17

Boas and Pythons

Joanna Hedley

Boas and pythons are two of the most popular groups of nonvenomous snakes kept in captivity, ranging in size from dwarf boas of only 30–60 cm in length, up to the Green anaconda (*Eunectes murinus*) and Reticulated python (*Python reticulatus*) which may reach over 8 m. However, despite considerable variation in size, lifestyle, and external appearance, all these snakes share a number of common anatomical characteristics. Both boas and pythons possess a vestigial pelvic girdle and hind limbs (seen externally as small spurs either side of the cloaca). Unlike many other snakes, most also have a left lung which can be up to 75% as large as the right lung.

Pythons can be differentiated from boas by several external features. Although both types of snakes can have heat-sensing pits (labial pits) lining the upper lip, in pythons these pits are positioned centrally in the scales, as opposed to boas where the pits are positioned between the scales if present. A python also possesses extra postfrontal bones and premaxillary teeth, whereas a boa lacks these. Finally, examination of the tail reveals an undivided subcaudal scute in a boa, compared to divided scutes in a python.

Biological and environmental parameters of commonly kept boa and python species are listed in Table 17.1.

17.1 Boas

The taxonomy of boas (Table 17.2) can be confusing due to a recent reclassification (Pyron et al. 2014), but currently boas can be divided into the following subfamilies as defined by the Reptile Database (Uetz et al. 2017). The natural habitat and lifestyle can vary considerably according to species as shown by the following examples;

- **Boa constrictors (*Boa constrictor* and *Boa imperator*)**

The Boa constrictor (often known as the Common or Red tailed boa) (Figure 17.1) originates from Central and South America, where it is found throughout a variety of habitats from dense rainforest to drier lowlands. It lives a moderately arboreal lifestyle and is mostly crepuscular or nocturnal, but appears very adaptable and is often found around human habitats where rodent prey is plentiful. A number of subspecies exist and reclassification is ongoing. The two most common boas kept in captivity are *Boa constrictor constrictor* and *Boa imperator (*previously *B. c imperator)*. Both grow into large snakes, often at least 2–3 m in length and can live for 20–30 years in captivity.

- **Emerald tree boa (*Corallus caninus*)**

The Emerald tree boa as its name implies, lives an arboreal lifestyle, originating from the rainforests of South America where it is active at night. Juveniles have a distinctive brick-red to orange appearance, before gradually changing colour over a period of 12 months to the classic emerald green. In captivity, these snakes can be difficult to keep due to the challenges of mimicking their high humidity natural environment without compromising on temperature range or ventilation. They also appear easily stressed and have the reputation of a more aggressive temperament than some other boas.

- **Green anaconda (*Eunectes murinus*)**

The Green anaconda is found in the wetlands of South America where it lives a nocturnal lifestyle. The eyes and nares have a dorsal position on the anaconda's head allowing them to lie almost completely submerged to ambush prey. With a potential adult weight of >200 kg, the Green anaconda is the heaviest snake in the world and can overpower large prey animals including deer, wild pigs, and even caiman. These snakes can be challenging to keep in captivity due to their size and unpredictable nature.

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Table 17.1 Biological parameters of selected species.

	Average adult weight	Average adult length	Average lifespan (years)	Geographical range	Lifestyle	Habitat	Preferred temperature range (°C)	Preferred humidity (%)	Feeding interval for adult
Boa constrictor (*Boa constrictor*)	10–25 kg	1.5–4 m	25–30	Central and South America	Terrestrial, semi-arboreal	Rainforest, lowlands	26–32	50–80	q2–3 weeks
Emerald tree boa (*Corallus caninus*)	1.5–2 kg	1.5–2 m	15–20	South America	Arboreal	Rainforest	25–35	60–80	q10 days-3 weeks
Green anaconda (*Eunectes murinus*)	50–75 kg but can reach >200 kg	5–6 m	20–25	South America	Mostly aquatic	Wetlands	26–32	60–90	q2–6 weeks
Rosy boa (*Lichanura trivirgata*)	300–600 g	60–120 cm	20–30	California, Arizona, and Mexico	Terrestrial	Desert, arid scrubland	25–30	30–50	q7–10 days
Reticulated python (*Python reticulatus*)	60–90 kg	3–6 m but can reach >7 m	15–25	South East Asia	Arboreal, terrestrial	Grasslands, rainforest, wetlands	26–32	50–80	q2–4 weeks
Royal python (*Python regius*)	1.3–1.8 kg	1–1.5 m	20–30	Central and Western Africa	Mostly terrestrial	Grasslands, forest	24–32	50–80	q10–14 days
Carpet python (*Morelia spilota*)	8–10 kg	1.5–3 m	15–25	New Guinea, Indonesia, Australia	Semi-arboreal	Rainforests, woodland	26–32	40–60	q2–3 weeks
Green tree python (*Morelia viridis*)	1.1–1.6 kg	1.2–1.8 m	15–20	New Guinea, Indonesia, Australia	Arboreal	Rainforest	24–32	40–70	q10 days-3 weeks

Table 17.2 Taxonomy of boas.

Family Boidae	
Subfamily Boinae (Boas)	‘True’ boas including the Boa constrictor (*Boa constrictor*), Emerald tree boa (*Corallus caninus*), Rainbow boa (*Epicrates cenchria*) and Anacondas (*Eunectes* spp.)
Subfamily Ungaliophiinae	Dwarf boas
Subfamily Erycinae	Sand boas
Subfamily Calabariinae	African burrowing python (*Calabaria reinhardtii*)
Subfamily Candoiinae	South Pacific boas
Subfamily Sanziniinae	Madagascan ground and tree boas
Subfamily Charininae	Rosy boa (*Lichanura trivirgata*) and rubber boas (*Charina spp.*)
Family Bolyeriidae	Round Island Boas
Family Tropidophiidae	Another group of dwarf boas

- **Rosy boa (*Lichanura trivirgata*)**

The Rosy boa is a small- to medium-sized boa recognised by its pattern of three wide black, brown, or orange stripes running along the body. Found throughout California, Arizona, and Mexico, mostly in desert or arid scrubland habitats, it lives a nocturnal lifestyle and rests the majority of the day hidden between rocks and crevices. As a smaller snake, predators are a significant threat, but unlike more aggressive boids, its defence tactic is to curl up in a ball with its head in the centre. Rosy boas therefore tend to make fairly docile pets in captivity although can be shy if unused to handling.

Boas are typically viviparous, giving birth to live young. Breeding seasons may be altered in captivity and gestation periods can vary according to species and external temperatures. However, examples for some of the common pet species are listed in Table 17.3.

Figure 17.1 Common boa.

17.2 Pythons (Family Pythonidae)

Pythons are found throughout the Old World in varying habitats and genera commonly kept are listed in Table 17.4 (Pyron et al. 2014). As with boas, natural habitat and lifestyle can vary considerably according to species as shown by the following examples.

- **Royal python (*Python regius*)**

Royal or ball pythons originate from Central and Western Africa, where they can be found in grasslands and forest habitats. They live a mostly terrestrial, nocturnal lifestyle, curling into a ball when threatened by predators such as

Table 17.3 Breeding information for selected boa species.

	Average gestation period (months)	**Typical breeding season**	**Comments**
Boa constrictor (*Boa constrictor*)	4–8	October–February	(Ross and Marzec 1990). Parthenogenesis reported (Booth et al. 2010)
Emerald tree boa (*Corallus caninus*)	6–7	January–June	(Ross and Marzec 1990)
Green anaconda (*Eunectes murinus*)	6–7	March–July	(Ross and Marzec 1990). Parthenogenesis reported (O’Shea et al. 2016)
Rosy boa (*Lichanura trivirgata*)	4–6	March–April	(Ross and Marzec 1990)
Brazilian Rainbow boa (*Epicrates cenchria cenchria*)	4–5	February–May	Parthenogenesis reported (Kinney et al. 2013)

Table 17.4 Python genera maintained in captivity.

Antaresia	Children's pythons
Apodora	Papuan python (*A. papuana*)
Aspidites	Black headed python (*A. melanocephalus*) and Woma (*A. ramsayi*)
Bothrochilus	Bismarck ringed python (*B. boa*)
Leiopython	White lipped python
Liasis	Water pythons
Morelia	Tree pythons including the Carpet python (*M. spilota*) and Green tree python (*M. viridis*)
Python	'True' pythons including the Royal python (*P. regius*), Reticulated python (*P. reticulatus*)

humans (Figure 17.2). They only grow to 1–1.5 m in length and are popular pets due to their manageable size and docile nature. Initially most individuals in the pet trade were wild-caught, but in subsequent years 'ranching' became more popular. This involves capture of gravid female snakes from their natural environment, and maintaining them in captivity until their eggs are laid. Eggs are then incubated and juveniles exported to the international market. Both capture of wild snakes and ranching methods carry significant welfare and health concerns. Nowadays, captive breeding supplies the majority of the pet population in the UK, with a huge demand for breeding numerous colour mutations or 'morphs'. Popular morphs include albino, leucistic, jungle, pinstripe, and spider varieties. Such specific breeding is associated with its own set of problems, in particular various genetic disorders. A classic example would be that of 'wobble syndrome' in the spider morph. Affected snakes may be seen with tremors, torticollis, ataxia, and reduced righting reflex and signs appear to be exaggerated during periods of increased activity such as feeding. Exact prevalence is uncertain, but it has been suggested that all individuals of this morph are affected to some degree (Rose and Williams 2014).

- **Reticulated python (*Python reticulatus*)**

The Reticulated python originates from South East Asia, and is the longest snake species in the world with recorded lengths of over 9 m. Habitats are variable ranging from grasslands to rainforest, although they are often associated with rivers and lakes and are excellent swimmers. They naturally prey on a variety of mammals and birds in the wild and may be found around human habitats at times. In captivity, their size and unpredictable nature should not be underestimated.

Figure 17.2 Royal or ball python demonstrating defensive behaviour.

Figure 17.3 Green tree python (*Source:* Photo courtesy of Chris Mitchell).

- **Green tree python (*Morelia viridis*)**

The Green tree python (Figure 17.3) originates from the rainforests of New Guinea, Indonesia, and Northern Australia, where it is active at night. Despite sharing a remarkably similar appearance and lifestyle to that of the South American Emerald tree boa, the two species have evolved completely separately to fit into their ecological niches. Green tree pythons can be distinguished from boas by differences in their heat sensing pits; green tree pythons only have pits within the first rostral scales, whereas in the boas they lie between the scales all along the upper lip. The juveniles of both species take time to develop the bright green adult colouration, but in green tree pythons the

Table 17.5 Breeding parameters for common python species (Ross and Marzec 1990).

	Typical breeding season	Oviposition	Incubation period (days)
Reticulated python (*Python reticulatus*)	September–November	December–May	86–95
Royal python (*Python regius*)	September–February	March–June	56–64
Carpet python (*Morelia spilota*)	December–March	March–June	49–72
Green tree python (*Morelia viridis*)	August–January	November–May	39–65
Burmese python (*Python molurus*)	November–February	February–May	58–63

hatchlings can have a bright yellow colouration which is never seen in the juvenile boas.

Pythons are oviparous; they reproduce by laying eggs. Breeding seasons may be altered in captivity and both gestation periods and incubation periods can vary according to species and external temperatures. Examples for some of the common pet species are listed in Table 17.5.

17.3 Husbandry

Boas and pythons need to be kept in a secure enclosure, adequate for their size. Whilst there are no legal minimum space requirements in UK, it is recommended that snakes are at least able to stretch out completely. This may be difficult to ensure for some of the larger snake species if kept in standard commercial vivaria or rack systems. Supervised exercise time in a secure room is therefore particularly encouraged for those snakes in smaller set ups. For terrestrial species (e.g. Kenyan Sand boa, *Eryx colubrinus*), the enclosure should be long and wide, whereas height is more important for the arboreal species (e.g. Emerald Tree Boa). Concerns are often raised that younger snakes or particularly shy species may be anxious in a large space. There is however, no evidence for this in either wild or captive snakes as and as long as plenty of hide areas are provided, enclosures should be as large as possible.

The enclosure itself should be well-ventilated, but also insulated to avoid excessive temperature fluctuation. This balance can be difficult to achieve especially in species which require a higher level of humidity. A primary background heat source should be used to provide a general minimum temperature. This may be a heat mat, ceramic heat source, reptile radiator, or background room heating. A secondary heat source such as a basking lamp can then be placed at one end of the enclosure to create a temperature gradient, allowing the snake to move to its chosen temperature within a set range. This secondary heat source should be turned off at night, mimicking the natural temperature decrease. Heat sources should be controlled by a thermostat and maximum and minimum temperatures carefully monitored. Care should be taken to protect the snake from direct contact with the heat source to avoid burn injuries, for example by placing a heat mat on the external wall of the enclosure rather than the floor, or applying a guard around the lamp. Each species will have a slightly different natural temperature range (see Table 17.1) and this should be replicated in captivity.

Many boa and python species are crepuscular or nocturnal and ultraviolet (UV) light requirements have not been established (Hedley and Eatwell 2013). However addition of a UVA/B light has been suggested to have behavioural benefits even if snakes are only emerging from hide areas at dawn and dusk when UV levels are less intense. Photoperiods should ideally mimic those in the wild (on average 12 hours light per day) and output of lights should be monitored weekly or lights changed regularly according to manufacturer's guidelines. Care should be taken to avoid higher intensity lights and give the opportunity to hide as many of these snake species will not naturally be exposed to strong sunlight in the wild (Gardiner et al. 2009).

The enclosure may need to be sprayed or misted multiple times over the course of a day to maintain humidity levels and these should be monitored using a hygrometer. For those species requiring particularly high humidity levels, automated misting systems can be useful.

On the floor, substrate should be provided which should be easy to clean and non-irritating. The ideal choice will depend on the species; whether they need a dry or humid environment and how much they exhibit burrowing behaviour. Aromatic substrates such as cedar chip should always be avoided due to risks of respiratory and skin irritation. The enclosure should be spot cleaned whenever urates or faeces are passed, in addition to regular substrate changes and cleaning using a reptile-specific disinfectant. Finally, appropriate furniture should be provided to allow hiding areas at both the hotter and cooler ends, in addition to opportunities to bask, burrow, or climb depending on species preference.

Natural diet may vary depending on species, but all boas and pythons eat whole prey. In captivity this is generally replicated by the feeding of pre-killed rodents, or rabbits for the larger individuals. It is important that these food animals are themselves healthy and in good nutritional status. If frozen, they should be defrosted properly and warmed before being fed. Owners may choose to feed their snake in a separate enclosure so that snakes do not associate the opening of their vivarium door with food being placed inside. This minimises the risk of accidental owner injury and also avoids the risk of inadvertent substrate ingestion for the snake. However, more nervous individuals may not feed in less familiar surroundings so routines may need to be adapted accordingly. The feeding of live vertebrate prey is never recommended, as it results in a highly stressful death for the prey species and also puts the snake at risk of injuries from rodent attack.

Feeding frequency will depend on snake size, age, reproductive status, and activity levels. Obesity is a commonly seen problem in captivity as wild lifestyles are generally less sedentary and food availability is less reliable. Recommendations vary from every one to two weeks for smaller boas or pythons to every one to two months for larger individuals. Although snakes can physically ingest extremely large food items, ideally they should be fed prey of a size that is approximately the width of the widest part of the snake's body.

Species should not be mixed, due to varying husbandry requirements, the potential for aggression, and potential susceptibility to pathogens that may be carried asymptomatically by another species. However if mixing is necessary, only those from the same geographical origins should be kept together to minimise potential for differing husbandry requirements or exposure to novel pathogens (Varga 2004).

17.4 Clinical Evaluation

17.4.1 History-Taking

In addition to a full medical history, an extensive husbandry and diet assessment should always be collected, as many health concerns can be secondary to environmental or nutritional deficits. Husbandry questionnaires can be useful to ensure no details are missed. If the owner keeps records of feeding, weights, or shedding or has photos of the enclosure these should also be provided.

17.4.2 Handling

Small boa or python species can easily be handled by one person, but for larger snakes of over 5 ft, at least two handlers will be necessary. Well-handled snakes can usually be gently scooped out of their enclosure. The snake should be held so that its body is fully supported. Larger more aggressive snakes may require a snake hook for initial capture. The head should then be restrained and the rest of the body supported. Salmonellosis is a potential zoonotic risk, so protective gloves may be considered and good hygiene is vital.

17.4.3 Sex Determination

Male and female boas and pythons may be distinguished by their external appearance once mature. Males usually have a longer thinner tail with larger cloacal spurs, whereas females have a shorter broader tail and smaller spurs. However, cloacal probing is usually used to confirm gender more objectively. A small well-lubricated blunt metal snake sexing probe is inserted into the cloaca towards the tail. In a male snake, this probe should pass into the hemipene pocket to a depth of six or more scales, whereas in a female the probe will pass fewer than six scales.

17.4.4 Clinical Examination

Clinical examination should ideally begin with indirect observation of the snake within its enclosure or transport container if possible. If the individual's behaviour is a concern, owners should be encouraged to bring in videos of their snake displaying the abnormal behaviour. Respiratory rate and effort can be observed, although are likely to vary depending on external temperature and stress levels. Locomotion and neurological status can also be assessed.

Next a full head to tail examination can be performed. Eyes should be assessed to check that the spectacles are clear and smooth. Nares should be checked for any signs of discharge. The face should appear symmetrical. Examination of the oral cavity may be performed at this point or left until later in the procedure as it is often resented by the snake. A thin folded layer of paper or card may be inserted into the diastema at the rostral extent of the mouth and used as a gag to encourage the snake to open its mouth. The mucous membranes, dentition, and the glottis may then be fully assessed. Auscultation can be challenging in snakes as sounds may not transmit well via a standard stethoscope. However the apex beat of the heart may be visualised externally on the ventral body wall and a Doppler probe can be used to listen to the heart beat if there are any concerns. The ventral surface of the snake may then be palpated for any masses or swellings. The skin should be thoroughly examined for any lesions such as burns or other traumatic injuries or mites. The cloaca should be checked for any prolapses. All snakes should be weighed at every examination.

17.5 Basic Techniques

17.5.1 Sample Collection

Blood samples can be taken from the ventral tail vein or via cardiocentesis. The ventral tail vein is preferred, but is a blind technique and the short broad tail of many boas and pythons can make this more challenging than in other snake species. Cardiocentesis may be performed following observation of the apex beat or by using a Doppler probe to locate the heart (Figure 17.4). Although generally considered a 'safe' technique, sampling can be resented and cardiac tamponade has been reported leading to death in one case (Isaza et al. 2004; Selleri and Girolamo 2012). Therefore, sedation may be considered to minimise stress and movement, especially if other diagnostics are also due to be performed. Blood volume of a reptile is approximately 5–8% of bodyweight so 0.5 ml blood per 100 g bodyweight can be safely taken. Blood should be placed into a heparin tube if only a small sample is available and submitted to a laboratory that is experienced in interpreting reptile samples. Manual haematology is necessary as nucleated erythrocytes cause erroneous results in automated counts. Interpreting both haematology and biochemistry results can be challenging, due at least in part to the lack of data for many species, and the wide variation in 'reference ranges' for others. Many of the 'reference ranges' are in fact based on small sample sizes, and sometimes a mixture of both clinically normal and subclinically abnormal specimens. Results may also be affected by a number of variables including age, sex, reproductive status, temperature, season, nutritional status, and stress. Serial blood sampling may therefore be necessary to identify significant variations for an individual.

Figure 17.4 Cardiocentesis for collection of a blood sample.

Faecal samples may be collected and checked for endoparasites including *Cryptosporidium* if there is any suspicion of gastrointestinal disease. Faecal culture and sensitivity may be considered in select cases, but is not routinely performed as results are often unhelpful. Many snakes have been found to carry *Salmonella* spp. as part of their commensal intestinal flora and although this has potential zoonotic implications, it rarely seems to cause a problem for the snake unless intestinal integrity is compromised.

17.5.2 Fluid Therapy

Fluid requirements for snakes are generally considered to be lower than for mammals of the same weight, due to their lower metabolic rate. Volumes of 15–30 ml/kg/day are recommended and fluid types are similar to those used in mammals. Fluids are normally administered only once or twice daily as absorption is slow and handling may be stressful. The following routes can be considered:

Bathing – some snakes may choose to drink when placed in a warm water bath and allowed to almost completely submerge. Care should be taken to ensure the snake is able to hold its head up and bathing should be supervised.

Oral route – fluids may be administered via a lubricated stomach tube (a urinary catheter or similar soft flexible tube can be used). The tube should be pre-measured to the level of the stomach (located approximately half way between head and vent), the mouth gently opened using an atraumatic gag and the tube gently passed caudally with the snake supported in an upright position. Initially a smaller volume is administered and if tolerated then larger volumes up to 3% body weight can be given.

Subcutaneous route – snakes have minimal subcutaneous space so large volumes cannot be given by this route. Absorption is best when administered via the lateral sinuses, which are located between the epaxial muscles dorsally and the ribs ventrally. Warming fluids or adding hyaluronidase also appears to increase absorption.

Intravenous route – intravenous jugular catheterisation is possible, but requires general anaesthesia for a cut down technique for placement so is not routinely performed.

17.5.3 Nutritional Support

If clinically well snakes are not eating voluntarily, a full review of the environment and feeding strategies should however be considered to encourage the snake to start eating again. Tricks can include;

- Ensuring that the snake is completely undisturbed when presented with food – many snakes will not eat when observed
- Varying the time of day that food is presented – pythons are naturally more likely to eat at night time
- Feeding in a separate small dark secluded hide, pillow case or similar, within the vivarium. Pythons are ambush predators, feeding on rodents who pass into their burrows in the wild
- Varying the food type or size e.g. albino rodents are not always perceived as a recognisable food source and brown rats may be better accepted
- Feeding recently killed prey or moving the prey in front of the snake using long forceps can stimulate interest.

Royal pythons have a reputation for poor appetites and can be difficult to get feeding consistently in captivity. Traditionally this was more of a problem in wild-caught individuals who were more nervous in their new captive environment and did not appear to recognise the unfamiliar laboratory rodent prey offered. However even with captive bred individuals appetite can be variable. This may be due to stress, seasonal changes, overfeeding, or potentially underlying disease. It is therefore important to maintain accurate feeding and weight records. If maintaining weight and otherwise clinically well, a short period of anorexia may not be a cause for concern.

Adult boas and pythons can survive for long periods without eating but if beginning to lose weight will eventually need nutritional support. Animals should always be hydrated prior to feeding to prevent any risks of refeeding syndrome. There are various powdered food types specifically available for exotic carnivore species. Alternatively cat or dog recovery formulas may be used in the short-term. These may be mixed with water and administered by stomach tube as for fluids. Volumes and frequencies will depend on individual's weight and the manufacturer's guidelines. However, multiple repeat force feeding should be avoided if possible as the stress of frequent interventions may discourage the snake from eating voluntarily. Every effort should be made to try to encourage voluntary eating.

17.5.4 Anaesthesia

Anaesthesia of boas and pythons can be a time-consuming process. Pre-anaesthetic stabilisation is vital, with the patient warmed to an appropriate temperature, rehydrated, and any underlying diseases addressed if possible. Ideally the snake should also not have been fed for at least three days prior to the anaesthetic as regurgitation is possible. Analgesia should always be provided for any potentially painful procedure. Unfortunately pain in snakes can be difficult to recognise and consequently the efficacy of analgesics is currently uncertain. Feeding behaviour has been suggested as a potential method of assessing pain in royal pythons, but there are many other factors that may also affect failure to eat including the temperament of certain royal pythons who can be known for their variable feeding habits (James et al. 2017). Any change from the individual's normal behaviour, whether that be appetite, activity levels, or temperament should therefore be taken into account when trying to assess level of potential pain.

Due to the lack of data regarding analgesic efficacy, multimodal analgesia is usually recommended. Pre-operative administration of meloxicam has been evaluated in royal pythons and although no side-effects were reported, no evidence of actual analgesic effect was established (Olesen et al. 2008). NSAIDS may however be used for their anti-inflammatory properties, as snakes have been shown to possess both COX-1 and COX-2 enzymes (Sadler et al. 2016). Opioids have also been evaluated, both kappa and full mu agonists, but again no evidence of analgesic effect has been proven in boid or python species. Mu agonists appear the most clinically useful in other reptile groups and it is thought that transdermal fentanyl patches may have some use for delivering fentanyl to the bloodstream in snakes at what is generally considered to be clinically effective in other species (Darrow et al. 2016). However again, no actual evidence of analgesic effect has been established at this stage (Kharbush et al. 2017). More recent research has evaluated the effect of dexmedetomidine on ball pythons (Bunke et al. 2018). Results appear promising with dexmedetomidine causing increased noxious thermal withdrawal latency without causing excessive sedation. However, use in clinical cases has not yet been evaluated. Finally although efficacy is uncertain, local anaesthetics should also be considered for any surgical procedures as physiologically their mode of action should be similar to that in other species.

Following stabilisation, sedation or general anaesthesia may be performed. Gaseous induction within a chamber is an option for very small patients, but ideally injectable agents are preferred prior to the administration of gaseous agents to provide a faster, less stressful induction and more stable anaesthetic. Drugs may be administered either via the intramuscular (Figure 17.5) or intravenous route (ventral tail vein). Intracardiac administration of propofol has been reported, but other routes are preferable if possible (McFadden et al. 2011a). Propofol and alfaxalone are two of the most commonly used anaesthetic agents and usually provide sufficient sedation to allow intubation. Alternatively combinations of sedatives such as alpha-2

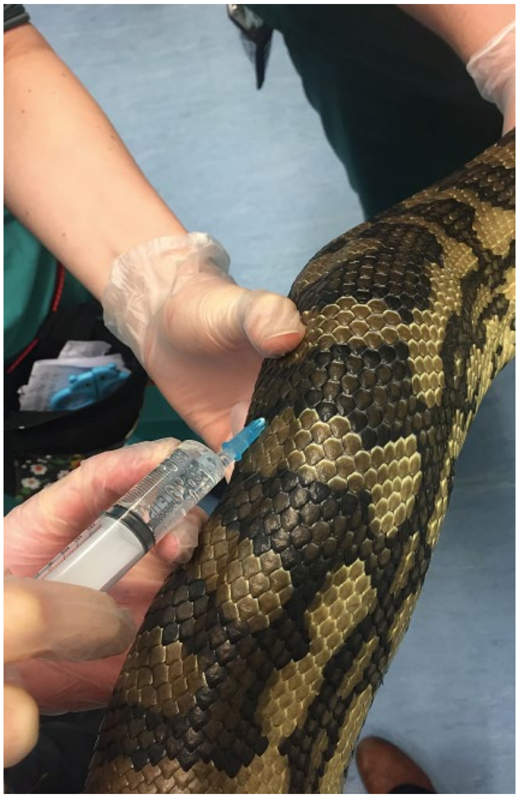

Figure 17.5 Intramuscular injection of alfaxalone for sedation.

agonists or midazolam plus ketamine may be administered via intramuscular injection, although effects appear more variable. Intubation is usually straightforward as the glottis can be easily visualised (Figure 17.6). Long, narrow uncuffed endotracheal tubes (or adapted urinary catheters) should be used to avoid tracheal damage. Once intubated, snakes may then be maintained on gaseous anaesthesia with isoflurane or sevoflurane most commonly used.

Intermittent positive pressure ventilation is usually required (either manually or mechanically) as spontaneous ventilation relies on active muscle movements which are suppressed under general anaesthesia. Initially high concentrations of gaseous agents (4–5% isoflurane or 6–8% sevoflurane) and higher than normal respiratory rates are likely to be necessary to ensure surgical anaesthesia. However, once the appropriate depth of anaesthesia has been established by lack of response to surgical stimulation, both ventilation rates and gaseous agent concentrations can be reduced. Response to changes in anaesthetic concentration are slow, so anaesthetic gas may be turned off prior to the end of the procedure to avoid a prolonged recovery. When ventilating, care should be taken not to overinflate the lungs. Depth of each ventilation should be visually observed, compared to normal breathing movements, and pressures kept <10–15 mmHg.

Figure 17.6 The glottis is readily visualised for intubation, the smaller and more rostral tongue sheath should be avoided.

Figure 17.7 Use of a Doppler probe for monitoring cardiac rate and rhythm under anaesthesia.

Anaesthetic monitoring can be challenging especially if controlling ventilation, as many of the monitoring devices used on other species are unreliable in snakes. Heart rate and rhythm can be monitored by taping a Doppler probe over the heart (Figure 17.7) or by watching the apex beat. Temperature can be monitored using a deep cloacal probe, but due to their poikilothermic nature, an anaesthetised snake's temperature is likely to be close to that of the room temperature which should be kept warm (~25–30 °C) throughout the procedure. Depth of anaesthesia can be difficult to assess as heart rate often does not change, but a positive reaction to tail pinch usually indicates a reduction in anaesthetic depth as snakes tend to recover tail first. Alternatively running a hand firmly down the side of the snake may elicit a reaction if at a light plane of anaesthesia (the Bauchstreich response) (Redrobe 2004).

Additional monitoring aids such as pulse oximetry or capnography may be used to help establish trends, but absolute figures are unlikely to be accurate. Oscillometric blood pressure monitoring has been evaluated in various boa and python species with a cuff placed around the tail immediately distal to the vent. Measurements were however found to be unreliable when compared to direct blood pressure recording (Chinnadurai et al. 2009). Unfortunately direct blood pressure monitoring involves cut down methods to cannulate a large artery so is not likely to be practical in most cases.

Recovery from anaesthesia can often be prolonged due to a snake's slow metabolic rate. Unlike mammals, the respiratory drive is thought to be more sensitive to hypoxia (which stimulates respiratory rate) rather than hypercapnia (which stimulates tidal volume) (Redrobe 2004). Recovering snakes are therefore usually ventilated with room air rather than 100% oxygen. Increasing temperature will also increase tidal volume, so maintaining a suitable environmental temperature and additional warming aids such as the use of a hairdryer can be helpful. However care should be taken not to warm the animal excessively without providing adequate ventilation as oxygen demand will increase with temperature. Care should also be taken to avoid burn injuries caused by aggressive heating in the immobile animal. Extubation should only occur when normal voluntary breathing is occurring and jaw tone has returned. Anaesthetic monitoring should be continued until the animal is consistently moving around and can be returned to their enclosure.

17.5.5 Euthanasia

Euthanasia should ideally be performed by an intravenous overdose of an anesthetic agent (e.g. pentobarbitone) (Leary et al. 2013). If intravenous access is not possible, the intracardiac route should be used ideally following sedation or anaesthesia. Complete death (as defined by loss of brainstem activity) may be difficult to confirm, so once the animal appears to have lost all reflexes and the heart beat is no longer audible using a Doppler probe, pithing should be performed to destroy the brain. This may be either via the oral cavity or occipital route.

17.5.6 Hospitalisation Requirements

Snakes should be housed in a secure vivarium which can be easily cleaned between patients. Plastic vivaria with newspaper substrate are often favoured in a clinical setting. Temperature range and humidity should be controlled as appropriate for the species. A hide should be provided and this may either be a disposable cardboard box or one from the home setting that will be familiar to the snake. Arboreal species require secure raised branch structures.

Inpatients should be examined and weighed daily, although treatment frequencies may need to be minimised if animals are not accustomed to frequent handling.

17.6 Common Medical and Surgical Conditions

Boas and pythons can be presented to the veterinary clinic for a variety of reasons, but clinical signs are often non-specific, for example, lethargy or anorexia. Behavioural changes such as anorexia may occur naturally at certain times of year, during periods of reproductive activity (Table 17.5) or ecdysis. These normal patterns must be differentiated from anorexia as a sign of underlying disease. Long periods of anorexia however, may lead to weight loss and predispose to hepatic lipidosis in previously obese individuals (Simpson and Langenburg 2006). A detailed history, physical examination, and diagnostic work up are, therefore, often necessary to establish the underlying problem.

17.6.1 Stomatitis

Stomatitis is a common problem in captive boas and pythons and often associated with respiratory infections. Owners may have noticed facial swellings or gingival discolouration (Figure 17.8), or alternatively reluctance to feed may be the only clinical sign. Predisposing factors include suboptimal environmental temperatures, poor hygiene, or trauma. Inflammation and secondary infection then occur, in particular an overgrowth of commensal Gram negative bacteria such as *Pseudomonas, Aeromonas, Proteus* and *Escherichia coli*, and a variety of anaerobes (Draper et al. 1981; Stewart 1990; Steeil et al. 2013). On clinical examination, gingival mucosa may appear inflamed or discoloured and excess mucus can be visualised within the oral cavity. A sample should be taken from the oral cavity for bacterial and fungal culture and sensitivity to guide antimicrobial choice. If swelling appears severe, further investigations such as radiography and biopsy for histopathology may also be necessary. Atypical infections such as *Mycobacterium chelonei* may initially present as stomatitis and a number of different oral tumours have also been reported in various boa and python species (Quesenberry et al. 1986; Thompson et al. 2015). Treatment usually involves a combination of topical and systemic antibiotics in addition to correcting any underlying husbandry deficits. Anti-inflammatories should be considered as this is

Figure 17.8 Mild–moderate stomatitis, note the diffuse gingival oedema and focal erythema.

potentially a very painful condition. Supportive feeding may also be required, especially if the animal has not eaten for some time.

17.6.2 Respiratory Conditions

Respiratory infections can often be seen in association with stomatitis, or as a sole concern. Owners may report wheezing, clicking sounds, bubbles from the mouth or nares, or have seen the snake resting in abnormal postures, often stretched out. Alternatively, lethargy and anorexia may be the only clinical signs. Inadequate temperatures, poor hygiene, and poor ventilation may all predispose to the overgrowth of commensal bacteria or fungi within the respiratory tract. However, atypical bacterial infections such as mycobacteriosis, fungal pathogens, or viral infections such as ophidian paramyxovirus or nidovirus should also be considered, especially if a new snake has been added to the collection in recent months (Hernandez-Divers and Shearer 2002; Miller et al. 2004; Uccellini et al. 2014). The diagnostic approach may include imaging to establish location and extent of disease and sampling for cytology, culture, and sensitivity and viral screens. Computed tomography (CT) is particularly useful to avoid superimposition of skeletal structures allowing more subtle lesions to be detected (Pees et al. 2007). Microbiology samples may be collected via a tracheal wash or performed endoscopically (as described later). Treatment usually involves a prolonged course of systemic antimicrobial therapy (from two weeks up to several months). Nebulisation can also be effective in combination with systemic treatment.

Tracheal obstructions should be considered in dyspnoeic patients that fail to respond to standard therapeutics. Obstructions may occur following ongoing infections, or in royal pythons, tracheal chondromas should be considered as a potential differential (Penner et al. 1997; Drew et al. 1999). Masses may be detected by radiography or CT, although tracheoscopy is necessary to obtain samples for histopathology. Surgical resection of the affected portion of the trachea and subsequent anastomosis has been reported to have successful outcomes in some cases (Diethelm et al. 1996). Alternatively, proliferative tracheitis associated with bacterial infections may also result in partial or complete obstructions. Saccular lung cannulation may be required to allow ventilation and can be maintained in place for one to two weeks until the tracheal pathology has been resolved (Myers et al. 2009).

17.6.3 Cardiac Conditions

Cardiac disease is not uncommon in boas and pythons and may be seen in association with respiratory or systemic signs. A variety of pathologies including endocarditis, myocarditis, and restrictive cardiomyopathy have all been reported, ultimately resulting in congestive heart failure (Rishniw and Carmel 1999; Schilliger et al. 2003; Wernick et al. 2015; Schilliger et al. 2016). Alternatively, congenital defects can also be found (Jensen and Wang 2009). Diagnosis can be challenging as minimal clinical signs are evident until disease is advanced. Owners may report lethargy, anorexia, weight loss, or dyspnoea. Auscultation using a standard stethoscope is limited, but on clinical examination, an enlarged heart may be visualised. Radiography can be used to rule out other more common problems and to assess cardiac size. The administration of barium into the oesophagus can help highlight the cardiac silhouette but size may vary post-prandially (Zerbe et al. 2011). Echocardiography however is the diagnostic tool of choice for cardiac disease and standard techniques have been reported for performing an echocardiographic examination in boas and pythons (see Section 17.7). If cardiac disease is detected, treatment options are similar to those for dogs and cats, but efficacy and dose regimens of medications are not known in reptiles. In theory, frusemide should have limited effect in reptiles, as its main site of action, the loop of Henlé is absent. However, in practice it does appear useful for reducing oedema. Unfortunately treatment is often just palliative before euthanasia becomes necessary.

17.6.4 Neurological Conditions

Neurological problems in boas and pythons can occur for a variety of reasons and obtaining a definitive diagnosis pre-mortem can be challenging. Neurological examination and diagnostic tests can be difficult to perform or interpret due to anatomical and physiological limitations, as well as patient size or temperament. There are however two significant viral infections that may be associated with neurological signs in these species; Ophidian paramyxovirus (oPMV) and arenavirus (the aetiological agent for inclusion body disease [IBD]). Other viruses such as Sunshine virus are also emerging as potential pathogens in pythons which may become more significant (Hyndman et al. 2012).

oPMV may result in a variety of neurological signs including torticollis, stargazing, a reduced righting reflex, and eventually death. Respiratory and gastrointestinal signs may also be seen (Orós et al. 2001). Alternatively, some individuals appear totally asymptomatic. Transmission is mainly by direct contact with respiratory secretions but also potentially via snake mites. Diagnosis has historically been based on repeat serological testing or post-mortem examination. Nowadays however PCR testing of choanal or cloacal swabs is preferred. Treatment is supportive only so euthanasia should be considered for clinically affected animals.

IBD may result in neurological signs similar to oPMV and is prevalent in captive boas and pythons (Chang et al. 2016). However in boas, neurological signs usually only occur at the terminal stage of disease, often following a period of regurgitation and gradual weight loss. In pythons, neurological signs can be seen at an early stage and the disease appears to progress more quickly. The exact aetiology was unknown until recently, but appears to be due to an arenavirus (Hetzel et al. 2013). Diagnosis has historically been based on histopathology with biopsies taken from multiple organs to increase the chances of detecting the characteristic intracytoplasmic inclusion bodies. Liver, kidney, and oesophageal tonsil biopsies are the best ante-mortem samples or alternatively brain and pancreas post-mortem. A PCR test is now available to screen for arenavirus infection from a blood sample and an oesophageal swab. As with paramyxovirus, treatment is supportive only and euthanasia should be considered.

In younger snakes, congenital abnormalities can also be seen. ‘Wobble syndrome’ appears relatively common in spider morphs of royal pythons. A caudal coiling syndrome has also been described in hatchling boa constrictors (Fitzgerald et al. 1990) and has been seen by the author in rosy boas (Figure 17.9). Under anaesthesia, the coils could be straightened out, but in conscious animals the muscles contracted to permanently coil in the caudal half. The condition appears progressive with no effective treatment and the pathogenesis not fully understood.

Figure 17.9 Congenital coiling deformity in a rosy boa.

17.6.5 Reproductive Disease

Both pre- and post-ovulatory dystocia may be seen in boas and pythons, although post-ovulatory dystocia is the most common presentation, especially in oviparous pythons. Predisposing factors include lack of a suitable nesting site, stress, inappropriate nutrition, or other underlying disease. Snakes may appear lethargic, anorexic, or begin to pass eggs but not complete parturition. If the process has not been completed within 48–72 hours, dystocia is suspected. Eggs may often be palpable or even visible in the caudal third of the body as soft oval masses. Treatment may be as simple as correcting any underlying stressors in the environment, and providing a warm, secluded nesting area. Warm water bathing may also be useful. However, often by the time animals are presented, more invasive treatment is required. One option is sedation and manual manipulation of eggs to gently ease them out of the cloaca. There are however, risks to this approach with oviduct prolapse or rupture being a possible consequence. If possible, saline insufflation of the oviduct and removal of the eggs under endoscopic guidance is preferred. After the procedure the oviduct can then be examined again to confirm there has been no iatrogenic trauma. Alternatively in some cases, surgical removal of the eggs or whole reproductive tract may be necessary via a standard coeliotomy approach as described later (Patterson and Smith 1979).

Boas are ovoviviparous and give birth to fully formed neonates. Signs of dystocia may be less pronounced. Radiography of snakes with clinical signs, or that have exceeded the expected gestation period, can help with assessment. The foetuses should be individually coiled within their membranes but with dystocia membrane rupture often occurs with foetal uncoiling evident on radiographs (Figure 17.10). Caesarian section is necessary in this situation (Figure 17.11).

17.6.6 Skin Conditions

The structure of a snake's skin is vastly different to that of mammals or birds with skin being regularly shed in one piece throughout an individual's life (ecdysis). Dysecdysis (difficulty shedding) generally occurs secondary to husbandry deficits such as inappropriate environmental temperatures or humidity, or malnutrition. Alternatively, it may be seen secondary to dermatological disease such as ectoparasites, bacterial or fungal infections, or traumatic injuries (White et al. 2011). Treatment is usually fairly simple and involves increasing environmental humidity, warm water baths, and gentle manipulation of retained skin with a wet cotton bud to aid removal. Retained skin should never be pulled off with excessive force as underlying tissues may be easily damaged. Problem areas (e.g. areas of scarring or retained spectacles) may need treatment over several consecutive sheds.

Snake mites (*Ophionyssus natricis*) are the most common ectoparasite seen and will infest any snake species. They can be particularly hard to eliminate as mites do not spend their entire life cycle on the snake, but have several resting non-feeding stages (Wozniak and DeNardo 2000). Owners may physically see mites on their snake or in the environment. Mites are a brown-black colour and are commonly found between scales especially around the eyes, mouth,

Figure 17.11 Multiple incisions required for caesarean section to remove foetuses from the snake shown in Figure 17.10.

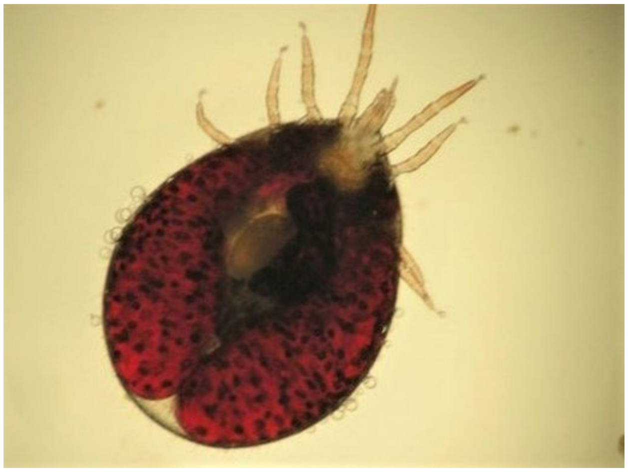

Figure 17.12 *Ophionyssus natricis* mite.

and cloaca. Identification of mites on a tape strip confirms diagnosis (Figure 17.12). In the environment they may be found in dark moist places such as wood décor or vivarium joints. Alternatively, snakes may be noted to spend more time soaking in the water bowl, presumably to relieve

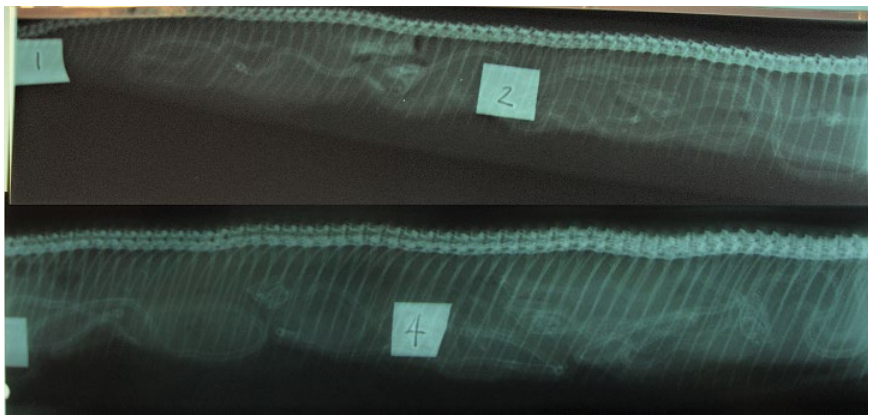

Figure 17.10 Lateral radiographs of a boa with prolonged gestation. Note the uncoiling of foetuses consistent with membrane rupture and dystocia.

irritation caused by the mites. As well as dysecdysis, mites can also cause more serious problems such as anaemia and have been suggested to be involved in the transmission of some infectious diseases (e.g. oPMV). Various treatments are available although fipronil and ivermectin are the most common choices. Care should be taken to avoid overdosage, especially when treating smaller individuals. Concurrent treatment of the environment is vital to prevent recontamination, although infections can be difficult to eliminate especially from wooden vivaria. All substrate should be discarded and replaced with paper which can be changed daily. All cage furniture should also be discarded if it cannot be completely cleaned and disposable hides such as cardboard boxes used until the infection has cleared. Vivaria may be treated with the same parasiticides as those used on the animal, but should be allowed to air fully before the reptile is returned to this environment. Alternatively predatory mites may be used as a form of biological control, for example in collections where chemical treatment is undesirable (Schilliger et al. 2013).

Burns are another common dermatological presentation, either due to the use of inappropriate heat devices in the vivarium or a device malfunction (Figure 17.13). All heating devices should be well protected from direct contact with snakes who often appear poor at perceiving thermal pain (especially if the rest of their body is not warm), so will not move away from excessive heat. Burns can consequently be deep and extensive. Burn injuries should be gently washed under cool water and analgesia provided. If superficial, then application of a topical treatment (e.g. silver sulphadiazine) may be sufficient, but if deeper then thorough flushing, topical and systemic antibiotic treatment, and bandaging may be necessary. Fluid loss from a burn can be significant so rehydration should be considered. Secondary infection is common so antibiotic cover should also be provided and substrate changed to clean paper that will minimise contamination of any open wounds. Healing can be prolonged and scarring is likely.

Figure 17.13 First degree burn in a common boa associated with direct contact with a malfunctioning heat source.

17.6.7 Musculoskeletal Conditions

Proliferative spinal osteopathy is associated with new bone formation and bridging of vertebrae and has been reported in a variety of species, although often the exact cause is difficult to establish. Suggested aetiologies include bacterial or viral infection, trauma, hypovitaminosis D, hypervitaminosis A, neoplasia, or prolonged inactivity (Fitzgerald and Vera 2006). Snakes may be presented with limited movement or visible spinal swellings. Bony proliferation may be seen on radiography, although advanced imaging modalities will provide more information and can be particularly helpful to plan sites to biopsy (Di Girolamo et al. 2014; Hedley and Volk 2015). Samples should be submitted for both culture and histopathology. Antimicrobial treatment and analgesics may provide some palliative support, but this is often a progressive condition and euthanasia may need to be considered.

Spinal problems such as osteoarthrosis or osteoarthritis often occur in older individuals and may present in similar fashion but pathology remains localised to a small area.

17.6.8 Ocular Conditions

A variety of ocular conditions are encountered in boas and pythons, including retained spectacles, pseudobuphthalmos, subspectacular abscesses, trauma, cataracts, congenital microophthalmia and anophthalmia (Hausmann et al. 2013; Da Silva et al. 2015). In one study, *Epicrates* spp. appeared to have a higher prevalence of ocular lesions than other species, in particular retained spectacles, although the reason for this was unclear (Hausmann et al. 2013).

Generally principles of ophthalmological examination, diagnostics, and treatment are similar to those in other species, although the presence of the spectacle may limit visualisation of the posterior eye and effects of topical treatments. The spectacle is a clear layer of skin which covers and protects the cornea and is shed regularly along with the rest of the skin during ecdysis. A narrow corneospectacular space exists between the cornea and overlying spectacle and subspectacular abscesses can occur either secondary to a penetrating wound or by infection ascending the lacrimal duct. The eye will appear opaque and enlarged (Figure 17.14). Abscesses may be drained under general anaesthesia by excising a small part of the spectacle. The lacrimal duct may also be cannulated. Alternatively, pseudobuphthalmos may also present as enlargement or protrusion of the globe.

Retained spectacles occur in snakes in association with dysecdysis (Figure 17.15). Predisposing factors such as poor husbandry or mites should therefore be corrected. Increasing humidity and soaking with warm water may help to loosen spectacles. Alternatively, various tear replacement drops or contact lens solutions have been used. Once loosened the spectacle may be rolled away from the cornea gently with a damp cotton bud. If this is not possible, excessive force should not be used as it is easy to damage the delicate cornea beneath. Instead husbandry should be improved and the spectacle may be lost at the subsequent shed, or removal can be attempted again. If spectacles are retained for consecutive sheds despite conservative treatment, a general anaesthetic may be necessary for the spectacle to be carefully removed.

Figure 17.14 Subspectacular abscess in a Burmese python.

Figure 17.15 Retained spectacle in a common boa with concurrent dehydration.

17.6.9 Surgical Considerations

In snakes, the standard coeliotomy approach is at the lateral margin of the body between the first and second row of lateral scales counting upwards from the ventral scutes. Due to the elongated layout of the internal organs, multiple organs may not be easily accessible from a small incision and a good knowledge of surgical anatomy is necessary in order to plan the most appropriate incision site along the snake's length. Multiple incisions may be preferred, if for example taking biopsies of more than one organ, or removing eggs from the length of the oviduct. The incision is made in the soft tissues between the scales, following the line of the scales. Radiosurgery or laser surgery may be considered to minimise haemorrhage, but are associated with more inflammatory response than a simple scalpel incision (Hodshon et al. 2013). Visibility within the coleomic cavity may be limited and the use of good lighting, retractors and magnifying loupes can help minimise tissue trauma.

Following surgery, wound healing is slow and the nature of a snake's inelastic skin causes wound edges to naturally invert. Everting patterns such as horizontal mattress sutures are therefore recommended. Tissue glue appears associated with the least inflammatory reaction so can be used to close small superficial wounds. Polyglactin 910 (Vicryl®) and chromic gut appear to be associated with the most inflammatory changes, so monofilament suture types are recommended (McFadden et al. 2011b). Even suture types which would be completely absorbed in mammals remain present for more than 90 days following surgery. Skin sutures should not be removed until at least six weeks post-surgery and ideally also after one cycle of ecdysis has occurred.

17.7 Imaging

Plain radiographs may be obtained without the need for sedation. The snake can be positioned either within a box or tube or directly on the x-ray plate. Dorsoventral and laterolateral (preferably using a horizontal beam) views should be taken. Positioning may not always be ideal, but obvious findings such as significant skeletal abnormalities, eggs or foreign bodies should be detected. Images may however be limited by poor contrast and superimposition of the ribs and spine. Multiple images will also be required to examine the whole length of the snake for survey radiographs. For larger or less compliant individuals, chemical restraint is likely to be necessary, especially for diagnostic images of the head or lungs. Contrast radiography should be considered for evaluation of the gastrointestinal system. Barium sulphate can be administered via an oesophageal tube at 15–25 ml/kg and highlights the oesophagus and stomach well, although distribution throughout the intestines can vary (Banzato et al. 2012a).

Ultrasound can be performed without sedation and will provide helpful information about coelomic structures. A probe size of ~ 7.5 mHz is ideal for medium-larger snakes and a dorsolateral approach to probe placement with the snake in normal ventral recumbency is recommended for visualisation of most organs. Normal ultrasonographic anatomy of coelomic organs has been described in several boid and python species (Isaza et al. 1993; Banzato et al. 2012b). The liver, gall bladder, stomach, pancreas, intestines, and kidneys should all be identifiable. Spleen, gonads, and hemipenes may also be visualised and some authors suggest ultrasound to be the preferred method of gender determination if probing is not possible (Gnudi et al. 2009). A higher frequency probe (10 mHz) and some experience with this technique would however be needed.

Echocardiography has been well described in both boas and pythons due to the variety of cardiac disorders reported in these species. A standard examination technique is recommended with the snake restrained in dorsal recumbency for a ventral approach. The right and left intercostal approaches can also be used to provide additional information. A good knowledge of normal snake anatomy is vital to interpret normal and abnormal findings. Both cardiac anatomy and the echocardiographic procedure are well-described by Schilliger et al. (2006). Normal images and dimensions are available for some species, but body mass, body length, and sex may affect cardiac measurements (Snyder et al. 1999; Conceição et al. 2014). It should be noted that cardiac dimensions will also fluctuate depending on how recently the snake has fed, so physiologic changes should be considered when interpreting measurements (Zerbe et al. 2011).

Advanced imaging techniques such as CT and magnetic resonance imaging (MRI) are increasingly being used in reptile medicine as they become more widely available. Both techniques will eliminate many of the limitations of radiography by avoiding superimposition of skeletal structures and allowing accurate reconstruction of the animal's anatomy. CT is particularly useful for imaging of the respiratory and skeletal systems, in addition to certain soft tissue structures such as follicles which are readily visualised (Pees et al. 2009; Banzato et al. 2011). Usually snakes are sedated or anaesthetised for the procedure, but images obtained from a curled snake can be reconstructed using curved multiplanar reformatting (MPR) software to yield clinically useful information (Hedley et al. 2014). MRI in contrast is more useful for evaluation of soft tissue structures, but will require chemical restraint, due to the length of procedure and sensitivity to motion artefacts.

Endoscopy can be a helpful technique for further evaluation of the gastrointestinal tract, respiratory system, or other coelomic structures. Sedation or general anaesthesia is generally necessary to provide complete immobilisation and analgesia should be administered for any invasive procedures. Rigid endoscopes are used most commonly, with a 2.7 mm scope usually the most versatile for multiple different species. However, flexible endoscopes of similar sizes can also be helpful for evaluation of the respiratory tract or the gastrointestinal tract in smaller species. The length of scope compared to snake size will be the main limiting factor as to how much of the gastrointestinal tract can be evaluated via either the oral or cloacal approach. The respiratory tract may be accessed either via the trachea or a surgical approach via the air sac (Jekl and Knotek 2006). Samples may be obtained via this route for culture, cytology or histopathology (Stahl et al. 2008).

Coelioscopy is less commonly performed as multiple entry sites would be necessary to examine all major organs. Snakes also have more diffuse coelomic fat than other reptiles and insufflation can be more challenging. If a targeted endoscopic approach of one organ or region is required, the position of the desired organ should be identified (via another imaging modality if necessary) and a small incision may be made between the first and second rows of lateral scales, similar to a surgical coeliotomy approach. The endoscope may then be directed either between the ribs in larger snakes, or just medial to the ribs in smaller species (Divers 2010).

17.8 Preventative Health Measures

Signs of disease in snakes can be subtle until problems are advanced. Owners should therefore be advised to keep accurate records of weights, feeding, and shedding so that any changes are noticed at an early stage. Annual physical examinations are recommended for all boas and pythons with further disease screening if indicated.

All individuals should be quarantined when entering a new snake collection and observed for any signs of disease. The progression of infectious diseases in snakes is often slow, therefore a minimum period of three months is recommended, although longer periods for up to 12 months have been suggested in certain situations (Lock and Wellehan 2015). During this time period, a full physical examination should be performed, plus any relevant disease screening. This may vary depending on the collection, but faecal parasitology (including acid-fast stain for *Cryptosporidium*), arenavirus, and paramyxovirus screening should be considered (Varga 2004). Microchipping if desired may be performed in the left flank anterior to the cloaca (BVZS 2017). Tissue glue should be applied over the needle entry site.

17.9 Formulary

Research into pharmacokinetics and pharmacodynamics is limited in snakes, but some drugs have been studied in certain python species. Where, species specific information is unknown, dosages are extrapolated from that available for other snakes or reptiles. Suggested dose rates for commonly used drugs are listed in the formulary.

Formulary

Medication	Dose	Dosing interval	Comments
Sedatives/anaesthetics			
Alfaxalone	<9 mg/kg IV		Based on study involving a variety of snake species including carpet pythons (Scheelings et al. 2011)
Propofol	5 mg/kg IV		(Meredith 2015)
Medetomidine and Ketamine	0.1–0.2 mg/kg (Me); 20–30 mg/kg (K) IM		(Meredith 2015)
Midazolam and Ketamine	0.2–0.8 mg/kg (Mi); 20–30 mg/kg (K) IM		(Meredith 2015)
Analgesia			
Morphine	1 mg/kg IM one-off		Anecdotal dose with no proven effect
Meloxicam	0.2 mg/kg SC, IM	q24h	Anecdotal dose with no proven effect
Lidocaine	1–2 mg/kg		as local infusion/nerve block (Meredith 2015)
Meloxicam	0.1–0.5 mg/kg PO, SC, IM	q24–48h	(Meredith 2015)
Antibiotics			
Ceftazidime	20 mg/kg	q72h	Based on study involving a variety of snake species (Lawrence et al. 1984)
Piperacillin	100 mg/kg IM	q48h	Based on pharmacokinetic study in blood pythons (Hilf et al. 1991a)
Enrofloxacin	10 mg/kg loading dose, then 5–10 mg/kg IM	q48h	Based on study in Burmese pythons (Young et al. 1997)
Marbofloxacin	10 mg/kg s.c., i.m., p.o. q48h		Based on studies in royal pythons (Coke et al. 2006; Hunter et al. 2007)
Amikacin	3.48 mg/kg IM	q 6 days (q72h for *Pseudomonas*)	Based on studies in royal pythons (Johnson et al. 1997)
Gentamicin	Most snakes: 2.5 mg/kg IM Blood pythons: 2.5 mg/kg IM then 1.5 mg/kg	q72h q96h	(Hilf et al. 1991b; Meredith 2015)
Azithromycin	10 mg/kg PO	q3d for skin infections; q5d for respiratory tract infections; q7d for liver and kidney infections	Based on studies in royal pythons (Coke et al. 2003; Hunter et al. 2003)
Metronidazole	100 mg/kg PO	repeat after 14 days	(Meredith 2015)

(*Continued*)

(Continued)

Medication	Dose	Dosing interval	Comments
Anti-parasitic agents			
Fenbendazole	50–100 mg/kg PO 20–25 mg/kg PO	Once q24h for 3–5 days	(Holt and Lawrence 1982)
Fipronil	Spray on to cloth first then wipe over surface of reptile	q7–14d until negative for ectoparasites.	(Meredith 2015) Beware of use in debilitated reptiles, those which have recently shed their skin and in small species where overdosage and toxicity may occur
Ivermectin	0.2 mg/kg SC, PO Environmental control for snake mites (*Ophionyssus natricis*) at dilution of 5 mg/l water sprayed in enclosure	repeat in 10–14 days until negative for ectoparasites q7–10d	Accurate dosage is particularly important in small individuals where overdosage and toxicity may occur

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