife, often suffering from ailments caused by humans. To be able to offer efficient and evidence-based care and treatment to wildlife, more research is needed.

The purpose of this study is to better understand what type of wildlife patients that are being admitted into veterinary care in Australia, their reasons for admission, care in the acute phase and outcome after care. Using data on wildlife admissions from two wildlife hospitals in southeast Australia this study confirms what previous research has shown.

The study shows that the most common patients are birds, the most common reason for admission is traumatic injuries and the trauma is most often caused by car strikes. The mortality rate is about 50% for the hospitals reviewed, there is a poor prognosis for patients admitted for trauma or disease but a better prognosis for orphaned animals.

Keywords: Amphibians, Birds, Mammals, Native Animals, Reptiles, Veterinary Nursing, Veterinary Nurse, Veterinary Technician, Veterinary Hospital.

Sammanfattning

Australien har ett unikt djurliv och det ökade antalet av utrotade och hotade arter i Australien är därför en oro för många. Veterinärsjukhus och klinker är en av aktörerna som kan bidra till överlevnaden hos skadade vilda djur, många gånger har djurens skador uppstått på grund av människan. För att kunna erbjuda evidensbaserad omvårdnad och behandling behövs mer forskning.

Målet med denna studie är att beskriva vilka vilda djur som får veterinärvård i Australien, anledningar till behov av vård, omhändertagande i den akuta fasen samt vårdens resultat. Studien undersöker data från två veterinärsjukhus specialiserade på vilda djur lokaliserade i sydöstra Australien och resultaten stämmer överens med tidigare forskning.

Studien visar att de vanligaste patienterna som kommer in för veterinärvård är fåglar, vård uppsöks vanligen på grund av traumatiska skador och den vanligaste orsaken till trauma är att djuret blivit påkört. Mortaliteten för patienterna på båda veterinärsjukhusen var nära 50%, sämst prognos har djur som kommer in på grund av trauma eller sjukdom och bäst prognos har unga föräldralösa djur.

Nyckelord: Amfibier, Djuromvårdnad, Djursjukskötare, Däggdjur, Fåglar, Inhemska Arter, Reptiler, Veterinärsjukhus.

List of tables

List of figures

Abbreviations

DOA	Dead on arrival
EDTA	Ethylenediaminetetraacetic acid
HBC	Hit by car
IC	Intracoelomic
IM	Intramuscular
IO	Intraosseous
IV	Intravenous
LPS	Lorikeet Paralysis Syndrome
PBFD	Psittacine beak and feather disease
SLU	Swedish University of Agricultural Sciences
SC	Subcutaneous

1 Introduction

Veterinary care for wildlife involves many challenges not normally encountered at a hospital working with domestic animals. Not only does the species differ, wildlife's little experience with humans and high requirements on rehabilitation will affect how wildlife are cared for at a veterinary hospital.

To admit wildlife, hospitals need to be able to predict what patients to expect and have the knowledge to care for these patients. In a national survey, Orr and Tribe (2018) found the lack of knowledge and skill, together with lack of time, to be the main challenges for veterinary hospitals to treat wildlife patients. Another survey by Haering et al. (2021) found knowledge and skill to be the second biggest challenge, after financial funding. Many veterinary nurses considered their formal training insufficient in preparation for working with wildlife (Haering et al. 2021).

The purpose of this study is to give insight into care for wildlife in the acute phase in Australia, including common causes for veterinary treatment, common species, seasonal variations and outcome after care. It is written with the hope of laying a foundation for future research and development of educational materials for veterinary nurses regarding treatment of wildlife. The report is written as a bachelor thesis focusing on veterinary nursing at the Swedish University of Agricultural Sciences.

As of now there are few studies that describe the overall distribution of species and reasons for admissions among wildlife at veterinary hospitals in Australia. One study by Tayler-Brown et al. (2019) looked at admission and outcome of wildlife patients at Australia Zoo Wildlife hospital. Two other studies by Kwok et al. (2021) and Tribe and Brown (2008) looked at animals taken into care by volunteer wildlife rehabilitation organisations. Animals taken into care by wildlife carers are often, but not always, admitted to a veterinary hospital for examination. Admission data from veterinary hospitals is therefore essential in understanding which the most common wildlife patients are.

There are several studies that describe the reasons for admission at veterinary hospitals for individual species of wildlife in Australia. Such studies can be found describing koalas (Griffith et al. 2013; Burton & Tribe 2016; Gonzalez-Astudillo et al. 2017; Charalambous & Narayan 2020), monotremes (Scheelings 2016), reptiles (Scheelings 2015), black cockatoos (Le Souëf et al. 2015), coastal raptors (Thomson et al. 2020) and flying foxes (Scheelings & Frith 2015). However, there are many species that have not been studied and thus there is not enough knowledge to provide a clear picture of the whole situation.

Knowledge about how to care for wildlife patients in the acute phase is an important skill for veterinary nurses. Haering et al. (2021) argue that the role of the nurse might be more important for wildlife than for domestic animals and that this role is not fully appreciated today. Improved veterinary nursing skills, such as correct handling techniques, will contribute both to a safer workplace and better welfare for the Australian wildlife.

2 Aim & Research Questions

This study aims to describe the common causes for veterinary visits among Australian wildlife, and how to care for them in the acute phase. The study is focusing on the acute phase of an injury or illness since it is often in this phase that the animals are admitted to a veterinary hospital.

Research questions:

- What types of wildlife are admitted to veterinary hospitals in Australia?
- Is there a seasonal variation in admissions of different types of animals?
- What are the common reasons for admission of wildlife?
- Does the reason for admission differ between different types of animals?
- What is the outcome after veterinary treatment?

3 Background

Surrounded by ocean, Australia has been isolated from other continents for 38 million years (Godthelp et al. 1992). This has led to a unique evolution of species, many that are not found elsewhere in the world (Early 2008). Unfortunately, many species have already gone extinct, and the rate of extinction is increasing for birds and mammals in Australia (Geyle et al. 2018).

It can be argued that humans should let nature take its course and avoid interfering. However, many wildlife injuries are caused by humans, both directly and indirectly from human-built machinery and structures (Tribe & Brown 2008; Scheelings & Frith 2015; Scheelings 2015; Taylor-Brown et al. 2019; Thomson et al. 2020). Treatment of wildlife can attempt to counter the negative actions of man (Mullineaux 2014).

Today there are many organisations and individuals working to protect and help Australian wildlife. A large part of this work is done by wildlife carers working non-profit towards better animal welfare (Kwok et al. 2021; Tribe & Brown 2008). Another important resource in helping wildlife is veterinary personnel that are able to help sick and injured animals.

The animals that arrive at hospitals are usually brought in by wildlife carers or caring citizens (Haering et al. 2021). A good relationship with local volunteer wildlife rehabilitation organisations is therefore important, these organisations often also help with prolonged care and rehabilitation after the acute phase (Haering et al. 2021).

3.1 Statistics of wildlife patients

Several studies describe that increasing human populations and urbanisation have a large impact on wildlife. In southern Queensland 80% of admissions to a wildlife veterinary hospital was caused by anthropogenic factors such as car strikes, entanglement or attacks from domestic animals (Taylor-Brown et al. 2019). Further, these were found to have higher mortality rates than many other causes. A majority of wildlife patients' injuries have been found to be indirectly or directly caused by humans (Tribe & Brown 2008), same as for 59 % of all raptors (Thomson et al. 2020) and 63.7% of all flying foxes (Scheelings & Frith 2015). Another study suggests that there is a link between reptile trauma patients and urban spreading with forced cohabitation of humans and wildlife (Scheelings 2015).

Trauma is often described as the most common reason for admission of wildlife into veterinary care. A national survey found that 82% of admitted wildlife patients had traumatic injuries (Orr & Tribe 2018). Other studies found trauma to be the reason for admission for 90,1% of echidnas (Scheelings 2016), 73,7% of platypuses (Scheelings 2016), 73% of reptiles (Scheelings 2015), 76,7% of black cockatoos (Le Souëf et al. 2015) and 41% or 38% of koalas (Griffith et al. 2013; Burton & Tribe 2016).

The origin of trauma varies between species. Studies show that trauma to koalas, echidnas as well as reptiles is commonly caused by car strikes or domestic animal attacks (Griffith et al. 2013; Burton & Tribe 2016; Schlagloth et al. 2022; Scheelings 2016; Scheelings 2015; Koenig et al. 2002). In platypuses it is commonly caused by entanglement in fishing line (Scheelings 2016) and in flying foxes by entanglement in fruit-netting or barbed wire (Scheelings & Frith 2015; Mo et al. 2020). Car strikes or gun shots seems to be common in cockatoos (Le Souëf et al. 2015) and fishing line entanglement, bird attacks or car strikes seems to be common in coastal raptors (Thomson et al. 2020).

Koalas are often admitted because of trauma or disease, according to some trauma is more common (Griffith et al. 2013; Gonzalez-Astudillo et al. 2017; Schlagloth et al. 2022) and according to others disease is more common (Burton & Tribe 2016; Charalambous & Narayan 2020). All of these studies mention that chlamydia can be a major contributor to disease in koalas and Gonzalez-Astudillo et al. (2017) points out that several koalas admitted due to trauma also showed signs of chlamydia. In mainland Australia chlamydia infection rates varies, depending on region, between 21% to 88% of all koalas (Quigley & Timms 2020).

Overall, considering all types of patients, animals hit by cars and orphaned animals are common in care (Tribe & Brown 2008; Orr & Tribe 2018; Taylor-Brown et al. 2019; Kwok et al. 2021). In the study by Taylor-Brown et al. (2019) the most common reasons for admission of wildlife were car strikes (34.7%), orphaned (24.6%), overt signs of disease (9.7%), attacked by dogs (9.2%), entanglement (7.2%) and attacked by cats (5.3%). Mortality was high for animals affected by car strikes and attacks by dogs or cats, mortality was lowest for orphans.

Birds and mammals are common among wildlife patients. According to a national survey by Orr and Tribe (2018) birds were most common, followed by mammals.

A study by Tribe and Brown (2008) showed that birds were most common in New South Wales and Queensland while mammals were most common in Victoria. In accordance with this, studies in New South Wales found wildlife admitted to veterinary care to consist of 56.2% birds, 29.4% mammals and 13% reptiles (Haering et al. 2021) and that wildlife carers encountered 53.4% birds, 34.1% mammals and 12.5% reptiles (Kwok et al. 2021). In southern Queensland Taylor-Brown et al. (2019) however found mammals more commonly admitted into veterinary care, patients were distributed as 51.1% mammals, 35.2% birds, 14.4% reptiles and 0.3% amphibians.

There are seasonal variations in the number of admitted patients. Reptiles are usually admitted on days with dry and warm weather, consistent with when reptiles are usually active (Shine & Koenig 2001; Koenig et al. 2002). Admission of echidnas, platypuses, grey-headed flying foxes and reptiles seems to be more common during summer (Scheelings 2016; Scheelings & Frith 2015; Shine & Koenig 2001; Taylor-Brown et al. 2019). Koalas, birds and mammals in general seems to be more common during spring (Griffith et al. 2013; Burton & Tribe 2016; Thomson et al. 2020; Taylor-Brown et al. 2019). The total number of animals, considering all species, needing care also seems to be highest in spring (Taylor-Brown et al. 2019; Kwok et al. 2021). According to Kwok et al. (2021) there were six times more orphaned animals taken into care during spring than during winter. Vehicle accidents however were described as more common during autumn and winter.

The outcome of animals taken into care was investigated in several studies. Taylor-Brown et al. (2019) found that the mortality was 57.4% of all admitted patients, it was highest for amphibians and lowest for mammals. Mammals were on the contrary reported to have the highest mortality in the study by Kwok et al. (2021). Other studies on specific types of animals showed mortality rates of 57% for black cockatoos, 44% for raptors, 57.9% for platypuses, 50.5% for echidnas, 53.9% for grey-headed flying foxes, 65.5% for koalas and 47.5% for reptiles (Le Souëf et al. 2015; Thomson et al. 2020; Scheelings 2016; Scheelings & Frith 2015; Burton & Tribe 2016; Scheelings 2015).

While most animals that die at veterinary hospitals are euthanized, there are indications that unassisted deaths are more common in volunteer wildlife care organisations. Studies in veterinary hospitals show that 10% of all black cockatoos, 9.2% of all grey-headed flying foxes and 7.4% of all reptiles died without euthanasia (Le Souëf et al. 2015; Scheelings & Frith 2015; Scheelings 2015). This is supported by Cope et al. (2022) that found birds to have a mean probability of 10% of unassisted death in Oceania. However, two studies using data from wildlife care organisations shows that more than half of the animals which died in care died unassisted (Mo et al. 2020; Tribe & Brown 2008).

3.2 Laws and regulations

Wildlife welfare is regulated on a national level through the Environment Protection and Biodiversity Conservation act and on a reginal level in each state and territory (Australian Government 2023). An understanding of local laws and regulations is therefore important.

All states and territories have, or are in the process of developing, a code of practice or general guidelines for the rehabilitation of protected wildlife (Englefield et al. 2019). Most native animals are considered protected wildlife but there are a few exceptions. Dingoes, eastern grey kangaroos, common brushtail possums, Bennett's wallabies, and Tasmanian pademelons are not always considered protected wildlife (Englefield et al. 2019). Euthanasia might be recommended for these species in some areas, same as for introduced species.

Although veterinarians can be obliged to treat wildlife in need of care, that does not necessary allow keeping wildlife during the rehabilitation period or to release wildlife back into the wild (Englefield et al. 2019; Haering et al. 2021). A licence or permit is required for rehabilitation of wildlife in all states and territories except Western Australia (Englefield et al. 2019). Licences and permits can be granted either to individuals, organisations or a combination of both depending on the local laws and regulations (Tribe & Brown 2008). All wildlife carers are required to keep records of patients, although the level of detail required varies (Englefield et al. 2019).

All states and territories intend for wildlife to be returned to the wild (Englefield et al. 2019). In order to release an animal a permit or notification to the relevant government department is needed in some states and territories (Englefield et al. 2019; Haering et al. 2021). The maximum time until release of a fully rehabilitated animal is also stipulated in some cases (Englefield et al. 2019).

The assessment of whether an animal is ready for release is important and should preferably be done by a veterinarian trained in wildlife medicine according to Englefield et al. (2019). The authors describe that several states, but not all, require an assessment prior to release although the person allowed to perform it varies between states. It can be either a wildlife veterinarian, veterinarian or experienced wildlife rehabilitator depending on the local laws and regulations. Animals that cannot be released are often euthanized, in Victoria this is mandatory but in other states and territories animals can sometimes be granted permits to be kept in care (Englefield et al. 2019).

Englefield et al. (2019) and Mullineaux (2014) argues that post-release monitoring is important in order to evaluate the effectiveness of wildlife care and rehabilitation. For this to be possible the individual animal needs to be identifiable. However, while marking of a wild animal is encouraged in some states it is considered an offense in others (Englefield et al. 2019). Local laws and regulations always need to be considered since different practices are used.

3.3 Treating wildlife patients

There are several practical and ethical aspects that needs to be considered when treating wildlife patients. According to Cooper and Cooper (2006) it is important to consider the welfare of the patient during the whole rehabilitation process. The authors encourage that a cost and benefit analysis should be made for individual cases. In order to protect the welfare of the patient, the decision to euthanise should be made early in case of a poor prognosis (Tribe & Brown 2008).

While domestic animals often have access to lifelong care, wildlife needs to be able to fend for itself upon release (Tribe & Brown 2008; Mullineaux 2014). What abilities an animal need to be self-sufficient and what injuries that are considered a disability varies between different species (Mullineaux 2014). Hunting animals might for example have high requirements on movement and eyesight, climbing animals might need sharp claws or dexterous tails and jumping animals need strong and functional hindlimbs.

Several things should be considered apart from the prognosis of the injury. Resources, such as facilities and personnel to provide both acute veterinary care and rehabilitation, need to be available (Mullineaux 2014). A suitable release site should be identified, safe to both the released individual and to other resident animals in the habitat (Tribe & Brown 2008). The risk of introducing new diseases into the wild fauna should be considered, especially since stressed and injured animals have an increased susceptibility to pathogens (Tribe & Brown 2008). There is also a risk that diseases are transmitted the other way around, from the wildlife patient to domestic animals in care at the same hospital (Mullineaux 2014).

The risk of zoonotic infections should always be considered when working with wildlife. Personnel caring for bats are at risk of being exposed to Australian bat lyssavirus and should be adequately vaccinated (O’Connor et al. 2022). Kangaroos are listed as a high-risk animal for spreading Q fever and vaccination against this disease is thus also recommended (Mathews et al. 2021). Other zoonotic infections in wildlife includes salmonellosis, psittacosis, toxoplasmosis, tuberculosis and ringworm (Tribe & Brown 2008).

Minimizing stress is of utter importance for patient welfare when treating wild animals (Tribe & Brown 2008). The stress during capture and handling has been showed to affect behaviours of possums for several days afterwards and contribute to a high mortality rate in kangaroos after release (Dennis and Shah 2012; Cowan et al. 2020). The stress associated with handling can be directly harmful, especially to critically ill individuals (Lennox 2007). Anaesthesia should therefore be used for large or aggressive animals and during stressful or painful procedures (Riley & Barron 2016; Lennox 2007).

Analgesia is important but the presence or severity of pain in wildlife are often underestimated (Machin 1999; Hawkins 2006). Some veterinary hospitals never administer analgesia to wildlife patients (Orr & Tribe 2018). The inability to measure pain does not mean that there is no pain, situations deemed painful in other animals should be assumed to be painful also in wildlife (Stoskopf 1994; Machin 1999; Hawkins 2006; Lierz & Korbel 2012; Riley & Barron 2016). Changes in behaviour should be evaluated during pain assessment and understanding normal behaviours of different species is thus important (Machin 1999; Hawkins 2006; Riley & Barron 2016).

Prey species hide their illness as long as possible to not seem like an easy target for others (Machin 1999; Hawkins 2006). This means that a chronic illness usually presents in an acute form when the animal is no longer able to hide it (Lennox 2007). This knowledge is important to keep in mind when dealing with prey species.

In the following sections, methods of care for amphibians, birds, mammals and reptiles are described with a focus on the role of the veterinary nurse in the acute phase.

3.3.1 Amphibians

Handling

Amphibians are ectotherm animals with diverse species that live in both aquatic, semiaquatic and terrestrial environments (Clayton & Gore 2007).

The amphibian skin is thin and easily damaged (Gentz 2007). Although most amphibians have well developed lungs, part of their respiratory function is provided by cutaneous gas exchange (Gentz 2007). The balance of fluid and electrolytes can also be controlled through the skin for many species of amphibians (Clayton &

Gore 2007). Keeping amphibians moist is important to allow for these regulations (Clayton & Gore 2007).

The permeable skin of amphibians makes them vulnerable to many chemical compounds. Tap water should be avoided unless filtered with active coal since dissolved substances, such as chlorine or lead, will be absorbed through the skin (Clayton & Gore 2007). Many agents used for disinfection such as soap, isopropyl alcohol, or iodine solutions should also be avoided (Gentz 2007). When disinfection is needed a 0.75% chlorhexidine solution can be used (Gentz 2007).

It is important to wear gloves when handling amphibians to protect their sensitive skin from irritants, the gloves should be powder free and the outside should be moistened (Gentz 2007; Clayton & Gore 2007). Gloves also helps in protecting staff from infective agents and possible toxins produced by many amphibians (Gentz 2007; Clayton & Gore 2007).

Administration of medications

The ability to absorb chemical compounds through the skin can be used for topical administration of many drugs. It is however important to monitor the skin for potential irritation and to consider the permeability of the skin for different species, waxy skin may affect the delivered dose (Clayton &Gore 2007).

Oral and topical administration of drugs is often preferable in amphibians (Hadfield & Whitaker 2005). Other common routes of administration are intramuscular (IM), subcutaneous (SC) or lymph sac injections. According to Clayton and Gore (2007) most SC injections administered dorsally or laterally on the body can be considered injections into the lymphatic system. After about five minutes drugs administered into the lymphatic system will enter the circulation, reaching maximum levels within one hour (Crawshaw 1998). Intravenous (IV) injections are difficult in amphibians but can be administered in the ventral abdominal vein in larger species, intracoelomic (IC) injections should be considered for larger volumes of fluid (Walker & Whitaker 2000).

Amphibians have a renal-portal system and IM injections is thus preferred in on one of the front legs according to Walker and Whitaker (2000). The authors point out that the effect of the renal-portal system on drug kinetics is however debated and for smaller species injection into the hindquarters can sometimes be preferred.

When euthanizing amphibians, Gentz (2007) recommends either prolonged immersion in a tricaine methanesulfonate solution or administration of pentobarbital through either intracardiac, intracoelomic or subcutaneous lymph sac injection. Hadfield and Whitaker (2005) and Clayton and Gore (2007) recommends the same methods as Gertz, but does also recommend pithing after loss of reflexes to ensure that all neural activity is seized.

Fluid therapy

Fluid therapy is often administered topically since transdermal absorption is not considered stressful and is often sufficient to restore an adequate hydration level in amphibians (Clayton & Gore 2007). The ideal soaking solution suitable for amphibians is unknown and several different mixtures are proposed by different authors. Many crystalloid fluids that are often used in mammals, such as lactated Ringer's solution, Plasma-Lyte A or Normosol-R, are slightly hypertonic to amphibians according to Clayton and Gore (2007). The authors also point out that use of lactated Ringer's solution could potentially lead to acidosis in amphibians since they have a slow clearance of lactic acid.

Four different articles recommend amphibian Ringer's solution to be used if available, consisting of 6.6 g NaCl, 0.15 g KC1, 0.15 g $CaCl_2$, and 0.2 g $NaHCO_3$ per litre of water (Gentz 2007; Clayton & Gore 2007; Crawshaw 1998; Hadfield & Whitaker 2005). When amphibian Ringer's solution is not available several mixtures are suggested to treat dehydration:

- 4 parts lactated Ringer's solution + 1 part of 5% dextrose (Crawshaw 1998; Hadfield & Whitaker 2005; Clayton & Gore 2007).
- 4 parts lactated Ringer's solution + 1 part sterile water (Crawshaw 1998).
- 1 part 2.5% dextrose in 0.45% sodium chloride + 1 part lactated Ringer's solution (Clayton & Gore 2007).
- 1 part of saline (0.9% NaCl) + 2 parts of 5% dextrose (Gentz 2007; Hadfield & Whitaker 2005).
- 9 parts saline (0.9% NaCl) + 1 part of sterile water (Hadfield & Whitaker 2005).
- 7 parts of saline (0.9% NaCl) + 1 part of sterile water (Gentz 2007).

Diagnostics

The maximum volume of blood samples considered safe for a healthy amphibian corresponds to 1% of their total body weight, half of that volume is recommended for ill patients (Gentz 2007). Lithium heparin is the preferred anticoagulant to avoid haemolysis (Clayton & Gore 2007). Blood samples can be taken from the heart, ventral abdominal vein, femoral vein or lingual vein (Gentz 2007).

Anaesthesia

Amphibians can be put under anaesthesia using inhalation of anaesthetic agents or through IM injections (Clayton & Gore 2007). Due to their permeable skin anaesthesia in amphibians can also be obtained by soaking in a solution with tricaine methanesulfonate (Hadfield & Whitaker 2005).

Amphibians should always be kept moist, for this reason amphibian surgery is generally considered clean-contaminated rather than sterile (Gentz 2007). For disinfection, a sterile gauze with 0.75% chlorhexidine should be in contact with the skin area for 10 minutes before being rinsed with sterile saline according to Gentz (2007). The same author suggest that drapes can be useful to protect the area from contamination, however adhesive drapes should be avoided on amphibian skin. 100% oxygen can be bubbled through water in contact with the amphibian skin to facilitate for cutaneous respiration (Gentz 2007).

Just as for any other animal, anaesthetic monitoring is important. The pulse should not drop more than 20% from baseline, it can be monitored either by visualizing the heartbeat directly through the skin or with the use of a doppler (Gentz 2007). The heart rate is lower than for mammals of similar size, 20 to 60 beats per minute is normal for sedated amphibians (Clayton & Gore 2007). Gular respiration may slow down or stop entirely; thus, intubation is recommended for longer surgeries if possible (Gentz 2007). Use of pulse oximetry is not validated for amphibians, although it may still be applied to monitor trends (Clayton & Gore 2007). The loss of righting reflex and corneal reflex is expected during anaesthesia, the loss of withdrawal reflex to deep pain stimulation indicates a surgical level of anaesthesia (Gentz 2007; Hadfield & Whitaker 2005).

3.3.2 Birds

Handling

Birds will often not show any signs of illness unless the condition is severe (Bowles et al. 2007; Raftery 2013). The stress of handling can worsen the condition and sometimes be fatal (Bowles et al. 2007; Abou-Madi 2001). Covering the head of the bird (Graham & Heatley 2007) or letting the bird stand or grasp something with their feet (Abou-Madi 2001) can help in minimizing stress.

A towel can be used to restrain the bird during handling, although it is important not to obstruct breathing by hindering the movement of the chest (Riley & Barron 2016; Abou-Madi 2001). The grip used for restraint varies with size of the bird and the purpose of the restraint, if the feet are restrained a finger should be placed in between the restrained legs to prevent injury (Raftery 2013). Some seabirds, for example pelicans, lacks nostrils and it is therefore important that any restraint used in these species will allow for them to breathe through their mouth (Riley & Barron 2016). If the bird escapes, darkening the room can sometimes help with capture (Bowles et al. 2007; Abou-Madi 2001).

Protective gear, such as leather gloves and eye protection, should be worn when handling birds with hooked beaks or stabbing beaks, for example raptors or herons (Riley & Barron 2016; Graham & Heatley 2007). Ear plugs is recommended when handing birds with loud shrieks, for example cockatoos (Abou-Madi 2001).

Administration of medications

The pharmacokinetics may vary between different species of birds. There is for example indications that some birds belonging to the order Pelecaniformes have slower elimination of meloxicam compared to other birds (Horgan et al. 2020).

IM injections can be administered in the pectoral muscles of birds and the safest place for SC injections are the inguinal region, just cranial to the knee according to Wade (2009). The author points out the risk of penetrating an air sac if the needle is advanced too deep during SC administration. Intranasal administration is possible for some medications (Mans 2014). Because of the renal portal system, injections into the legs should be avoided for nephrotoxic drugs and drugs with a high excretion level through the kidneys according to Abou-Madi (2001). However, Bowles et al. (2007) argue that the stress during administration and subsequent activation of the sympathetic nervous system will direct blood flow away from the kidneys.

IV injections can be given in the jugular veins, cutaneous ulnar vein or medial metatarsal vein (Riley & Barron 2016; Jenkins 2016; Bowles et al. 2007). IV catheters can also be placed in these veins, however maintaining them can be hard since many birds do not tolerate the wrapping needed to keep the catheter in place (Bowles et al. 2007). Intraosseous (IO) catheters can therefore be an option, it can be placed in the proximal end of tibiotarsus or the distal end of ulna (Bowles et al. 2007; Gunkel & Lafortune 2005).

Euthanasia is usually performed through IV injection, otherwise the bird should be put under anaesthesia followed by either intracardiac or occipital sinus injection (Riley & Barron 2016).

Fluid therapy

Isotonic crystalloid solutions such as lactated Ringer's solution, Plasma-Lyte 148, Normosol R or 0.9% saline solution is often used for fluid therapy in birds (Jenkins 2016; Gunkel & Lafortune 2005). Lactated Ringer's solution is recommended by Jenkins (2016) for most critically ill birds since acidosis is common in these patients.

Diagnostics

There are differences between bird species that needs to be considered. An example is the subcutaneous air diverticula found in pelicans, gannets and boobies that should not be mistaken for subcutaneous emphysema (Stidworthy & Denk 2018; Daoust et al. 2008).

The maximum volume of blood samples considered safe for a healthy bird corresponds to 1% of their total body weight, in ill patients only half of that is recommended (Bowles et al. 2007; Gunkel & Lafortune 2005). Blood samples can be taken from the jugular vein, in larger species the medial metatarsal vein or the basilic vein can also be used (Bowles et al. 2007; Gunkel & Lafortune 2005).

Typical heart rates for birds varies between 200 and 500 beats per minute depending on species and can in some species be even higher (Abou-Madi 2001). Healthy birds have minimal respiratory sounds, auscultated sounds are thus often abnormal (Bowles et al. 2007).

The body temperature of birds varies between 37° C and 42° C depending on species (Abou-Madi 2001). Since birds lacks sweat-glands dissipation of excess heat is provided through gular fluttering or panting (Abou-Madi 2001).

Indirect blood pressure measurement using a Doppler is possible in birds weighing over 70 g according to Lichtenberger (2005). The author recommends the cuff to be placed around the distal humerus, if the bird weighs more than 300 g it can also be placed around femur. The doppler probe is recommended to be placed over the ulnar or metatarsal artery, depending on cuff placement. Normal values are not clearly defined in birds but according to Lichtenberger (2005) systolic blood pressure measurements of 90 -180 mmHg is common in awake and anesthetised psittacine birds. According to Graham and Heatley (2007) the upper limit for raptors is higher, systolic values of up to 240 mmHg can be considered normal for anesthetised raptors.

Anaesthesia

Anaesthesia in birds is usually induced through inhalation of anaesthetic gases (Kubiak 2017). Use of injectable anaesthesia is possible and can be beneficial in many water birds where apnoea due to the dive response can hinder administration via face mask (Kubiak 2017; Raftery 2013).

Face masks for different types of beaks can be produced from plastic bottles or syringes, in smaller birds the whole head can be inserted into the mask (Gunkel & Lafortune 2005; Abou-Madi 2001). Preoxygenation is sometimes omitted in birds since the stress of being restrained can be considered too harmful (Gunkel & Lafortune 2005).

Food and fluid can easily seep up from the crop through the relatively wide oesophagus in birds, aspiration is therefore common (Chavez & Echols 2007). The lack of epiglottis also increases the risk for aspiration (Lierz & Korbel 2012). In an emergency situation, when fasting is not possible, the crop might be emptied using oral gavage (Chavez & Echols 2007; Abou-Madi 2001; Gunkel & Lafortune 2005). Oral gavage is however not recommended by Lierz and Korbel (2012) due to the additional stress it causes to the patient. The authors instead recommends that the bird is intubated, positioned with the head elevated and that the pharynx is blocked with a gauze sponge.

There is an increased risk for mucus obstructing the endotracheal tube in small birds (Lichtenberger & Ko 2007). According to Raftery (2013) this problem is common in birds weighing less than 100 g and Gunkel and Lafortune (2005) recommends that birds weighing less than 80 g should not be intubated to avoid occlusion of the endotracheal tube.

Intubation of birds is generally uncomplicated compared to mammals due to bird’s larger laryngeal opening and lack of epiglottis (Bowles et al. 2007). An uncuffed tracheal tube should be used since the tracheal rings of birds are complete (Gunkel & Lafortune 2005; Abou-Madi 2001; Lierz & Korbel 2012). In some cases, administering anaesthetic gases directly into the air sacks of birds can be used as an alternative to endotracheal intubation (Gunkel & Lafortune 2005; Lierz & Korbel 2012).

The laterally positioned and protruding eyes of birds need to be protected from damage to the cornea when the head is placed laterally during anaesthesia. A ring made of gauze can for example be used to lift the eye up above the substrate (Abou-Madi 2001).

A surgical plane of anaesthesia is indicated by muscle relaxation and lack of withdrawal reflex to nociceptive stimuli (Raftery 2013; Lierz & Korbel 2012). The palpebral reflex and corneal reflex can be slow or intermittent in birds during anaesthesia (Abou-Madi 2001). According to Lierz and Korbel (2012) loss of palpebral reflex with a remaining corneal reflex indicates a surgical level.

Monitoring of birds during anaesthesia should preferably include measurement of blood pressure, capnometry, temperature, electrocardiography, pulse oximetry and monitoring of reflexes and mucous membranes (Raftery 2013; Lierz & Korbel 2012). Some things to consider is that the electrocardiography machine needs to be able to measure the rapid heartbeat of birds and since pulse oximetry is not validated in birds it should only be used to follow trends (Raftery 2013). A doppler flow detector is recommended by Abou-Madi (2001) for cardiovascular monitoring.

Bradycardia in birds under anaesthesia have been linked to pain and hypothermia according to Abou-Madi (2001). The author warns that plucking of feathers to prepare the surgical site can cause severe bradycardia and hypotension. The risk for hypothermia is increased in birds due to the large surface area of the air sacks (Lierz & Korbel 2012).

Respiratory depression is common in birds (Gunkel & Lafortune 2005) and is less tolerated in birds compared to mammals (Abou-Madi 2001). Lateral recumbency is preferred over dorsal recumbency, when possible, to facilitate for normal respiration (Raftery 2013; Gunkel & Lafortune 2005; Abou-Madi 2001). Respiratory rates of 10 to 25 breaths per minute is recommended for ventilation of large birds and 30 to 40 breaths per minute is recommended for small birds (Gunkel & Lafortune 2005).

Since expiration is an active process in birds, ventilation can be achieved by gently compressing the sternum and letting it recoil into neutral position between repetitions (Bowles et al. 2007). The highly compressible air sacs that surrounds the heart also leads to sternal compressions having little effect on circulation during resuscitation (Jenkins 2016).

3.3.3 Mammals

Handling

Wild mammals are often handled similarly to domestic mammals. It is however important to remember that even small wild mammals can be dangerous (Riley & Barron 2016). The use of protective clothing is especially important when handling bats since all bats should be treated as a potential source of Australian Bat Lyssavirus (O´Connor 2022; Eshar & Weinberg 2010). When handling echidnas leather gloves can be used to prevent being pricked by the sharp quills (Johnson et al. 2006). When feeling threatened the echidna will curl up, a hand placed on the abdomen when the animal is picked up can help to prevent complete closure into the defensive position (Johnson et al. 2006).

Administration of medication

IV catheters can be placed in any accessible vein, cephalic catheters are often used (Riley & Barron 2016; Colgan & Green 2018). For IO catheters the tibia or femur is preferred (Lennox 2007; Riley & Barron 2016).

Euthanasia is usually preformed through IV or IO injection. With smaller mammals or difficulty with venous access, the patient is often anesthetized through inhalation anaesthetics and euthanized via intracardiac injection (Riley & Barron 2016).

Fluid therapy

Medium to large sized mammals can be treated with a dose and fluid type similar to domestic mammals, in smaller mammals the maintenance dose is generally higher due to the higher metabolic rate (Riley & Barron 2016).

Diagnostics

The normal body temperature of mammals varies between species. Marsupials have slightly lower body temperatures than eutherians (Dawson & Hulbert 1970) and monotremes have the lowest temperature range at 31°C - 32°C (Nicol 2017). Cloacal temperature measurements can be lower than core body temperature, 32°C is for example considered a normal cloacal temperature in sugar gliders although the core body temperature exceeds 36°C (McLaughlin & Strunk 2016). Some species, including echidnas, bats and several marsupials, can lower their temperatures during torpor (Geiser & Körtner 2010). The length of torpor varies between daily torpor to hibernation for over 6 months (Geiser & Körtner 2010).

Blood can usually be drawn from any vein used in small domestic animals (Riley & Barron 2016). Lennox (2007) describes blood drawn from vena cava during sedation as a successful technique even with extremely small, obese or severely compromised mammals.

Echidnas usually have few accessible veins for blood collection, Johnson et al. (2006) presents a method for venepuncture on anesthetised echidnas on the dorsal aspect of the beak. The authors amplify the importance of not swabbing the surface of the beak with an excessive amount of alcohol to minimise the risk of accidental entry of alcohol into the nasal cavity.

Anaesthesia

Endotracheal intubation of exotic mammals can be challenging but nonetheless important for better respiratory control and minimizing aspiration (Glendinning 2022).

Anaesthetics for wildlife with a morphological difference to the usual patient require modified solutions. Johnson et al. (2006) presents a customized inhalation mask for echidnas made from a 10 mL syringe case. The hard edges of the syringe are padded using bandaging material to protect the soft tissue of the beak from injury.

Apnoea and bradycardia are common in platypuses during induction or in recovery according to Macgregor et al. (2014). The authors identified risk factors to be placement in dorsal recumbency and stress around capture and handling. The authors further speculated that it could be a response to the irritating nature of isoflurane which could trigger the natural dive response. Using warmed and humidified sevoflurane gas, avoiding dorsal recumbency and minimising stress is proposed to minimise the risk of sudden apnoea and bradycardia in platypuses.

3.3.4 Reptiles

Handling

Reptiles are ectotherm animals and should be kept in the preferred optimal temperature zone specific to each species (Sykes & Greenacre 2006; Martinez-Jimenez & Hernandez-Divers 2007). Many bodily functions such as immune system, metabolism, absorption, distribution and excretion of drugs is affected by body temperature, a correct temperature is therefore important (Sykes & Greenacre 2006).

Aquatic and semiaquatic species should be kept dry docked when debilitated to avoid drowning (Norton 2005). The skin and shell can when necessary be kept moist using regular misting or by applying Vaseline or a water-soluble jelly (Norton 2005).

Before handling any reptile, the species should be established to determine if the reptile is venomous or not (Riley & Barron 2016; Long 2016). Never handle venomous animals without experience in proper handling techniques, relevant equipment and an emergency plan (Wilkinson 2014).

Understanding the species that is being handled is also important in order to distinguish between normal and abnormal behaviours. As an example, the threats with open mouth made by bearded dragons can be mistaken for respiratory distress (Long 2016).

Equipment used for safe handling techniques can be relevant also for non-venomous snakes in case of scared and aggressive individuals. Snake hooks can be used to lift a snake but should never be used to restrain the snake with force, such as pinning the head to the surface, due to the high risk of injury (Wilkinson 2014). Make sure the hook is long enough to keep hand out of striking distance, which can be up to three quarters of the snake's body length (Wilkinson 2014). Thongs and forceps can be used to manipulate equipment and to offer food but should never be used to grab the snake since it can create crush injuries (Wilkinson 2014).

A snake can be restrained by grasping behind the head or by inserting the snake into a clear plastic tube, often called snake tube (Wilkinson 2014). The snake tube needs to be small enough that the snake cannot turn around inside the tube, a grip around the end of the tube and the body of the snake ensures that it can't reverse out of it (Wilkinson 2014). Textile bags can be used for transporting snakes, although keep in mind that many snakes can bite through the bag if provoked (Wilkinson 2014).

Lizards can be restrained similarly to reptiles with a grip behind the head, however leather gloves should be used in large or aggressive lizards (Sykes & Greenacre 2006). Applying a gentle pressure to both eyes, for example using cotton balls taped over the closed eyes, elicits a vagal response that can calm the lizard for a short period of time (Sykes & Greenacre 2006).

Getting access to the head of a chelonian can be difficult due to many species ability to retract into their shell. Approaching the head from below rather than from above can reduce the defensive reaction since most chelonians expects threats to come from above (Sykes & Greenacre 2006). In some species pressure to the back end can make it extend the front half (Sykes & Greenacre 2006).

Suturing of skin in reptiles with scales should be done with everted skin edges, usually achieved by using horizontal mattress sutures (Mitchell & Diaz-Figueroa 2004). The suture material can be either absorbable or not but chromic catgut should be avoided since it can cause an intense inflammatory response in reptiles (Mitchell & Diaz-Figueroa 2004). The sutures are usually removed after 4 to 6 weeks (Mitchell & Diaz-Figueroa 2004).

Administration of medications

Medications given in the caudal part of reptiles might be filtered through the renal-portal system, thus injection in the cranial part is preferred for some medications

(Riley & Barron 2016; Sykes & Greenacre 2006; Sladky & Mans 2012). This is recommended since renal filtration can alter the pharmacokinetics and increase potential nephrotoxic effects of administered medications (Sykes & Greenacre 2006).

When injecting a snake or a lizard the needle should be inserted between the scales, there is often no need to tent the skin for SC injections in these species (Sykes & Greenacre 2006). SC injections are administered on the lateral side of the body for snakes or lizards, the needle should be well inserted to avoid seepage when larger volumes are administered (Sykes & Greenacre 2006). SC injections in chelonians are administered into any available skin fold, usually the inguinal and ventral neck folds (Sykes & Greenacre 2006).

IM injections are administered in the epaxial muscles on snakes, located in between the dorsal midline and the lateral aspect of the body (Sykes & Greenacre 2006; Martinez-Jimenez & Hernandez-Divers 2007). The forearm is used for IM injections in lizards and chelonians (Sykes & Greenacre 2006; Martinez-Jimenez & Hernandez-Divers 2007).

The use of IV injections is limited in reptiles and used mostly for unresponsive patients or for administration of anaesthetic agents or contrast fluid (Sykes & Greenacre 2006). Maintaining IV catheters on reptiles can be difficult unless the patient is compromised, sedated or anaesthetised (Music & Strunk 2016).

The jugular vein can be used for IV injections in all reptiles but cut-down is generally required to access the vein (Sykes & Greenacre 2006; Martinez-Jimenez & Hernandez-Divers 2007). In lizards the ventral coccygeal vein or the cephalic vein can also be used for IV injections (Riley & Barron 2016; Music & Strunk 2016; Sykes & Greenacre 2006). In snakes the ventral coccygeal vein or intracardiac administration are used (Sykes & Greenacre 2006). Care should be taken to keep the needle still during an intracardiac injection since fluid accidently administered into the pericardial space can be fatal due to cardiac tamponade (Sykes & Greenacre 2006). In chelonians the subcarapacial vein can be used for IV injections, in sea turtles the cervical sinus is another option (Norton 2005).

Intraosseous catheters can be placed in the tibial medullary cavity of lizards and chelonians and into the plastrocarapacial bridge of chelonians (Riley & Barron 2016; Music & Strunk 2016; Martinez-Jimenez & Hernandez-Divers 2007). If the plastrocarapacial bridge is to be used care should be taken to not penetrate into the coelom, the viability of this option varies between species (Martinez-Jimenez & Hernandez-Divers 2007).

Euthanasia is usually performed through IV injection, otherwise the reptile should be put under anaesthesia followed by either intracardiac or intracoelomic injection (Riley & Barron 2016). In chelonians the subcarapacial sinus may be used for administering euthanasia solution but this route is not recommended for any other medications (Sykes & Greenacre 2006). To allow for proper absorption and metabolism the reptile should be kept warm throughout the euthanasia process, otherwise the process can be prolonged (Music & Strunk 2016).

Although consciousness and withdrawal reflex to nociceptive stimuli may be lost quickly the loss of cardiac function generally requires longer time in reptiles than it does in birds or mammals (Riley & Barron 2016). Reptiles can survive for hours of hypoxia due to their ability to switch to anaerobic metabolism (Martinez-Jimenez & Hernandez-Divers 2007). Pithing should therefore be considered when cardiac function has ceased to ensure successful euthanasia (Music & Strunk 2016).

Fluid therapy

The skin of reptiles is not very elastic and large SC boluses should be divided into multiple small boluses (Music & Strunk 2016). Intracoelomic (IC) injections through the inguinal fossa can be an alternative for chelonians, commonly used in sea turtles (Norton 2005).

Fluids containing lactate can potentially put a high load on the slow metabolism of reptiles (Martinez-Jimenez & Hernandez-Divers 2007). Although, according to some authors lactated Ringer's solution is only a problem for reptiles with severe hepatic compromise (Music & Strunk 2016; Martinez-Jimenez & Hernandez-Divers 2007). This is supported by two experimental studies on fluid therapy in stranded sea turtles by Camacho et al. (2015) and dehydrated bearded dragons by Parkinson and Mans (2020). In neither of those studies any increased levels of blood lactate level could be measured after treatment with lactated Ringer's solution.

Reptile Ringer's solution is sometimes used for reptiles, although the definition of this solution varies between different authors. Norton (2005) describes it as one part lactated Ringer solution plus two parts 2.5% dextrose with 0.45% sodium chloride. Clayton and Gore (2007) instead describes mixing equal parts of the above mentioned fluids and Parkinson and Mans (2020) describes mixing equal part of 5% dextrose solution and any isotonic crystalloid solution.

What type of fluids that should be used in reptiles is debated. Martinez-Jimenez and Hernandez-Divers (2007) advice against the use of fluids that are isotonic to mammals since such solutions are hypertonic to reptiles, these solutions are however described as acceptable to use by Music and Strunk (2016). Norton (2005) and Martinez-Jimenez and Hernandez-Divers (2007) recommend using Reptile

Ringers’ solution, however two experimental studies by Camacho et al. (2015) and Parkinson and Mans (2020) found such solution to cause severe hyperglycaemia. For sea turtles Camacho et al. (2015) advise that a solution with equal parts 0.9% saline and lactated Ringer’s solution should be used until acid base equilibrium is reached, after that 0.9% saline can be used. According to Parkinson and Mans (2020) lactated Ringer solution and Plasma-Lyte A provides adequate rehydration in bearded dragons.

Diagnostics

Auscultation of the heart can be difficult in the reptilian patient, a doppler probe is thus useful when monitoring heartrate (Music & Strunk 2016; Sladky & Mans 2012). If a stethoscope is used, moist gauze can be placed between the stethoscope and skin to reduce air trapped between the scales (Music & Strunk 2016). The heartrate of reptiles is low compared to many mammals of similar size, 30–100 beats per minute can be normal depending on species (Martinez-Jimenez & Hernandez-Divers 2007).

Variations in anatomy between species should be considered, for example monitor lizards which have their hearts located more caudally than other lizards (Music & Strunk 2016). In snakes the hearth is found in the cranial third of the body (Martinez-Jimenez & Hernandez-Divers 2007). For chelonians the heart can be monitored using a doppler probe placed in the cervical region over the carotid artery (Music & Strunk 2016).

It is important to consider the species when evaluating blood pressure. While a mean arterial pressure of 15–40 mmHg is common in chelonians there are some lizards with mean arterial pressure as high as 60–80 mmHg (Martinez-Jimenez & Hernandez-Divers 2007). When using a doppler, the cuff is placed over the brachial artery at the proximal front leg in chelonians and lizards and in snakes the cuff is placed over the caudal tail artery just distal of the cloaca (Martinez-Jimenez & Hernandez-Divers 2007). The results should be interpreted carefully since indirect measurements of blood pressure does not always have a good correlation with direct blood pressure measurements in reptiles (Sladky & Mans 2012).

Different veins are used for blood samples depending on the species of reptile. In snakes and lizards the same veins are suggested as for IV injections (Music & Strunk 2016; Martinez-Jimenez & Hernandez-Divers 2007; Riley & Barron 2016). The cranial vena cava can also be used in lizards under sedation or anaesthesia (Music & Strunk 2016). In chelonians the jugular veins, preferably the right one to minimize risk of lymph contamination, the brachial vein, the dorsal tail vein or the subcarapacial sinus can be used for blood samples (Riley & Barron 2016).

According to Music and Strunk (2016) the subcarapacial sinus should only be used as a last resort due to the risk of paresis.

The preferred anticoagulant used in reptiles varies between different species (Riley & Barron 2016; Martinez-Jimenez & Hernandez-Divers 2007). If the suitable anticoagulant in unknown and two samples cannot be taken, using ethylenediaminetetraacetic acid (EDTA) and lithium heparin respectively, Martinez-Jimenez and Hernandez-Divers (2007) recommends using lithium heparin.

A snake tube with capped ends can be used to restrain snakes for radiograph imaging (Wilkinson 2014). Dorsoventral and lateral projections are usually taken, in chelonians an anterior-posterior projection can also be useful (Riley & Barron 2016). The lateral and anterior-posterior projection in chelonian should be made with horizontal beams to visualise the lungs (Norton 2005; Martinez-Jimenez & Hernandez-Divers 2007). Potential barnacles should be removed since they are radiopaque and will show on the image (Norton 2005).

Anaesthesia

Inhalant anaesthetics is often used in reptiles, however injectable anaesthetics can be preferred in many chelonian species that are prone to breath holding (Riley & Barron 2016). For injectable anaesthetics both IM injections and SC injections are feasible (Sladky & Mans 2012). If needed, a mask can be fitted at the end of a snake tube to administer inhalant anaesthetics (Wilkinson 2014; Sladky & Mans 2012).

In all reptiles except crocodilians, the circulating blood can bypass the lungs during apnoea through cardiac shunting (Long 2016). Apnoea can be sustained for long periods of time, especially in diving species, since reptiles have a high ability to buffer lactic acid allowing for anaerobic metabolism (Long 2016). Long periods of apnoea and cardiac shunting can affect the anaesthetic depth when using inhalant anaesthetics. It can cause both delayed recovery or unexpected early recovery, as well as a discrepancy between exhaled gases and blood gases (Sladky & Mans 2012). Such effects are particularly common in sea turtles (Sladky & Mans 2012).

Some differences in the respiratory system of reptiles compared to mammals should be considered. Reptiles often have 10% to 20 % larger lung volumes (Long 2016) but the internal surface area for gas exchange is however only one-fifth of that in mammals (Schumacher 2003). The lungs are thin and with little external support which means they have a high compliance but can easily be damaged from overexpansion during ventilation (Long 2016). The consumption of oxygen is lower than in mammals due to the lower metabolic rate in reptiles (Long 2016).

In contrary to mammals and birds, where hypercapnia stimulates breathing, the reptile respiration is controlled by both hypercapnia and hypoxia (Schumacher 2003). A high inspired oxygen level will decrease ventilation, either through a decreased respiratory rate or through a decreased tidal volume (Schumacher 2003). Return of spontaneous respiration can therefore be stimulated by ventilating the patient using normal air instead of using a high percentage of oxygen (Long 2016).

Reptiles lack the epiglottis and intubation is generally uncomplicated, although chelonians with large tongues can sometimes pose a challenge (Sladky & Mans 2012). The trachea is fragile and endotracheal cuffs should be inflated carefully in lizards and snakes which have incomplete tracheal rings (Sladky & Mans 2012). Chelonians on the other hand have complete tracheal rings and cuffs should not be used in these species (Sladky & Mans 2012). In many chelonians the trachea is short and there is thus a risk for unilateral lung intubation if the endotracheal tube is advanced too far (Sladky & Mans 2012).

Apnoea or hypoventilation is common in reptiles during anaesthesia (Sladky & Mans 2012), ventilation is therefore often necessary. Approximately 2-3 breaths per minute is recommended together with a maximum peak inspiratory pressure of 10 cm H_2O in order to avoid causing any damage to the lungs (Sladky & Mans 2012).

The depth of anaesthesia should be evaluated using physiological reflexes (Sladky & Mans 2012). In many reptiles the corneal and palpebral reflex can be used similarly to the use in mammals, however this is not possible in snakes and some lizards due to the lack of eyelids (Sladky & Mans 2012). A surgical plane of anaesthesia is indicated by muscle relaxation, lack of movement and lack of withdrawal reflex to nociceptive stimuli (Sladky & Mans 2012). The muscle tone can be assessed in the neck of chelonians and in the tail in snakes since the tail is relaxed last during induction and resumes first during recovery (Sladky & Mans 2012).

Patient monitoring during anaesthesia is just as important for reptiles as for any other animal, however there are some differences that need to be considered. The use of capnography is not considered reliable in reptiles due to the possible cardiac shunting (Sladky & Mans 2012). Pulse oximeters developed for mammals does not always give accurate readings on reptiles (Martinez-Jimenez & Hernandez-Divers 2007). Oximetry reflectance probes placed within the oesophagus or cloaca seems to be more reliable than other probes (Sladky & Mans 2012).

4 Material and Methods

Two wildlife hospitals in Australia have provided data for this study, Byron Bay Wildlife Hospital in New South Wales and Adelaide Koala and Wildlife Centre in South Australia. The data provided was a summary of each hospital's medical records, prepared by each hospital as part of their record-keeping. It included the species of each patient, the reason for admission to the hospital, the outcome after care as well as a few other parameters that has not been included in this study.

Monthly data from Byron Bay Wildlife Hospital was available starting from April 2021 until December 2022, resulting in data from 21 months. Monthly data from Adelaide Koala and Wildlife Centre was available starting from January 2018 until November 2022, resulting in data from 59 months. Data for each individual patient was available for Byron Bay Wildlife Hospital, for Adelaide Koala and Wildlife Centre monthly summaries for outcome, species and reasons for admission was used.

The reasons for admission at the two hospitals were not comparable at the start of this study and were thus combined into fewer and wider categories. The data was sorted using Microsoft Excel, firstly listing every unique admission reason used by each hospital and removing obvious misspellings. This resulted in 96 different categories used by Byron Bay Wildlife Hospital and 10 different categories used by Adelaide Koala and Wildlife Centre. These categories were compressed into wider categories in different steps, firstly combining synonymous categories, then similar reasons for admissions, resulting in 6 matching categories for the two hospitals. The allocation of different categories is shown in Appendix 1.

The species relevant to this study were all vertebrates, which can be divided into seven classes. Since no patient included in this study could be classified as any type of fish all patients could be divided into one of the following classes: amphibians (Amphibia), reptiles (Reptilia), birds (Aves) and mammals (Mammalia).

When counting individuals belonging to a certain species, different names referring to the same species were combined into the same category, for example plover and masked lapwing. In some instances, when there was only one subspecies with habitats close to the relevant hospital, a wider category such as carpet python was combined into a more specific category like coastal carpet python. In all such cases the merge was first confirmed as applicable by the relevant hospital.

To present the outcome for patients after admission, four similar categories were used by both hospitals: “Euthanized”, “Died”, “Put into care” and “Released”. Byron Bay Wildlife Hospital had additional outcomes listed during some months. These outcomes were placed in one of the original four categories, “Dead on arrival” was included in “Died” while “Released by carer” and “Creche” were included in “Put into care” to represent the outcome of the hospital stay. Individuals where no outcome was described were excluded from the data.

A chi-2-test (χ^2) was used on the seasonal variations of admitted patients. The null hypothesis was chosen so that the total number of patients of each animal type were equally distributed over all months. The null hypothesis did not take into account monthly variation of the total number of patients since this would have been largely influenced by the variations of each type of animal.

5 Results

In total 2 613 patients were admitted to Byron Bay Wildlife Hospital. The data was complete except for the outcome analysis where 10 patients were excluded due to missing data.

The total number of patients deviated between the different summaries for Adelaide Koala and Wildlife Centre; 7 039 patients had a described outcome, 7 091 patients had a described reason for admission and 7 066 patients could be categorised as either an amphibian, bird, mammal or reptile. When data was combined 7 016 patients had both a known reason for admission and known species, 6 993 patients had both a known outcome and known species.

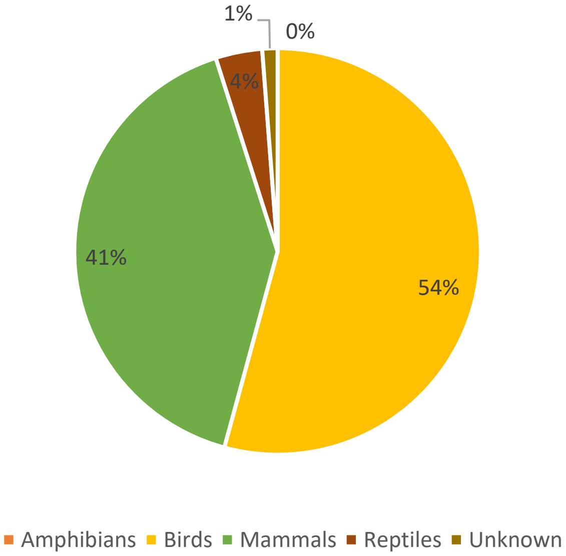

Figure 2: Types of animals admitted to Adelaide Koala and Wildlife Centre

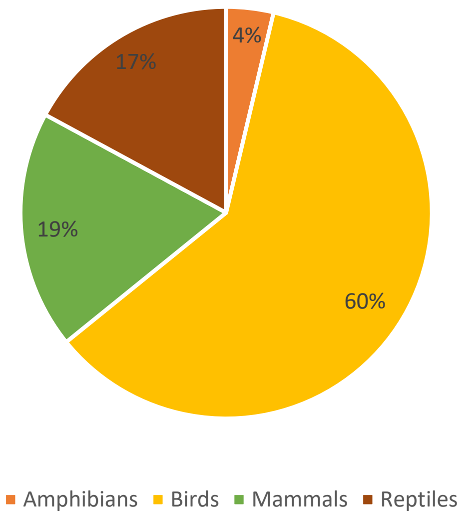

Figure 1: Types of animals admitted to Byron Bay Wildlife Hospital

Birds where the most common type of patient at both Adelaide Koala and Wildlife Centre and Byron Bay Wildlife Hospital, shown in Figure 2 and Figure 1. While mammals where the second most common type of patient for both hospitals the proportion of mammals was twice as big for Adelaide Koala and Wildlife Centre compared to Byron Bay Wildlife Hospital.

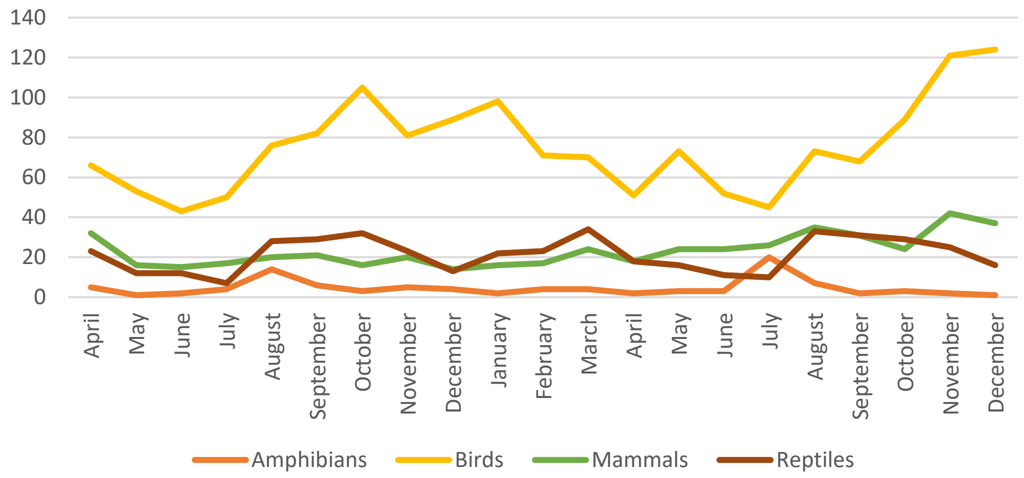

Figure 3: Monthly variations of patients admitted to Byron Bay Wildlife Hospital between April 2021 and December 2022.

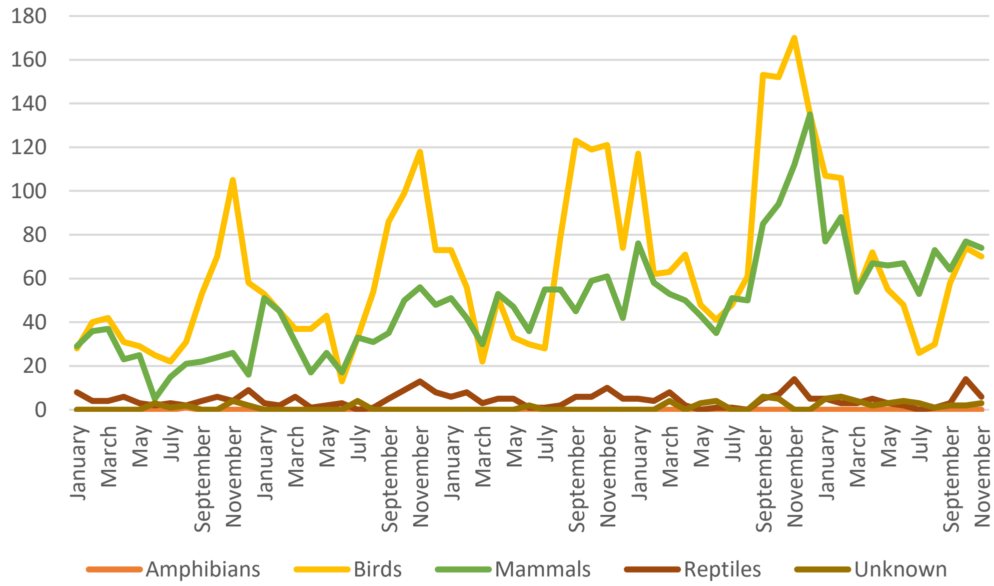

Figure 4: Monthly variation of patients admitted to Adelaide Koala and Wildlife Centre between January 2018 and November 2022.

Seasonal variations were found among patients admitted to both hospitals as shown in Figure 3 and Figure 4. The variations were statistically significant with a p-value below 0.05 for birds and mammals in both hospitals and reptiles at Byron Bay Wildlife Hospitals. There were not enough data on amphibians at any hospital or reptiles at Adelaide Koala and Wildlife Centre to apply the χ^2 test.

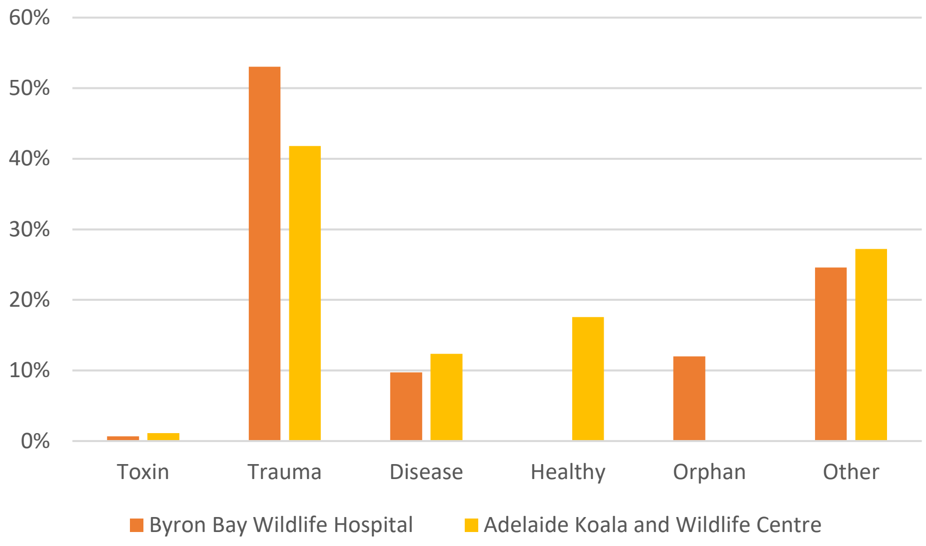

Figure 5: Reasons for admissions.

The most common reason for admission was trauma for both hospitals as seen in Figure 5. The category "Healthy" was only used by Adelaide Koala and Wildlife Centre and the category "Orphan" was only used by Byron Bay Wildlife Hospital. These categories were included since they contributed to a large part of admitted animals at the associated hospital.

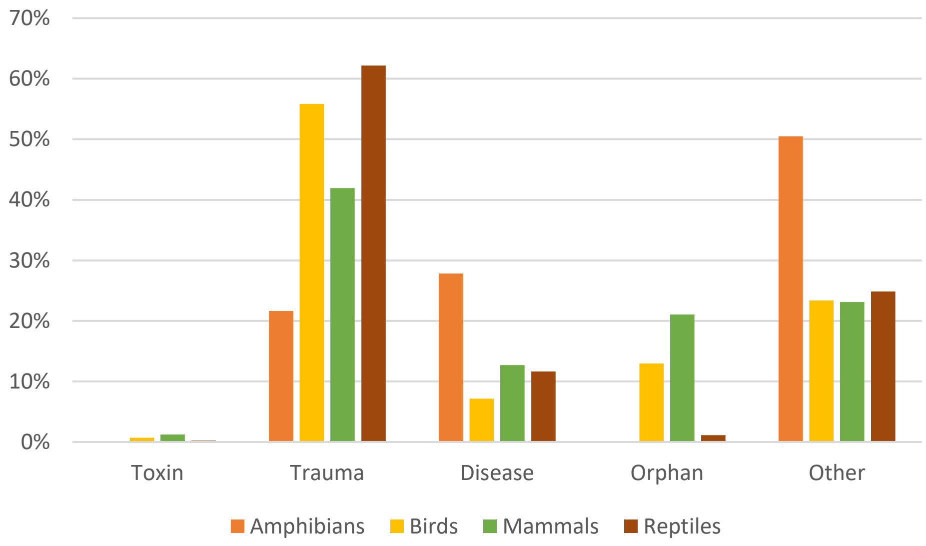

Figure 6: Reasons for admission of different types of animals admitted to Byron Bay Wildlife Hospital.

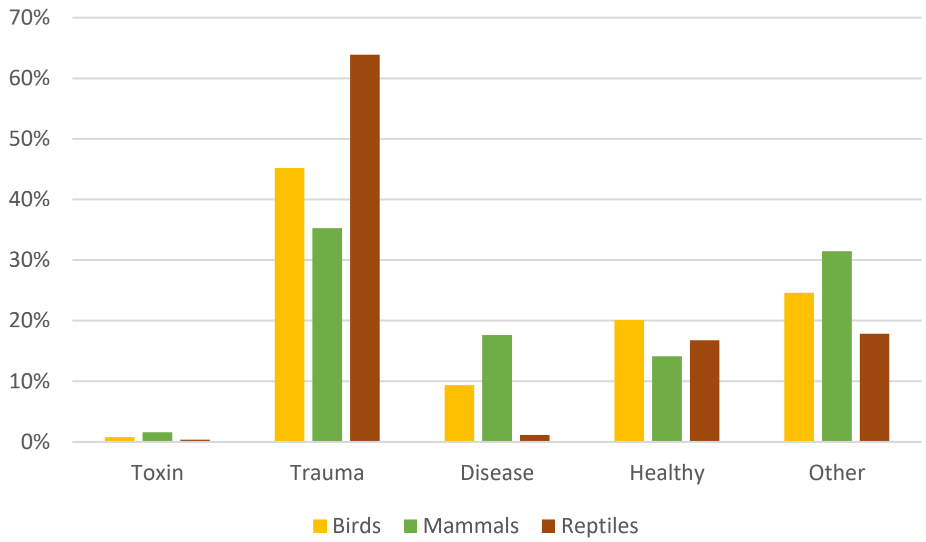

Figure 7: Reasons for admission of different types of animals admitted to Adelaide Koala and Wildlife Centre.

Amphibians were excluded in Figure 7, as Adelaide Koala and Wildlife Centre had only one admission in total of amphibians.

Reptiles, shortly followed by birds, were overrepresented in the category "Trauma" for both hospitals as seen in Figure 6 and Figure 7. Amphibians were however often admitted due to other reasons or because of disease.

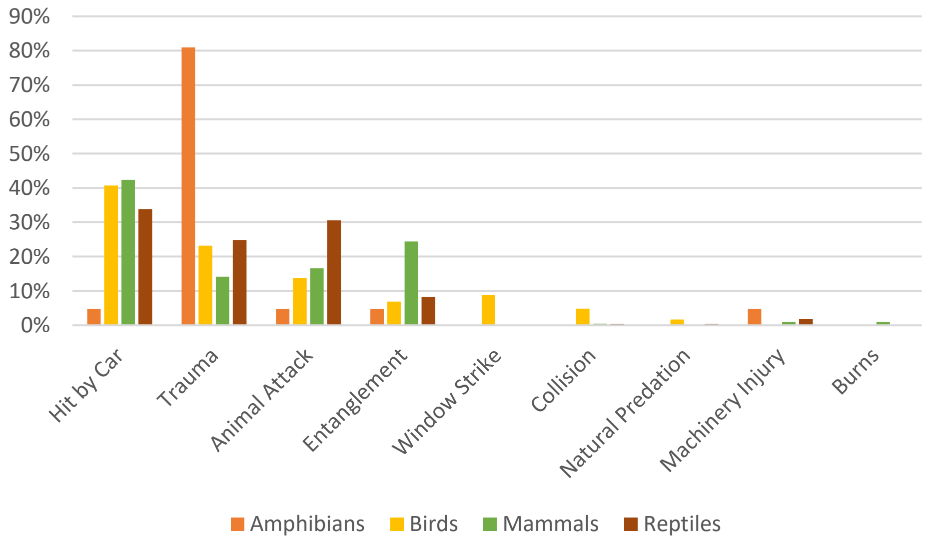

Figure 8: Causes of trauma in patients admitted to Byron Bay Wildlife Hospital.

Car strikes were the most common reason for trauma among birds, mammals and reptiles admitted to Byron Bay Wildlife Hospital. The trauma in amphibians were however often unspecified, as shown in Figure 8. Similar data on different causes of trauma was not available from Adelaide Koala and Wildlife Centre.

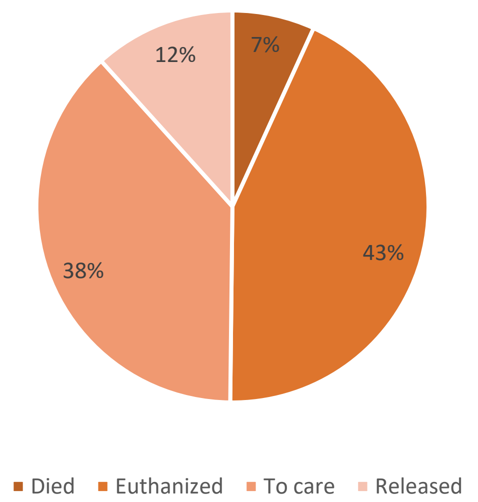

Figure 9: Outcome of patients admitted to Adelaide Koala and Wildlife Centre.

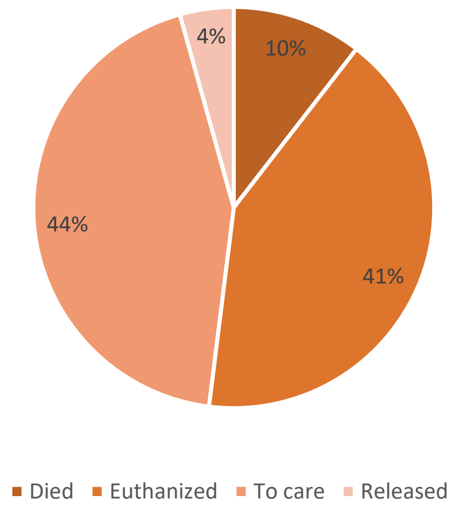

Figure 10: Outcome of patients admitted to Byron Bay Wildlife Hospital.

Figure 9 and Figure 10 shows that the total mortality for patients at Adelaide Koala and Wildlife Centre was 50%, close to that of Byron Bay Wildlife hospital at 51%.

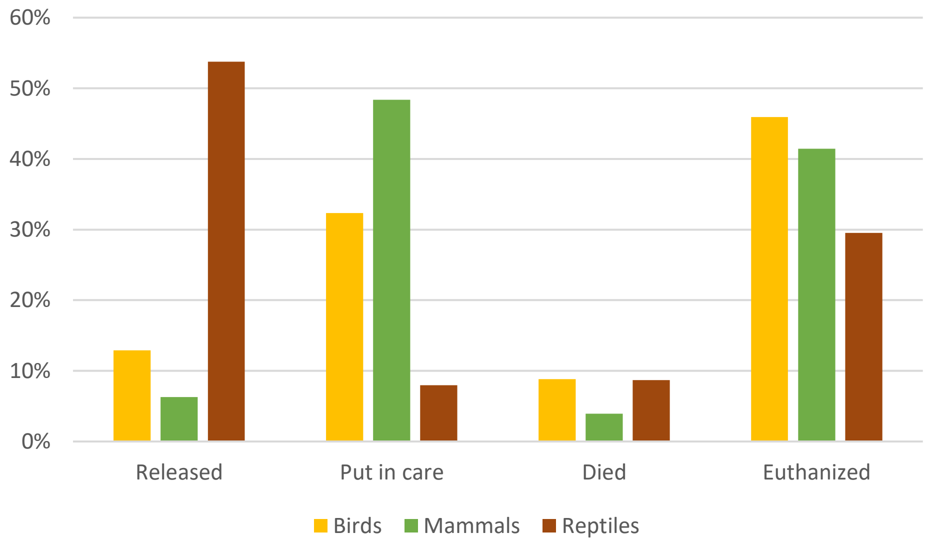

Figure 11: Outcome for different types of animals at Adelaide Koala and Wildlife Centre.

The most common outcome differed between species admitted to Adelaide Koala and Wildlife Centre, as shown in Figure 11. Reptiles were much more likely to be released than other animals, mammals were commonly put in care and birds were often euthanized.

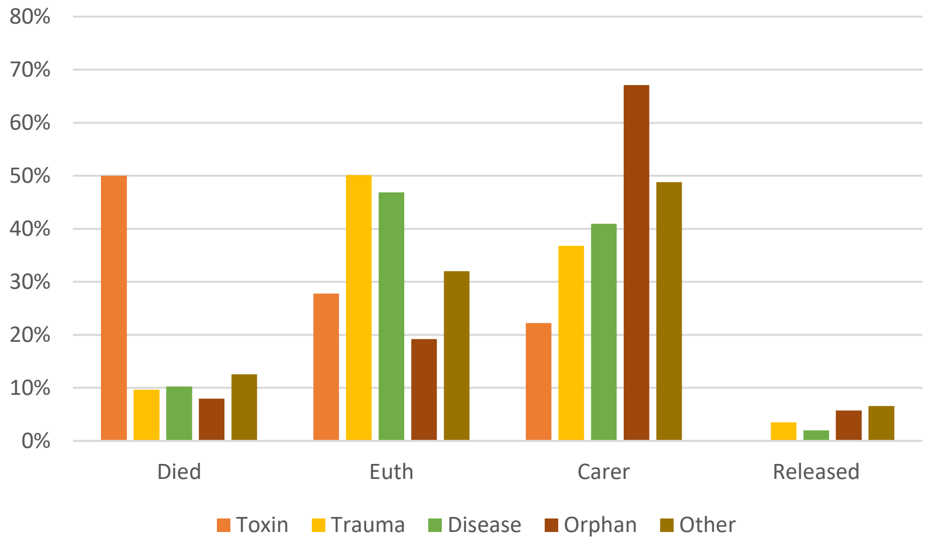

Figure 12: Outcome for different reasons of admission at Byron Bay Wildlife Hospital.

As shown in Figure 12, the outcome was best for orphaned patients and worst for patients affected by trauma or toxin at Byron Bay Hospital.

In the following sections the most common species are presented, the complete list of species can be found in Appendix 2.

5.1 Amphibians

Table 1: Amphibian species admitted to Byron Bay Wildlife Hospital.

Amphibian species ***Byron Bay Wildlife Hospital***	**% of amphibians**	**% of all patients**
Green Tree Frog	86.6%	3.2%
Dainty Green Tree Frog	6.2%	0.2%
Bleating Tree Frog	2.1%	0.1%
Cane Toad	2.1%	0.1%
Leaf Green Tree Frog	1.0%	0.04%
Striped Marsh Frog	1.0%	0.04%
Striped Rocket Frog	1.0%	0.04%

A total of 97 amphibians distributed over 7 different species were admitted to Byron Bay Wildlife Hospital.

Only one amphibian, a green tree frog, was admitted to Adelaide Koala and Wildlife Centre. This corresponds to 0.01% of all admitted patients at that hospital.

5.2 Birds

Table 2: The most common species of birds admitted to Byron Bay Wildlife Hospital.

Most common bird species ***Byron Bay Wildlife Hospital***	**% of birds**	**% of all patients**
Rainbow Lorikeet	10.1%	6.1%
Tawny Frogmouth	7.9%	4.8%
Australian Magpie	7.2%	4.4%
Laughing Kookaburra	5.8%	3.5%
Noisy Miner	5.3%	3.2%

A total of 1 580 birds distributed over 143 different species or descriptions were admitted to Byron Bay Wildlife.

Table 3: The most common species of birds admitted to Adelaide Koala and Wildlife Centre.

Most common bird species ***Adelaide Koala and Wildlife Centre***	**% of birds**	**% of all patients**
Rainbow Lorikeet	25.0%	13.6%
Australian Magpie	18.4%	10.0%
Pigeon	9.1%	4.9%
Galah	5.0%	2.7%
Musk Lorikeet	4.6%	2.5%

A total of 3 873 birds distributed over 45 different species or descriptions were admitted to Adelaide Koala and Wildlife Centre.

5.3 Mammals

Table 4: The most common species of mammals admitted to Byron Bay Wildlife Hospital.

Most common mammal species ***Byron Bay Wildlife Hospital***	**% of mammals**	**% of all patients**
Black Flying Fox	16.4%	3.1%
Short-beaked Echidna	11.5%	2.1%
Short-eared Brushtail Possum	11.2%	2.1%
Red-necked Wallaby	8.8%	1.6%
Grey-headed Flying Fox	6.1%	1.1%

A total of 489 mammals distributed over 40 different species or descriptions were admitted to Byron Bay Wildlife Hospital.

Table 5: The most common species of mammals admitted to Adelaide Koala and Wildlife Centre.

Most common mammal species ***Adelaide Koala and Wildlife Centre***	**% of mammals**	**% of all patients**
Koala	34.8%	14.2%
Brushtail Possum	31.5%	12.9%
Common Ringtail Possum	26.1%	10.7%
Grey Kangaroo	4.9%	2.0%
Red Kangaroo	0.9%	0.4%

A total of 2 917 mammals distributed over 14 different species or descriptions were admitted to Adelaide Koala and Wildlife Centre.

5.4 Reptiles

Table 6: The most common species of reptiles admitted to Byron Bay Wildlife Hospital.

Most common reptile species ***Byron Bay Wildlife Hospital***	**% of reptiles**	**% of all patients**
Coastal Carpet Python	32.0%	5.5%
Eastern Blue-tongued Lizard	15.9%	2.7%
Eastern Water Dragon	14.8%	2.5%
Green Sea Turtle	9.6%	1.6%
Eastern Bearded Dragon	4.3%	0.7%

A total of 447 reptiles distributed over 32 different species or descriptions of species were admitted to Byron Bay Wildlife Hospital.

Table 7: The most common species of reptiles admitted to Adelaide Koala and Wildlife Centre.

Reptile species ***Adelaide Koala and Wildlife Centre***	**% of reptiles**	**% of all patients**
Blue Tongue Lizard	73.8%	2.8%
Turtle	14.9%	0.6%
Bearded Dragon	5.8%	0.2%
Shingleback Skink	4.4%	0.2%
Unidentified reptile species	0.7%	0.03%
Water Dragon	0.4%	0.01%

A total of 275 reptiles distributed over 6 different species or descriptions were admitted to Adelaide Koala and Wildlife.

6 Discussion

6.1 Results

This study found birds, followed by mammals, to be the most common wildlife patients in the investigated regions. This is supported nationally by Orr and Tribe (2018) and in New South Wales by Tribe and Brown (2008) and Haering et al. (2021). Other studies have found mammals to be the most common patient in Victoria and southern Queensland which indicates that geographical variations exist (Tribe & Brown 2008; Taylor-Brown et al. 2019). This could possibly explain the difference in admitted mammals between the two hospitals. Other factors, such as proximity to larger cities, specialisation of the hospital, expertise of collaborating carers and competitive situations can also influence the type of patients admitted into care.

Some species were more common than others. Rainbow lorikeets were the most common bird species at both hospitals in this study, shown also by Taylor-Brown et al. (2019) in southern Queensland. Taylor-Brown et al. (2019) also supports that green tree frogs are the most commonly admitted amphibian species and that blue-tongued lizards are commonly seen.

Monthly variations in the number of admissions were seen for both hospitals, most prominent for birds admitted to Adelaide Koala and Wildlife Centre. Peaks occurred around November each year, possibly because chicks are leaving nests around this time. There were indications of a similar pattern for birds in the data from Byron Bay Wildlife hospital. The χ^2 test confirmed that variations exist, however this does not confirm that these variations are seasonal. There were for example also a trend towards an increasing number of patients, this would also have been considered a significant variation by the test used in this report. More detailed analyses are needed to fully understand the seasonal variations.

It is important to note that the reasons for admissions mirror injuries in animals admitted to a veterinary hospital, this does not necessarily correspond to the most common injuries in wildlife overall. There are several factors influencing whether the animal is admitted into care or not. Animals in a visible place close to humans are more easily found and some animals may be more popular than others in the eyes of people and thus have a higher chance of receiving help. Injuries that cause the animal to die at the scene are also rarely admitted, such as amphibians hit by cars.

Trauma was the most common reason for admission for both hospitals. This is supported by previous research by Orr and Tribe (2018) and for single species by Scheelings (2016), Scheelings (2015), Le Souëf et al. (2015), Griffith et al. (2013) and Burton and Tribe (2016). Trauma was the main cause for admission of all species except amphibians. One explanation can be that there were few amphibians admitted overall compared to the other groups, making the results less reliable for amphibians. Another explanation can be that amphibians are less likely to be brought to a wildlife hospital after traumatic events, possibly because of a high mortality when affected by trauma. It is also possible that signs of trauma are not recognised in amphibians to the same extent as in other animals.

For birds, mammals and reptiles the most common reason for trauma were car strikes. This is supported by Taylor-Brown et al. (2019), Orr and Tribe (2018), Tribe and Brown (2008) and Kwok et al. (2021) as well as several studies on individual species. Another common cause of trauma in mammals was entanglement, possibly because of the large proportion of flying foxes in this group. Scheelings and Frith (2015) and Mo et al. (2020) have shown that entanglement is the major cause of trauma in flying foxes. Reptiles were instead overrepresented in the category "Animal attack", similarly to results shown by Shine and Koenig (2001), Koenig et al. (2002) and Scheelings (2015). The fact that many reptiles are relatively small and ground dwelling might make them more vulnerable to attacks compared to the other groups. Birds being the only animals affected by window strikes was expected.

Since the categories "healthy" and "orphaned" only occurred for one hospital, the number of admissions to the other hospital was listed as zero even if this might not be the actual case. A theory is that at Adelaide Koala and Wildlife Centre orphaned animals might be listed as healthy if there were no other obvious admission signs or end up in the category "Other". Similarly, healthy animals admitted to Byron Bay Hospital might have been labelled as admitted due to "Misadventure" and thus fallen under the category "Other". This means that the results in this study should not be interpreted as no orphans were admitted to Adelaide Koala and Wildlife Centre and no healthy animals were admitted to Byron Bay Wildlife hospital.

Orphans being a common reason for admission is supported by Orr and Tribe (2018), Tribe and Brown (2008), Taylor-Brown et al. (2019) and by Kwok et al. (2021). In this study the most commonly admitted orphans were birds and mammals, similar results are shown by Taylor-Brown et al. (2019).

Reptiles in the category "Disease" were much lower for animals admitted to Adelaide Koala and Wildlife Centre compared to Byron Bay Wildlife Hospital. Again, this could potentially be explained by how the hospitals categorises admissions. Byron Bay Wildlife Hospital had a lot more subcategories falling under disease compared to Adelaide Koala and Wildlife Centre, creating a possible discrepancy between the hospitals. At Adelaide Koala and Wildlife Centre the category “combo/other” is expected to be common for reptiles with disease since disease itself might not be recognized by people. However, the disease can cause reptiles to be slower, become an easier target for animals or to end up on roads and thus be admitted to the hospital for other reasons than the underlying disease. When interpreting the results of this study reptiles cannot be assumed to be less affected by disease in one place compared to the other.

Outcome after admission was found to be surprisingly equal between the two hospitals and aligns with results presented by previous research. Studies have found that the mortality of admitted wildlife spans from 45% to 65% and that between 7% and 10% of animals at veterinary hospitals die unassisted (Taylor-Brown et al. 2019; Le Souëf et al. 2015; Thomson et al. 2020; Scheelings 2016; Scheelings & Frith 2015; Burton & Tribe 2016; Scheelings 2015).

The mortality around 50% shows that veterinary care for wildlife often consists of making the hard but important decision to euthanize wildlife without a good prognosis to live self-sufficiently in the wild. The high admission rate of trauma patients might further contribute to the mortality since trauma was found to often have a negative outcome. This, as well as the better prognosis for orphans, is supported by Taylor-Brown et al. (2019).

Contrary to the situation at veterinary hospitals, two studies show that deaths at volunteer wildlife care organisations are often unassisted i.e. without the use of euthanasia (Mo et al. 2020; Tribe & Brown 2008). In the study by Mo et al. (2020) the high number of deaths without euthanasia was largely influenced by bats admitted because of heat stress, only 92 out of 1017 bats that died in this group was euthanized. The discrepancy, when compared to veterinary hospitals, is not necessary caused by different assessments of the prognosis for the patient, it can also be caused by the fact that wildlife care organizations often see patients earlier than the veterinary hospitals when picking up patients from the location of the incident. At hospitals a decision to euthanize can be completed quickly, wildlife carers will however often need to travel to a veterinarian and might not have access to a veterinary hospital that is opened all around the clock. There are currently not enough studies to draw any conclusion to whether the discrepancy exists or if it is an artefact caused by differences in the study design or data evaluation.

6.2 Limitations

There are several different sources of error that could have influenced the results presented in this study. The patient history of wildlife is typically unknown upon arrival to the hospital and the reason for admission can be vague. The patient can also fit into more than one category, such as an orphan with a traumatic injury. Interpretation will thus depend on the person doing triage and may therefore not be consistent. The identification of different species can also be difficult, especially for young individuals that might not have their adult colour or features yet.

The data from Adelaide Koala and Wildlife Centre contained deviations in the total number of patients in the different summaries used as input to this study. These deviations most likely stem from human error when the data was filed each month at the hospital. The data on admitted species was considered by the hospital to be the most reliable number. In comparison to this number the monthly mean deviation as an absolute value was 1.9% for admission reasons data and 2.2% for outcome data. Both positive and negative deviations occurred.

The categories used in the data included both specific categories and wider categories of the same type, for example “Hit by car” and “Trauma”. The number of animals in the specific categories is thus not necessarily all animals admitted for that reason, several others may have been included in the wider categories.

The categories used to list reasons for admission were different for the two hospitals. For Byron Bay Wildlife Hospital the categories also varied over time due to several updates to the triage form. The merge into wider categories can introduce bias since the choice of wider categories can be done in several different ways. Some categories were hard to place, such as “Lorikeet Paralysis Syndrome” since it is not currently established if this is caused by disease or by toxin.

6.3 Future research

Several different topics are interesting candidates for future research. More research is for example needed to understand the possible discrepancy between use of euthanasia in veterinary hospitals and in wildlife care organisations. Investigations on fluid therapy for exotic species, especially reptiles and amphibians, are needed to provide evidence-based care for wildlife patients as well as exotic pets. More information on the pharmacokinetics of different drugs in wildlife species can contribute to further improvements. Similar to how cats and dogs differs, differences can also be expected within similar groups of wildlife. It is also important to evaluate the effects of any care given, for example looking at the outcome of patients put into care or the long-term effects after the animal has been released.

6.4 Conclusion

In conclusion this study confirms what several previous studies has shown. The most common types of animals admitted to wildlife hospitals are birds, the greatest reason for admission is trauma, most often caused by car strikes. Mortality rate for wildlife admitted into veterinary care is high, around 50%, and the outcome is worst for trauma patients but better for orphans. This study only reviewed data from two veterinary hospitals in the southeast part of Australia, more research is needed to understand the situation nationwide. This study also found that there is a need for more research on veterinary care and treatment of wildlife, especially from the perspective of the veterinary nurse.

References

Abou-Madi, N. (2001). Avian Anesthesia. *Veterinary Clinics of North America: Exotic Animal Practice*. 4(1), 147-167. https://doi.org/10.1016/S1094-9194(17)30055-5

Australian Government (2023). *Our role in protecting the environment under the EPBC Act.* https://www.dcceew.gov.au/environment/epbc/our-role [2023-03-18]

Bowles, H., Lichtenberger, M., & Lennox, A. (2007). Emergency and Critical Care of Pet Birds. *Veterinary Clinics of North America: Exotic Animal Practice.* 10(2), 345-394. https://doi.org/10.1016/j.cvex.2007.04.001

Burton, E. & Tribe, A. (2016). The rescue and rehabilitation of koalas (Phascolarctos cinereus) in Southeast Queensland. *Animals.* 6(9), 56. https://doi.org/10.3390/ani6090056

Camacho, M., del Pino Quintana, M., Calabuig, P., Luzardo, O.P., Boada, L.D., Zumbado, M., & Orós, J. (2015). Acid-Base and Plasma Biochemical Changes Using Crystalloid Fluids in Stranded Juvenile Loggerhead Sea Turtles (Caretta caretta). *PLoS ONE.* 10(7): e0132217. https://doi.org/10.1371/journal.pone.0132217

Charalambous, R. & Narayan, E. (2020). A 29-year retrospective analysis of koala rescues in New South Wales, Australia. *PloS ONE.* 15(10), e0239182. https://doi.org/10.1371/journal.pone.0239182

Chavez, W. & Echols, M.S. (2007). Bandaging, Endoscopy, and Surgery in the Emergency Avian Patient. *Veterinary Clinics of North America: Exotic Animal Practice.* 10(2), 419-436. https://doi.org/10.1016/j.cvex.2007.02.005

Clayton, L.A. & Gore, S.R. (2007). Amphibian Emergency Medicine. *Veterinary Clinics of North America: Exotic Animal Practice.* 10(2), 587-620. https://doi.org/10.1016/j.cvex.2007.02.004

Colgan, S. & Green, L. (2018). Laparoscopic ovariectomy in eastern grey kangaroos (Macropus giganteus) and red kangaroos (Macropus rufus). *Australian veterinary journal.* 96(3), 86–92. https://doi.org/10.1111/avj.12675

Cooper, J. & Cooper, M.E. (2006). Ethical and legal implications of treating casualty wild animals. *In Practice.* 28(1), 2-6. https://doi.org/10.1136/inpract.28.1.2

Cope, H.R., McArthur, C., Dickman, C.R., Newsome, T.M., Gray, R. & Herbert, C.A. (2022). A systematic review of factors affecting wildlife survival during rehabilitation and release. *PLoS ONE*. 17(3), e0265514. https://doi.org/10.1371/journal.pone.0265514

Cowan, M., Blythman, M., Angus, J. & Gibson, L. (2020). Post-release monitoring of western grey Kangaroos (Macropus fuliginosus) relocated from an urban development site. Animals (Basel), 10 (10), 1–23. https://doi.org/10.3390/ani10101914

Crawshaw, G.J. (1998). Amphibian Emergency and Critical Care. *Veterinary Clinics of North America: Exotic Animal Practice.* 1(1), 207-231. https://doi.org/10.1016/S1094-9194(17)30162-7

Daoust, P.Y., Dobbin, G.V. & Dawson, S.D. (2008). Descriptive anatomy of the subcutaneous air diverticula in the Northern Gannet Morus bassanus. *Seabird*. 21, 64-76. http://www.seabirdgroup.org.uk/journals/seabird-21/seabird-21-64.pdf

Dawson T.J. & Hulbert A.J. (1970). Standard metabolism, body temperature, and surface areas of Australian marsupials. *American Journal of Physiology Legacy Content.* 218(4), 1233-1238. https://doi.org/10.1152/ajplegacy.1970.218.4.1233

Dennis, T.E. & Shah, S.F. (2012). Assessing Acute Effects of Trapping, Handling, and Tagging on the Behavior of Wildlife Using GPS Telemetry: A Case Study of the Common Brushtail Possum. *Journal of applied animal welfare science*. 15(3), 189–207. https://doi.org/10.1080/10888705.2012.683755

Early, G. (2008). Australia's National Environmental Legislation and Human/Wildlife interactions. *Journal of international wildlife law and policy.*11(2-3), 101-155. https://doi.org/10.1080/13880290802470141

Englefield, B., Blackman, S.A., Starling, M. & McGreevy, P.D. (2019). A review of Australian animal welfare legislation, regulation, codes of practice, and policy, and their influence on stakeholders caring for wildlife and the animals for whom they care. *Animals.* 9(6), 335. https://doi.org/10.3390/ani9060335

Eshar, D. & Weinberg, M. (2010). Venipuncture in bats. *Lab animal.* 39(6), 175-176. https://doi.org/10.1038/laban0610-175

Geiser, F. & Körtner, G. (2010). Hibernation and daily torpor in Australian mammals. *Australian Zoologist.* 35(2), 204-215. https://doi.org/10.7882/AZ.2010.009

Gentz, E.J. (2007). Medicine and Surgery of Amphibians. *ILAR Journal*. 48(3), 255-259. https://doi.org/10.1093/ilar.48.3.255

Geyle, H.M., Woinarski, J.C., Baker, G.B., Dickman, C.R., Dutson, G., Fisher, D.O., Ford, H., Holdsworth, M., Jones, M.E., Kutt, A. & Legge, S. (2018). Quantifying extinction risk and forecasting the number of impending Australian bird and mammal extinctions. *Pacific Conservation Biology*. 24(2), 157-167. https://doi.org/10.1071/PC18006

Glendinning, I. (2022). Endotracheal intubation of small exotic mammals. *The Veterinary Nurse.* 13(6), 267-271. https://doi.org/10.12968/vetn.2022.13.6.267

Godthelp, H., Archer, M., Cifelli, R., Hand, S.J. & Gilkeson, C.F. (1992). Earliest known Australian Tertiary mammal fauna. *Nature.* 356(6369), 514-516. https://doi.org/10.1038/356514a0

Gonzalez-Astudillo, V., Allavena, R., McKinnon, A., Larkin, R. & Henning, J. (2017). Decline causes of Koalas in South East Queensland, Australia: a 17-year retrospective study of mortality and morbidity. *Scientific reports.* 7(1), 42587. https://doi.org/10.1038/srep42587

Graham, J.E. & Heatley, J.J. (2007). Emergency Care of Raptors. *Veterinary Clinics of North America: Exotic Animal Practice.* 10(2), 395-418. https://doi.org/10.1016/j.cvex.2007.01.003

Griffith, J.E., Dhand, N.K., Krockenberger, M.B. & Higgins, D.P. (2013). A retroprospective study of admission trends of koalas to a rehabilitation facility over 30 years. *Journal of wildlife diseases*. 49(1), 18-28. https://doi.org/10.7589/2012-05-135

Gunkel, C. & Lafortune, M. (2005). Current Techniques in Avian Anesthesia. *Seminars in Avian and Exotic Pet Medicine.* 14(4), 263-276. https://doi.org/10.1053/j.saep.2005.09.006

Hadfield, C.A. & Whitaker, B.R. (2005). Amphibian Emergency Medicine and Care. *Seminars in Avian and Exotic Pet Medicine. 14*(2), 79-89. https://doi.org/10.1053/j.saep.2005.04.003

Haering, R., Wilson, V., Zhuo, A. & Stathis, P. (2021). A survey of veterinary professionals about their interactions with free-living native animals and the volunteer wildlife rehabilitation sector in New South Wales, Australia. *Australian Zoologist*. 41(2), 254–282. https://doi.org/10.7882/AZ.2020.045

Hawkins, M.G. (2006). The use of analgesics in birds, reptiles, and small exotic mammals. *Journal of Exotic Pet Medicine*. 15(3), 177-192. https://doi.org/10.1053/j.jepm.2006.06.004

Horgan, M.D, Knych, H.K., Siksay, S.E. & Duerr, R.S. (2020). Pharmacokinetics of a Single Dose of Oral Meloxicam in Rehabilitated Wild Brown Pelicans (Pelecanus occidentalis). *Journal of Avian Medicine and Surgery.* 34(4), 329-337. https://doi.org/10.1647/1082-6742-34.4.329

Jenkins, J.R. (2016). Critical Care of Pet Birds. *Veterinary Clinics of North America: Exotic Animal Practice.* 19(2), 501-512. https://doi.org/10.1016/j.cvex.2016.01.014

Johnson, S.D., Madden, C., Nicolson, V., Cowin, G., Pyne, M. & Booth, R. (2006). Venipuncture in the short-beaked Echidna. *Australian Veterinary Journal.* 84(1-2), 66-67. https://doi.org/10.1111/j.1751-0813.2006.tb13132.x

Koenig, J., Shine, R. & Shea, G. (2002). The Dangers of Life in the City: Patterns of Activity, Injury and Mortality in Suburban Lizards (Tiliqua scincoides). *Journal of Herpetology*. 36(1), 62-68. https://doi.org/10.1670/0022-1511(2002)036[0062:TDOLIT]2.0.CO;2

Kubiak, M. (2017). Anaesthetic choice in avian patients. *Companion Animal.* 22(1), 44-49. https://doi.org/10.12968/coan.2017.22.1.44

Kwok, A.B.C., Haering, R., Travers, S.K. & Stathis, P. (2021). Trends in wildlife rehabilitation rescues and animal fate across a six-year period in New South Wales, Australia. *PLoS ONE.* 16(9), e0257209. https://doi.org/10.1371/journal.pone.0257209

Le Souëf, A., Holyoake, C., Vitali, S. & Warren, K. (2015). Presentation and prognostic indicators for free-living black cockatoos (Calyptorhynchus spp.) admitted to an Australian zoo veterinary hospital over 10 years. *Journal of Wildlife Diseases.* 51(2), 380-388. https://doi.org/10.7589/2014-08-203

Lennox, A.M. (2007). Emergency and Critical Care Procedures in Sugar Gliders (Petaurus breviceps), African Hedgehogs (Atelerix albiventris), and Prairie Dogs (Cynomys spp). *The veterinary clinics of North America. Exotic animal practice.* 10(2), 533–555. https://doi.org/10.1016/j.cvex.2007.01.001

Lichtenberger, M. (2005). Determination of Indirect Blood Pressure in the Companion Bird. *Seminars in Avian and Exotic Pet Medicine.* 14(2), 149-152. https://doi.org/10.1053/j.saep.2005.04.010

Lichtenberger, M. & Ko, J. (2007). Anesthesia and Analgesia for Small Mammals and Birds. *The veterinary clinics of North America. Exotic animal practice*. 10(2), 293–315. https://doi.org/10.1016/j.cvex.2006.12.002

Lierz, M. & Korbel, R. (2012). Anesthesia and Analgesia in Birds. *Journal of Exotic Pet Medicine.* 21(1), 44-58. https://doi.org/10.1053/j.jepm.2011.11.008

Long, S.Y. (2016). Approach to Reptile Emergency Medicine. *Veterinary Clinics: Exotic Animal Practice.* 19(2), 567 - 590. https://doi.org/10.1016/j.cvex.2016.01.013

Macgregor, J. W., Holyoake, C., Fleming, P. A., Robertson, I. D., Connolly, J. H. & Warren, K. S. (2014). Investigation into the characteristics, triggers and mechanism of apnoea and bradycardia in the anaesthetized platypus (Ornithorhynchus anatinus). *Conservation Physiology*. 2(1), cou053. https://doi.org/10.1093/conphys/cou053

Machin, K.L. (1999). Amphibian pain and analgesia. *Journal of Zoo and Wildlife Medicine.* 2-10. https://www.jstor.org/stable/20095815

Mans, C. (2014). Sedation of pet birds. *Journal of Exotic Pet Medicine.* 23(2), 152-157. https://doi.org/10.1053/j.jepm.2014.02.009

Martinez-Jimenez, D. & Hernandez-Divers, S.J. (2007). Emergency Care of Reptiles. *Veterinary Clinics of North America: Exotic Animal Practice.* 10(2), 557-585. https://doi.org/10.1016/j.cvex.2007.02.003

Mathews, K.O., Toribio, J-A., Norris, J.M., Phalen, D., Wood, N., Graves, S.R., Sheehy, P.A. & Bosward, K.L. (2021). Coxiella burnetii seroprevalence and Q fever in Australian wildlife rehabilitators. *One Health*. 12, 100197. https://doi.org/10.1016/j.onehlt.2020.100197

McLaughlin, A. & Strunk, A. (2016). Common emergencies in small rodents, hedgehogs, and sugar gliders. *Veterinary Clinics: Exotic Animal Practice.* 19(2), 465-499. https://doi.org/10.1016/j.cvex.2016.01.008

Mitchell, M.A. & Diaz-Figueroa, O. (2004). Wound management in reptiles. *Veterinary Clinics: Exotic Animal Practice.* 7(1), 123 - 140. https://doi.org/10.1016/j.cvex.2003.08.006

Mo, M., Roache, M., Haering, R. & Kwok, A. (2020). Using wildlife carer records to identify patterns in flying-fox rescues: a case study in New South Wales, Australia. *Pacific Conservation Biology.* 27(1), 61-69. https://doi.org/10.1071/PC20031

Mullineaux E. (2014). Veterinary treatment and rehabilitation of indigenous wildlife. *Journal of small animal practice.* 55(6), 293-300. https://doi.org/10.1111/jsap.12213

Music, M.K. & Strunk, A. (2016). Reptile Critical Care and Common Emergencies. *Veterinary Clinics: Exotic Animal Practice.* 19(2), 591-61. https://doi.org/10.1016/j.cvex.2016.01.009

Nicol S.C. (2017). Energy Homeostasis in Monotremes. *Frontiers in Neuroscience*. 11, 195. https://doi.org/10.3389/fnins.2017.00195

Norton, T.M. (2005). Chelonian Emergency and Critical Care. *Seminars in Avian and Exotic Pet Medicine.* 14(2), 106-130. https://doi.org/10.1053/j.saep.2005.04.005

O'Connor, T., Finlaison, D. & Kirkland, P. (2022). What can we learn from over a decade of testing bats in New South Wales to exclude infection with Australian bat lyssaviruses?. *Australian veterinary journal.* 100(4), 172–180. https://doi.org/10.1111/avj.13143

Orr, B. & Tribe A. (2018). Animal welfare implications of treating wildlife in Australian veterinary practices. *Australian Veterinary Journal.* 96(12), 475-480. https://doi.org/10.1111/avj.12765

Parkinson, L.A. & Mans, C. (2020). Evaluation of subcutaneously administered electrolyte solutions in experimentally dehydrated inland bearded dragons (Pogona vitticeps). *American Journal of Veterinary Research.* 81(5), 437-441. https://doi.org/10.2460/ajvr.81.5.437

Quigley, B.L. & Timms, P. (2020). Helping koalas battle disease – Recent advances in Chlamydia and koala retrovirus (KoRV) disease understanding and treatment in koalas. *FEMS microbiology reviews.* 44(5), 583-605. https://doi.org/10.1093/femsre/fuaa024

Raftery, A. (2013). Avian anaesthesia. *In Practice.* 35(5), 272-278. https://doi.org/10.1136/inp.f2861

Riley, J. & Barron, H. (2016). Wildlife Emergency and Critical Care. *Veterinary Clinics: Exotic Animal Practice.* 19(2), 613 - 626. https://doi.org/10.1016/j.cvex.2016.01.004

Scheelings T.F. (2015). Morbidity and Mortality of Reptiles Admitted to the Australian Wildlife Health Centre, Healesville Sanctuary, Australia, 2000–13. *Journal of Wildlife Diseases.* 51(3), 712-718. https://doi.org/10.7589/2014-09-230

Scheelings T.F. (2016). Morbidity and mortality of monotremes admitted to the Australian Wildlife Health Centre, Healesville Sanctuary, Australia, 2000-2014. *Australian veterinary journal.* 94(4), 121-124. https://doi.org/10.1111/avj.12417

Scheelings, T.F. & Frith, S.E. (2015). Anthropogenic Factors Are the Major Cause of Hospital Admission of a Threatened Species, the Grey-Headed Flying Fox (Pteropus poliocephalus), in Victoria, Australia. *PloS ONE.* 10(7), e0133638–e0133638. https://doi.org/10.1371/journal.pone.0133638Schumacher, J. (2003). Reptile respiratory medicine. *Veterinary Clinics: Exotic Animal Practice.* 6(1), 213 - 231. https://doi.org/10.1016/S1094-9194(02)00020-8

Schlagloth, R., Santamaria, F., Melzer, A., Keatley, M.R. & Houston, W. (2022). Vehicle collisions and dog attacks on Victorian koalas as evidenced by a retrospective analysis of sightings and admission records 1997 – 2011. *Australian Zoologist.* 42(3), 655–666. https://doi.org/10.7882/AZ.2021.030

Shine, R. & Koenig, J. (2001). Snakes in the garden: an analysis of reptiles “rescued” by community-based wildlife carers. Biological Conservation. 102(3), 227-348. https://doi.org/10.1016/S0006-3207(01)00102-1

Sladky, K.K. & Mans, C. (2012). Clinical Anesthesia in Reptiles. *Journal of Exotic Pet Medicine.* 21(1), 17-31. https://doi.org/10.1053/j.jepm.2011.11.013

Stidworthy, M.F. & Denk, D. (2018). Chapter 27 - Sphenisciformes, Gaviiformes, Podicipediformes, Procellariiformes, and Pelecaniformes. I: Terio, K.A., McAloose, D. & St. Leger, J. (red.) *Pathology of Wildlife and Zoo Animals.* Cambridge: Academic Press. 653-686. https://doi.org/10.1016/B978-0-12-805306-5.00027-4

Stoskopf, M.K. (1994). Pain and analgesia in birds, reptiles, amphibians, and fish. *Investigative ophthalmology & visual science*. 35(2), 775-780. https://iovs.arvojournals.org/article.aspx?articleid=2161976

Sykes, J.M. & Greenacre, C.B. (2006). Techniques for Drug Delivery in Reptiles and Amphibians. *Journal of Exotic Pet Medicine.* 15(3), 210-217. https://doi.org/10.1053/j.jepm.2006.06.007

Taylor-Brown, A., Booth, R., Gillett, A., Mealy, E., Ogbourne, S.M., Polkinghorne, A. & Conroy, G.C. (2019). The impact of human activities on Australian wildlife. *PLoS ONE.* 14(1), e0206958. https://doi.org/10.1371%2Fjournal.pone.0206958

Thomson, V.K., Jones, D., McBroom, J., Lilleyman, A. & Pyne, M. (2020). Hospital Admissions of Australian Coastal Raptors Show Fishing Equipment Entanglement is an Important Threat. *Journal of Raptor Research.* 54(4), 414-423. https://doi.org/10.3356/0892-1016-54.4.414

Tribe, A. & Brown, P.R. (2008). The role of wildlife rescue groups in the care and rehabilitation of Australian fauna. *Human Dimensions of Wildlife*. 5(2), 69-82. https://doi.org/10.1080/10871200009359180

Wade, L. (2009). Restraint and administration of subcutaneous fluids and intramuscular injections in psittacine birds. *Lab animal*. 38(9), 292-293. https://doi.org/10.1038/laban0909-292

Walker, I.D.F. & Whitaker, B.R. (2000). Amphibian Therapeutics. *Veterinary Clinics of North America: Exotic Animal Practice.* 3(1), 239-255. https://doi.org/10.1016/S1094-9194(17)30103-2

Wilkinson, S.L. (2014). Guide to Venomous Reptiles in Veterinary Practice. *Journal of Exotic Pet Medicine.* 23(4), 337-346. https://doi.org/10.1053/j.jepm.2014.07.012

Acknowledgements

We would like to express our deepest gratitude to our supervisor, Maria Andersson, for her generous guidance and support. This endeavour would not have been possible without the major help from everyone at Adelaide Koala and Wildlife Centre and Byron Bay Wildlife Hospital. Their expertise and generous help have taught us a great deal about how to care for wildlife, despite us living on opposite sides of the globe. We are also grateful for all advise and encouragement provided by our classmates. Lastly, we would like to recognize the patience and support provided by our families and our dogs Benji and Ejra.

Appendix 1

Unique descriptions used by Adelaide Koala and Wildlife Centre	Overall Categories	Detailed categories for Byron Bay Wildilfe Hospital	Unique descriptions used by Byron Bay Wildlife Hospital
Toxin	Toxin	Toxin	Botulism
			Poisoned
			Possible Rat Bait
			Tick Paralysis
			Toxin
Trauma	Trauma	Animal Attack	Animal Attack
			Animal Attack - Bird
			Animal attack - bird/dog/cat
			Animal Attack - Cat
			Animal Attack - Dog
			Attacked by Birds
			Domestic Animal Attack
		Collision	Collision
		Entanglement	Barb Wire Entanglement
			Entanglement
			Entanglement - Barb Wire
			Entanglement - fencing
			Entanglement - Fishing Line
			Entanglement - Mouse Trap
			Entanglement - netting
			Entanglement - Tape
			Fishing Line Entanglement
			Fishing Line Entanglement/ Injestion
		Hit by Car	HBC
			Motor Vehicle
		Machinery Injury	Machinery Injury
		Natural Predation	Natural Predation
		Trauma	Soft Tissue Trauma
			Trauma
		Window Strike	Window Strike
		Burns	Burns
			Fire

Disease	Disease	Disease	Chronic Illness
			Dermatitis
			Diarrhoea
			Disease
			Illness
			Impacted Uropygial Gland
Diarrhea			Impaction
			Stomatitis
		Infection - Viral/Bacterial/Fungal	Avian Pox
			Fibropapilloma
			Infected Vent
			Infection
Renal failure			Infection - Bacterial
			Infection - bacterial/viral/fungal
			Infection - Fungal
			Infection - Viral
			Pox Virus
			PBFD
Chlamydia		Infection - Parasitic	Infection - Parasitic
			Parasite Infestation
			Parasitic Infection
			Tape Worm Burden
		Neurological	Neurological
			Other - neurological
		Faecal Sample	Faecal sample
Healthy	Healthy		
	Orphan	Orphan	Fallen from nest
			Fallen from nest/ orphan
			Fell from Nest
			Fledgling
			Found on Ground
			Hatchling
			Orphan
			Orphan/Illness
			Orphaned
Heat stress / dehadration	Other	Anthropogenic	Anthropogenic
		Dead on Arrival	DOA
		Exhaustion	Exhaustion
		Lorikeet Paralysis Syndrome	Lori Paralysis
			Lori Paralysis Syndrome
			Lorikeet Paralysis
			LPS
		Misadventure	Misadventure
			Misadventure leading to injury/illness

			Misadventure resulting in Injury
Combo / other		Non Native Species	Feral Species
			Non Native
			Non Native Species
			Pest Species
		Oiled	Oiled
		Other	Other
			Other - lead toxicosis
		Pathology	Necropsy
			Pathology
		Plastic Ingestion	Plastic Ingestion
Unknown		Health Check	Currumbin Recheck
			Pre Release Check
		Stranded	Stranded
			Stranding
		Trapped	Trapped
		Unable to Fly	Unable to Fly
		Unknown	Unknown
			Blank
		Unsuitable Environment	Unsuitable Environment
		Weather Event	Weather Event

DOA = Dead On Arrival
HBC = Hit By Car
LPS = Lorikeet Paralysis Syndrome
PBFD = Psittacine Beak and Feather Disease

Appendix 2

	Patients admitted to Byron Bay Wildlife Hospital	Patients admitted to Adelaide Koala and Wildlife Centre
Amphibians (Amphibia)		
Anura		
Bleating Tree Frog	2	
Dainty Green Tree Frog	6	
Green Tree Frog	84	1
Leaf Green Tree Frog	1	
Striped Marsh Frog	1	
Striped Rocket Frog	1	
Non-native amphibians		
Cane Toad	2	
Birds (Aves)		
Accipitriformes		
Black-shouldered Kite	1	
Brown Goshawk	2	
Collared Sparrowhawk	2	
Grey Goshawk	3	
Osprey	*3*	
Pacific Baza	7	
Wedge-tailed Eagle	2	
Whistling Kite	1	
Aegotheliformes		
Owlet-nightjar	1	
Anseriformes		
Australian Wood Duck	15	
Black swan	1	
Duck	1	149
Pacific Black Duck	8	
Whistling Duck	1	
Apodiformes		
White-throated Needletail	1	
Caprimulgiformes		
White-throated Nightjar	1	
Charadriiformes		
Beach Stone-curlew	1	
Bush Stone-curlew	21	
Common Noddy	1	
Greater Crested Tern	15	
Little Tern	1	
Masked Lapwing	26	

Seagull		14
Silver Gull	14	
Sooty Tern	5	
White-capped Noddy	1	
Columbiformes		
Bar-shouldered Dove	7	
Brown Cuckoo-Dove	12	
Crested Pigeon	57	4
Pacific Emerald Dove	7	
Pigeon		352
Rose-crowned Fruit Dove	10	
Superb Fruit Dove	1	
Topknot Pigeon	9	
White-headed Pigeon	49	
Wompoo Fruit Dove	19	
Coraciiformes		
Azure Kingfisher	10	
Forest Kingfisher	1	
Kingfisher		1
Laughing Kookaburra	92	16
Oriental Dollarbird	5	
Rainbow Bee-eater	6	
Sacred Kingfisher	6	
Cuculiformes		
Brush Cuckoo	1	
Channel-billed Cuckoo	1	
Eastern Koel	2	
Fan-tailed Cuckoo	8	
Pheasant Coucal	9	
Shining Bronze Cuckoo	1	
Falconiformes		
Australian Hobby	2	1
Brown Falcon	2	
Peregrine Falcon	3	
Galliformes		
Australian Brush-turkey	28	
Gruiformes		
Australasian Swamphen	11	
Buff-banded Rail	3	
Chestnut Rail	1	
Dusky Moorhen	2	2
Pale-vented Bush-hen	1	
Passeriformes		
Australasian Figbird	45	
Australian Golden Whistler	1	

Australian Magpie	114	714
Black-chinned Honeyeater	1	
Black-faced Cuckoo-shrike	6	
Blue-faced Honeyeater	14	
Brown Honeyeater	5	
Butcherbird	2	
Common Mynah	1	
Crow	7	
Currawong	7	
Finch		1
Grey Butcherbird	3	
Honeyeater		46
Lewin's Honeyeater	8	
Little Raven	1	
Little Wattlebird	1	
Magpie-lark	17	114
Noisy Friarbird	1	
Noisy Miner	83	113
Noisy Pitta	3	
Olive-backed Oriole	6	
Paradise Riflebird	1	
Pied Butcherbird	13	
Pied Currawong	33	
Raven	2	
Raven / Crow		87
Red Wattlebird	2	
Red-backed Fairywren	1	
Red-browed Finch	3	
Regent Bowerbird	1	
Satin Bowerbird	5	
Silvereye	1	2
Spangled Drongo	6	
Swallow		17
Torresian Crow	18	
Wattlebird	3	70
Welcome Swallow	22	
White-breasted Woodswallow	1	
White-browed Scrubwren	1	
Willie Wagtail		6
Yellow-breasted Robin	4	
Pelecaniformes		
Australian Pelican	23	
Australian White Ibis	8	
Cattle Egret	7	
Egret	1	

Ibis	3	
Little Egret	3	
Royal Spoonbill	1	
White-faced Heron	9	
Phaethontiformes		
Red-tailed Tropicbird	4	
Phasianidae		
Brown Quail	1	
Quail		3
Red-backed Buttonquail	1	
Podargiformes		
Tawny Frogmouth	125	37
Procellariiformes		
Fairy Prion	1	
Gould's Petrel	1	
Little Shearwater	1	
Petrel	2	
Providence Petrel	1	
Shearwater	7	
Short-tailed Shearwater	6	
Wedge-tailed Shearwater	3	
Psittaciformes		
Australian King Parrot	4	
Budgerigar		29
Cockatiel		22
Corella	5	80
Eastern Rosella	21	
Galah	45	192
Little Corella	17	
Lorikeet	1	
Musk Lorikeet		177
Rainbow Lorikeet	160	970
Rosella	1	161
Scaly-breasted Lorikeet	55	
Sulphur-crested Cockatoo	7	49
Yellow-tailed Black Cockatoo	8	1
Sphenisciformes		
Australian Little Penguin	1	1
Strigiformes		
Australian Boobook	10	21
Australian Masked Owl	1	
Eastern Barn Owl	31	9
Powerful owl	1	
Sooty Owl	1	
Suliformes		

Australasian Darter	5	
Australasian Gannet	9	
Cormorant	2	2
Little Black Cormorant	3	
Little Pied Cormorant	1	
Pied Cormorant	18	
Bird Eggs		
Masked Lapwing Eggs	1	
Non-native species		
Alexandrine parrot		3
Common Blackbird	1	76
Common Starling		10
Domestic Canary		3
Domesticated Chicken		3
Homing Pigeon	1	
House Sparrow	1	41
Indian Mynah	2	
Indian Ringneck parrot		1
Japanese Quail	1	
Monk Parakeet		1
Pigeon/Dove (nonnative)		154
Rock Dove	6	
Spotted Turtle Dove	8	
Unidentified		
Unidentified bird species		118
Mammals (Mammalia)		
Chiroptera		
Black Flying Fox	80	
Chocolate Wattled Bat	1	
East-coast Free-tailed Bat	1	
Eastern Broad-nosed Bat	3	
Gould's Long-eared Bat	20	
Gould's Wattled Bat	2	
Grey-headed Flying Fox	30	
Little Bent-wing Bat	1	
Microbat	3	
Yellow-bellied Sheathtail Bat	1	
Diprotodontia		
Bettong		1
Brushtail Possum	11	920
Common Brushtail Possum	9	762
Eastern Grey Kangaroo	20	
Eastern Ringtail Possum	21	
Feathertail Glider	2	
Grey Kangaroo		142

Koala	7	1016
Red Kangaroo		26
Red-necked Pademelon	6	
Red-necked Wallaby	43	
Short-eared Brushtail Possum	55	
Southern Hariy-nosed Wombat		4
Squirrel Glider	13	
Sugar Glider	18	1
Swamp Wallaby	21	
Wallaby		15
Wallaroo		1
Whiptail Wallaby	1	
Monotremata		
Platypus	1	
Short-beaked Echidna	56	23
Peramelemorphia		
Bandicoot	1	
Northern Brown Bandicoot	13	
Long-nosed Bandicoot	17	
Rodentia		
Bush Rat	4	
Eastern Chestnut Mouse	2	
Rat (native)	1	
Rakali	1	
Rodent	1	
Swamp Rat	2	
Non-native mammals		
Black Rat	7	
Brown Rat	1	
European Fox	2	
European Hare	1	
Mouse (non-native)	2	1
Rat (non-native)	8	
Hare / Rabbit		5
Reptiles (Reptilia)		
Serpentes		
Australian Tree Snake	14	
Bandy Bandy	2	
Blind Snake	1	
Eastern Brown Snake	4	
Brown Tree Snake	2	
Coastal Carpet Python	143	
Eastern Small-eyed Snake	1	
Elegant Sea Snake	8	
Horned Sea Snake	5	

Red-bellied Black Snake	1	
Sea Snake	1	
Spectacled Sea Snake	1	
Stokes Sea Snake	1	
Yellow-bellied Sea Snake	5	
Lacertilia		
Bearded Dragon (Eastern/Central)		16
Eastern Bearded Dragon	19	
Eastern Blue-tongued Lizard	71	203
Eastern Water Dragon	66	1
Lace Monitor	6	
Land Mullet	1	
Pink-tongued Lizard	8	
Shingleback Skink		12
Testudines		
Broad-shelled River Turtle	1	
Eastern Long-necked Turtle	9	
Macquarie Turtle	8	
Eastern Snake-necked Turtle	9	
Green Sea Turtle	43	
Hawksbill Sea Turtle	1	
Loggerhead Sea Turtle	5	
Saw-shelled Turtle	6	
Turtle		41
Reptile Eggs		
Eastern Bearded Dragon Eggs	1	
Eastern Water Dragon Eggs	1	
Green Tree Snake Eggs	1	
Non-native reptiles		
Asian House Gecko	2	
Unidentified		
Unidentified reptile species		2
Sum	**2613**	**7066**

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