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Laboratory Testing in Reptiles

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Contents

As of: October 2019

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A guide to laboratory diagnostics in reptiles

This brochure provides information on the diagnosis of important reptile diseases. The main focus is on laboratory diagnostic options, divided into affected organ systems. Because of its compact form, this text serves as an overview. You will therefore find references to further literature, which may be helpful for clinicians interested in reptiles, at the end.

Taxonomy, husbandry, legal situation

There are more than 10,000 extant reptile species. These animals include chelonians, snakes and lizards (collectively called squamates) and crocodiles. Reptiles are a very diverse group of animals with varying demands on their environment. Some species do very well as pets and can also be easily bred in captivity, others are extremely demanding regarding their husbandry requirements. There are some species, especially of snakes, but also of lizards, that are venomous. Others, such as crocodiles or some chelonians, are dangerous due to their ability to defend themselves and must therefore be treated with appropriate caution. Reptile husbandry is regulated by many different laws and directives on an international and national level. Some commonly kept species (e.g. many tortoise species) are listed as protected species (CITES). Permits or other necessary permissions for keeping reptiles are regulated differently in various countries.

It is of particular note that reptiles are ectotherms. Thus, their body temperature and therefore also many physiological functions depend on the outside temperature. The immune system of these animals, for example, is particularly affected by how they are kept. Some species brumate, others require warm temperatures all year round. Overall, many of the diseases observed in reptiles can be attributed to poor husbandry. Accordingly, a detailed history and knowledge of the needs of certain species are important to be able to help these animals in veterinary practice. This folder provides a brief overview of some possible laboratory diagnostic tests that can be performed on reptiles, as well as information on possible diagnostic procedures for common clinical complexes. Our team of experts is happy to answer any further questions you may have.

Blood collection

There are several ways to obtain blood from various reptiles. When collecting blood, it is important to make sure that the animal is in its preferred temperature range. It is assumed that the amount of blood in reptiles is slightly lower than in mammals – a blood sample of approx. 0.7 ml per 100 g body weight can generally be collected without harming the animal. Some blood collection sites often provide samples that are mixed with lymph, which can affect some blood parameters. When collecting blood, it is important to choose a suitable anticoagulant. EDTA leads to haemolysis in some reptile species (e.g. tortoises), which is why lithium heparin is generally preferred (for PCR examinations, however, EDTA should be used or an anticoagulant should be avoided).

In **chelonians**, blood can be collected from different sites. Clinically, the jugular vein, the brachial vein, the dorsal tail sinus and the subcarapacial sinus are suitable (Fig. 1 A-C). Samples from all sampling sites (except the jugular vein) are regularly diluted with lymph.

Figures 1: Blood collection sites in chelonians which are frequently used in practice

Fig. 1 A: Blood collection from the jugular vein of a tortoise

Fig. 1 B: Blood collection from the dorsal tail sinus of a tortoise

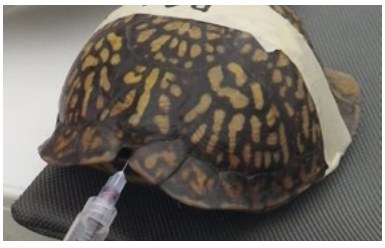

Fig. 1 C: Blood collection from the subcarapacial sinus of a box turtle

In **snakes** and **lizards**, blood can be collected from the ventral tail vein (Fig. 2). In these animals, care should be taken not to injure the hemipenises of the males. In lizards, there are some species in which manipulation results in tail autotomy (e.g. in some skinks, lacertids, geckos, and in some iguanas). In these species, blood should only be taken from the tail under anaesthesia. In snakes, blood can also be taken directly from the heart (Fig. 3), which can either be found by ultrasound or by external observation of the heartbeat (approx. 1/3 of the body length caudally from the head). In larger lizards, the jugular vein can also be used for blood collection.

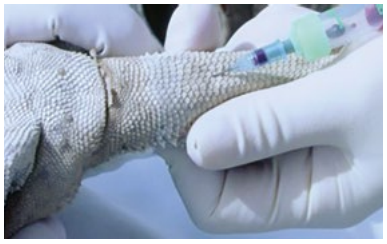

Fig. 2: Blood collection from the ventral tail vein of a bearded dragon

Fig. 3 A: Blood collection from the heart of a ball python

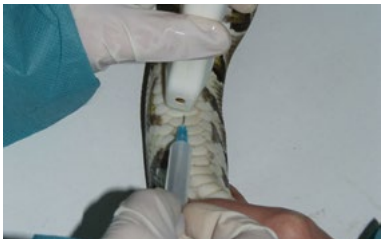

Fig. 3 B: Ultrasound can be helpful in locating and puncturing the heart in snakes

Blood testing

The **haematological examination** in reptiles is usually carried out manually using blood smears, since reptile erythrocytes contain nuclei and, thus, the validation of automated processes is extremely complex. The haematocrit can vary widely and is also influenced by the quality of the sample (lymph). The erythrocytes contain a central, oval nucleus. Artefacts, which may look like inclusions, occur regularly. Inclusions can also be observed in connection with parasitic, bacterial, or viral infections. Platelets are also nucleated, small, roundish to oval or spindle-shaped, and are often present in aggregates. White blood cells in reptiles are generally differentiated into granulocytes and mononuclear leukocytes. Granulocytes are divided into heterophils, eosinophils, and basophils. Reptile lymphocytes and monocytes are similar to those in mammals. Azurophils are found in some reptiles and are monocytes with azurophilic granules in the cytoplasm. Morphology of the individual cell types varies greatly between different reptile species. Species, gender, age and physiological state influence the number and ratio of the different leukocytes. Changes in the morphology of individual cells may indicate an infection. Shifts in cell numbers are usually less pronounced in reptiles than in birds or mammals and are somewhat more difficult to interpret (Table 1).

Table 1: Haematological parameters and their interpretation in reptiles

Parameter/cell type	Variation	Comments
General factors	Intrinsic factors	• Species, gender, age, physiologic status (e.g. reproductive status)
	Extrinsic factors	• Season, temperature, habitat, brumation, diet, disease, stress associated with captivity and venipuncture
Erythrocytes/ haematocrit	General comments	• Generally higher in males than in females
	Decreased	• **Haemorrhagic anaemia:** e.g. traumatic injuries, haematophageous parasites, coagulopathy, ulcerative lesions • **Haemolytic anaemia:** e.g. septicaemia, parasitaemia, toxaemia • **Non-regenerative:** e.g. chronic inflammatory diseases (infectious), chronic renal and hepatic diseases, neoplasia, chemical or drug reaction, hypothyroidism • **Regenerative:** e.g. post brumation, associated with inflammatory diseases, malnutrition, starvation; response is slower compared to mammals and birds
Heterophils	General comments	• Often higher during the summer and lower during brumation
	Decreased	• Some early inflammatory diseases, especially bacterial infections, environmental or chemical toxins, herpesviruses in tortoises
	Increased	• Inflammatory diseases caused by microbial and parasitic infections, stress, neoplasia, heterophilic leukaemia, glucocorticoid excess • Heterophils may show toxic changes, e.g. basophilic granula and basophilic cytoplasm, cytoplasmatic vacuoles, lobulation of the nuclei in some species

Lymphocytes	General comments	• Many species have more lymphocytes than heterophils • Highest during the summer and lowest during the winter in some species • In some species lymphocyte numbers are higher in females
	Decreased	• Immunosuppression, chronic stress, chronic malnutrition
	Increased	• During wound healing and ecdysis, inflammatory diseases, parasitic and viral infections, lymphoid leukaemia • Presence of reactive lymphocytes (deeply basophilic cytoplasm, less condensed nuclear chromatin) and plasma cells suggest stimulation of the immune system
Monocytes	General comments	• Azurophils are a subpopulation of monocytes and are found in low numbers in lizards, chelonians, and crocodilians, and in high numbers in snakes
	Increased	• Inflammatory diseases, especially granulomatous inflammation, some parasitaemias, dystocia in chameleons, fibropapillomatosis in sea turtles
Eosinophils	General comments	• Lizards often have lower numbers of eosinophils compared to some species of turtles • Lower during the summer and highest during brumation in some species
	Increased	• Parasitic infection, stimulation of the immune system, foreign body reaction
Basophils	General comments	• Some species of chelonians have a high number of circulating basophils (up to 40%) • Low seasonal variations
	Increased	• Parasitic and viral infections
Thrombocytes	General comments	• Often clumped together, making quantification difficult
	Decreased	• Excessive peripheral utilisation, decrease in production

Blood clinical chemistry values also depend on exogenous and endogenous factors such as species, gender, cycle phase, season and temperature in reptiles. Especially in carnivorous species, levels may change depending on the last feeding. Lymph contamination of the sample leads to reduced protein and potassium levels, trauma during blood collection leads to increased AP and CK levels. Reptile plasma is usually colourless; a green discolouration may be caused by increased biliverdin levels in the blood, e.g. due to liver problems. Table 2 lists some test parameters that can be measured in reptiles, as well as information on their interpretation. Laboklin offers several clinical chemistry panels for reptiles, and additional tests can be ordered as needed.

Because of the difficulties in interpreting blood levels and the variation of normal values in some species, it may be helpful in practice to measure blood levels from clinically healthy animals, e.g. during annual health checks. These values can then be used as a reference for interpretation of later test results.

Table 2: Information on clinical chemistry parameters and their interpretation in reptiles

Abbr.	Parameter	Comments
ALT	Alanine aminotransferase	• Found in a variety of tissues incl. kidneys, liver, and skeletal muscles • Not a reliable indicator of liver function in reptiles
Alb	Albumin	• Synthesised in the liver, large reserve capacity • Lower amounts in plasma than in mammals • Values in aquatic species generally lower • Hypoalbuminemia caused by e.g. hepatopathies, anorexia, stomatitis, intestinal parasites, dehydration, enteropathies • Values reduced if blood is diluted with lymphatic fluid
AP	Alkaline phosphatase	• Very unspecific, found e.g. in the kidneys, lungs, osteoblasts, small intestine, and spleen • Increased levels in juveniles and in animals with increased osteoblast activity • Strong differences between species
AST	Aspartate aminotransferase	• Not organ specific • High concentrations in muscles and liver • Evaluate in conjunction with CK (increased AST and normal CK indicate possible liver pathology, if both are increased, this could be due to damage of the musculature) • Also increases during systemic disease processes (septicaemia, toxaemia)
BA	Bile acids	• Produced in the liver • Chemical differences between reptile species • Few reference intervals available • Increased in hepatic insufficiency, dehydration, and postprandially
	Bilirubin	• Is not produced in all reptile species due to a lack of biliverdin reductase

	Biliverdin	• Primary final product of haemoglobin degradation in most reptiles • High levels cause green discoloration of plasma and urates • No standard method available for the detection of biliverdin in reptile blood
Ca	Calcium	• Blood calcium levels regulated by parathormone, calcitonin, vitamin D3 • Hypocalcaemia: e.g. nutritional – insufficient Ca and/or excess P in diet, insufficient vitamin D3, insufficient UV light, renal hyperphosphataemia • Hypercalcaemia: e.g. iatrogenic, primary/tertiary hyperparathyroidism, osteolytic bone loss, alimentary • Oversupply and vitamin D3 deficiency: excreted as calcium triple-phosphate • Oversupply of calcium and of vitamin D3: massive incorporation in blood vessels, organs, and bones
Ca:P	Calcium:phosphorus ratio	• Important for the diagnosis and prognosis of nephropathies • Shift toward phosphorus: nephropathies, mineralisation disorders (osteodystrophia fibrosa)
	Cholesterol	• Together with triglycerides can be increased in animals with hepatic lipidosis • Increased during vitellogenesis and before brumation
CK	Creatine kinase	• Found in heart and skeletal muscles • Increased at low ambient temperatures (seasonally) • Can be used to help differentiate between myelopathies and hepatopathies together with other enzymes, e.g. AST • Can increase due to trauma during blood collection
	Globulins	• Globulin fractions similar to those found in mammals • Currently very few reference ranges available for reptile species • Hypoglobulinaemia: e.g. wasting diseases, cachexia (albumin is also affected in these cases) • Hyperglobulinaemia: severe infectious diseases, necrosis
	Glucose	• Dependent on species, nutritional status, and environmental temperatures • Regulated by insulin and glucagon, temperature dependent in reptiles • Hypoglycaemia: e.g. malnutrition, severe hepatopathies, septicaemia • Hyperglycaemia: e.g. iatrogenic, nutritional, diabetes mellitus (rare), some neuroendocrine tumours • Stress during blood collection can lead to increased values
GLDH	Glutamate dehydrogenase	• Found mostly in the mitochondria of hepatocytes • Useful for detection of hepatocellular necrosis
K	Potassium	• Decreased if blood sample is contaminated with lymph fluid • Hypokalaemia: e.g. excessive loss via intestine, glomerulopathies, severe alkalosis • Hyperkalaemia: e.g. reduced renal secretion, acidosis, indication of haemolysis when found in conjunction with hyperphosphataemia • Increased in whole blood samples that have been kept at warm temperatures
PO4	Phosphate	• Important for evaluation of renal disease • Hypophosphataemia: e.g. sustained anorexia, nutritional imbalance • Hyperphosphataemia: e.g. nephropathies, excessive nutritional intake, hypervitaminosis D, haemolysis • Higher values in juvenile animals
Na	Sodium	• Changes caused by lymph dilution of blood sample • Affected by hyper- or dehydration • Some reptile species can regulate their sodium (and K and Cl) households with the help of the Harderian glands • Hyponatraemia: e.g. resorption dysfunction (diarrhoea), nephropathies, iatrogenic
TP	Total protein	• Generally lower than in mammals • Hypoproteinaemia caused by e.g. malabsorption, maldigestion, chronic hepatopathies, generalised neoplasia, long term anorexia, nephropathies with proteinuria, exudative enteropathies, possibly dermatitis, extensive blood loss • Hyperproteinaemia caused by chronic inflammation, dehydration, postprandial in carnivores, muscle loss caused by cachexia • Increases in females during folliculogenesis
	Triglycerides	• Often increased in animals with hepatic lipidosis • Increased during vitellogenesis and before brumation
	Urea	• Less important than uric acid in terrestrial species
UA	Uric acid	• Primary final product of protein and purin metabolism in terrestrial species • Concentration depends on diet • Values generally higher in carnivores • Hyperuricaemia: e.g. kidney diseases and gout, bacteraemias and septicaemias with renal dysfunction, necroses caused by renotoxic drugs (e.g. aminoglycosides and sulfonamides) • Hypouricaemia: often found in conjunction with hepatopathologies • Uric acid values can remain within normal ranges for extended periods of time, even in animals with renal disease and visceral gout

Infectious diseases

1. The significance of infectious agents in reptiles

There are many infectious agents that have been detected in reptiles so far. Our knowledge of the species that occur and their clinical significance is constantly expanding. In many cases it is only the interaction of different pathogens and possibly other factors that leads to clinical disease. This means the diagnosis of infectious diseases in reptiles is often a difficult process in which various aspects such as anamnesis, clinical picture and multiple laboratory findings should be included. A first important indication for the presence of an infectious disease can be provided by asking about other affected animals in the population or contact with other animals. Histological or cytological examinations can often help to assess the significance of individual infectious agents.

Viruses: The number of viruses known in reptiles has grown particularly fast in recent years. Some of them are known to be important pathogens, others must be studied further to understand their possible role in disease. Persistent viral infections seem to occur frequently, which increases the importance of quarantine. In many cases, both host factors, including animal species, immune status, nutritional status, husbandry, and stress, as well as viral factors, e.g. species and strain, play a role in the development of a disease.

Bacteria: In general, reptiles have a very diverse bacterial flora which mainly consists of gram-negative, facultative pathogens. This is why a bacteriological examination, e.g. of pharyngeal or cloacal swabs in healthy reptiles, is not generally helpful, as the interpretation of the results is only possible in connection with clinical signs and further testing. However, there are a few bacteria that are primarily pathogenic and often play an important clinical role. These include, for example, *Mycoplasma agassizii* in diseases of the upper respiratory tract of tortoises or *Devriesea agamarum* in skin lesions of spiny-tailed lizards and other lizards. Mycobacteria can also be important pathogens in reptiles.

Fungi: Ubiquitous fungi play the main role in reptile mycoses. A common cause is immunosuppression due to poor husbandry and feeding. However, there are also some species that are known to be important primary pathogens, including several members of the family Onygenaceae (e.g. *Nannizziopsis* spp. and *Ophidiomyces ophiodiicola*), which can cause skin lesions as well as systemic diseases. Members of the family Clavicipitaceae (*Metarhizium* (formerly *Chamaeleomyces*) spp.) are also obligate pathogens. Cytological and histological examinations can be helpful in the diagnosis of fungal infections. In addition, pathogen detection can be correlated with the clinical picture.

Parasites: There are numerous parasites that can occur in reptiles and which can be of clinical importance. In captive-bred animals, it is mainly endoparasites with a direct life cycle, such as oxyurids or coccidia, that play an important role, as reinfection and poor hygienic conditions can lead to high parasite loads. In animals captured in the wild, a larger spectrum of parasites can occur. While these are usually tolerated without clinical effects in natural habitats, stress and interaction with other pathogens can lead to disease outbreaks and death in captivity. Parasitological faecal examinations are an important diagnostic method and an integral part of a quarantine regime. Attention should be paid to both protozoa and helminths. Protozoa are usually detected in a direct smear during faecal analysis. Some protozoa (e.g. most flagellates) are regarded as normal commensals when occurring at a low to moderate level, others, such as amoebae *(Entamoeba invadens)* can be significant pathogens. Diagnosis of metazoans is usually made by faecal examination (flotation). There are many different species, some of which are clinically relevant (Table 3).

2. Diagnosis of infection in reptiles

There are two approaches to diagnosing infection: detection of the infectious agent and detection of an immune response to the infection. Both are used in reptile medicine.

Direct detection of an infectious agent can be done through direct visualization, e.g. for many parasites, or via microscopic examination of samples for parasites, bacteria and fungi; culture, e.g. for many bacteria and fungi, but also via cell culture isolation for some viruses; and by detection of parts of the infectious agents, i.e. specific antigens or part of the genome. The most commonly used method for the detection of parts of the infectious agent is a polymerase chain reaction (PCR) which uses specific primers to detect part of the genome of an organism. In reptile medicine, PCRs are used to detect a wide range of possible pathogens. In most cases, these are designed to be able to detect a range of related infectious agents, in order to have a single test that can be used in multiple species. Examples include the use of pan-herpesvirus or pan-adenovirus PCRs in diagnostic testing in reptiles. The use of these methods means that several different viruses that can infect an animal can be detected using a single test, but also means that it may be necessary to do additional testing (most often sequencing of PCR products) in order to identify the exact agent detected. This can be important in order to determine the prognosis in some cases (different herpesviruses of tortoises can have different pathogenicities, for example), but can also be necessary in order to differentiate between reptilian pathogens and those found in prey animals fed to the reptile. This is the case for cryptosporidia. Several different species of these parasites can infect and cause disease in various reptile species, but different *Cryptosporidium* spp. are found in prey animals, e.g. mice, which do not infect the reptile, but can still be detected.

Detection of an **immune response to infection** in reptiles is done by serology. Serology is used to determine whether an animal has had contact with a particular pathogen or a similar antigen. When interpreting serological tests, it should be kept in mind that the reptilian immune system depends on environmental factors to function optimally and the formation of antibodies therefore depends on temperature, season, stress, age of the animal, and other infections. Serology also only detects part of the immune response. In many cases, a cellular response is more significant with regard to the absence of pathogens. A positive serology result can therefore indicate that an animal has already

had contact with a pathogen (or a similar antigen), but usually does not provide information on the infection status. Repeated tests after a few weeks (normally 6 – 8 weeks) can help to determine titre changes and thus detect acute infections. Many infectious agents cause persistent infections in reptiles. In such cases, a positive serological reaction indicates an existing infection, regardless of the clinical findings.
Serological tests frequently described in reptiles are virus or serum neutralisation tests (NTs), haemagglutination inhibition assays (HIs) and enzyme-linked immunosorbent assays (ELISAs). Laboklin offers different NTs for tortoises and HIs especially for snakes. NTs are used in tortoises, mainly to detect antibodies against **herpesviruses** (HV). It is possible to detect antibodies against testudinid HV 1 (TeHV1) and TeHV3. TeHV1 mainly (but not exclusively) occurs in Russian tortoises (*Testudo horsfieldii*), while TeHV3 is found in many different species and is associated with higher morbidity and mortality rates. The detection of antibodies against these viruses also depends on the chelonian species. Unlike Greek tortoises (*T. graeca*), for example, Hermann's tortoises (*T. hermanni*) rarely produce detectable antibodies. NTs are also used to detect antibodies against **picornaviruses** (torchiviruses, also called virus "X") in tortoises.
HIs are used in reptiles to detect antibodies against **ferlaviruses** (also called ophidian paramyxoviruses, OPMV). These viruses mainly occur in snakes, but can also infect lizards and chelonians. There are serological differences between different strains, so that at least 2 strains should be tested. It is not known whether ferlaviruses cause persistent infections, so that antibody-positive animals should be considered possible carriers.

Table 3: Select reptile pathogens: important clinical signs and pathology. Specific information on diagnostic testing is listed in the tables on specific organ systems. DM = detection method, nd = has never been detected in these animals

PATHOGEN	DM	CHELONIANS	LIZARDS	SNAKES
Viruses				
Adenoviruses	PCR	Anorexia, oral lesions, diarrhoea	Enteritis, hepatitis, neurological signs, star gazing	Enteritis, hepatitis, possibly pneumonia
Arenaviruses	PCR, histology	nd	nd	Inclusion body disease (IBD) (boas and pythons) – CNS, respiratory, gastrointestinal, skin, liver, and other systems can be affected
Erythrocytic viruses (hemocytiviruses)	Cytology	Possibly anaemia	Anaemia, anorexia, stomatitis	Anaemia
Ferlaviruses (PMV)	PCR	Pneumonia	Pneumonia	Pneumonia, CNS signs
Herpesviruses	PCR, serology	Stomatitis, rhinitis, hepatitis, skin lesions	Oral lesions, hepatitis	Oral lesions, hepatitis
Iridoviruses (Invertebrate Iridovirus, IIV)	PCR	nd	Skin lesions, cachexia, sudden death	nd
Nidoviruses	PCR	Rare (in Australia)	Rhinitis in *Tiliqua* spp.	Pneumonia, stomatitis (esp. pythons)
Picornaviruses (torchiviruses, virus „X")	PCR, cell culture, serology	Rhinitis, softening of the carapace (possibly due to kidney damage), ascites	nd	nd
Ranaviruses	PCR	Stomatitis, hepatitis	Hepatitis, skin lesions	Hepatitis, stomatitis
Reoviruses	PCR, cell culture	Stomatitis, rhinitis	Pneumonia, enteritis, skin lesions	Pneumonia
Sunshinevirus	PCR	nd	nd	Respiratory and CNS signs (pythons)
Bacteria				
Chlamydia	PCR	Pneumonia, myocarditis, hepatitis, granulomatous lesions	Lethargy, anorexia, enteritis, granulomatous inflammation	Regurgitation, enteritis, hepatitis, granulomatous inflammation
Devriesea agamarum	Culture	nd	Skin lesions, systemic disease	nd
Mycobacteria	Histology, cytology, possibly PCR	Granulomatous lesions in lungs, liver, skin, and other tissues	Granulomatous lesions in lungs, liver, skin, and other tissues	Granulomatous lesions in lungs, liver, skin, and other tissues
Mycoplasma	PCR	Rhinitis	Unknown	Tracheitis, pneumonia

Fungi				
Metarhizium (Chamaeleomyces) granulomatis	Culture, histology	nd	Lesions in oral cavity and in the liver	nd
Metarhizium (Chamaeleomyces) viridis	Culture, histology	nd	Lesions in oral cavity and in the liver	nd
Nannizziopsis and *Paranannizziopsis* spp./ yellow fungus disease	Culture, histology	nd	Dermatitis, hepatitis	nd
Ophidiomyces ophiodiicola	PCR, histology	nd	nd	Dermatitis
Yeasts *(Candida* spp.)	Culture	Diarrhoea, dermatitis	Diarrhoea, dermatitis, hepatitis, enteritis, pneumonia	Skin lesions, pneumonia
Parasites				
Most intestinal parasites	Faecal	None to severe gastrointestinal disease	None to severe gastrointestinal disease	None to severe gastrointestinal disease
Akanthamoebae	Histology	nd	nd	CNS signs
Choleoeimeria	Faecal	nd	Changes in the bile ducts, hepatomegaly	Changes in the bile ducts, hepatomegaly
Entamoeba invadens	Faecal	Generally inapparent in herbivorous species	Carnivorous species: anorexia, weight loss, enteritis (large intestine)	Anorexia, weight loss, enteritis (large intestine)
Hexamites	Faecal, urine, histology	Nephritis in immune suppressed and juvenile animals, often no clinical signs	Rare	Rare
Intranuclear coccidia (TINC)	PCR	Rhinitis, lethargy, weight loss, dyspnoea, skin lesions, sudden death	nd	nd
Coccidia e.g. *Isospora* spp.)	Faecal	Rare	Enteritis	Rare
Cryptosporidia	PCR, Faecal, ELISA	Rare. Found in stomach and/or intestine, enteritis	Anorexia, cachexia, enteritis	Gastric swelling, regurgitation, cachexia, enteritis
Mites (e.g. *Ophionyssus natricis*)	Clinical exam	Rare	Skin lesions, anaemia in cases with severe burdens	Skin lesions, anaemia in cases with severe burdens
Oxyurids	Faecal	Usually no clinical signs, enteritis and death in juveniles	Usually no clinical signs, slower growth of juveniles	Rare
Pentastomids	Faecal	Rare	Rare	Lung lesions
Strongylids (e.g. *Kalicephalus* spp.)	Faecal	Rare	Rare	Anorexia, cachexia
Spirometra (tapeworms)	Faecal	Rare	Cachexia	Cachexia
Ascarides	Faecal	Gastroenteritis, can cause damage in other tissues	Gastroenteritis, can cause damage in other tissues	Gastroenteritis, can cause damage in other tissues

Pathology/Histology/Cytology/Tumours

Macroscopic and histological examinations provide important information for diagnosis and treatment evaluations of various conditions. This type of examination provides information on anatomy, provides a basis for surgical interventions and deepens insight into specific diseases of reptiles. Moreover, for clarifying non-specific or complex cases, this method, combined with further tests, can decisively contribute to a diagnosis. It can reveal mistakes in animal husbandry and contribute to responsible reptile husbandry practices. It also supports scientific progress.

Histopathology is concerned with the microscopic examination of tissue changes with the aim of providing a diagnostic evaluation that is as comprehensive as possible. Careful handling is necessary when taking samples. **A sampling method with a minimum of artefacts** and suitable for the localisation and sample must be chosen. A histological picture that reproduces the intravitam state as realistically as possible is crucial for the success of the examination. This requires **fixation** immediately after sampling, which should be performed in 4% neutral buffered formaldehyde (= 10% formalin). The **sample size** should not exceed an edge length of 1 cm. Ideally, samples are larger than 5 mm in diameter to be able to **assess the anatomical conditions** of the tissue. However, smaller sample sizes may be inevitable due to the sampling site (biopsies) or the species. Pathology and especially histology play an important role in reptile medicine. Pathological examination is used to diagnose diseases and clarify deaths in responsible animal husbandry. Particularly in larger collections, it is used to reveal mistakes in husbandry and to monitor the population. In **reptile practice**, clarifying the aetiology of various changes in the skin is of great importance. Skin lesions often have very similar macroscopic presentations and in most cases can only be clearly differentiated histologically. Histology can therefore be used directly to provide guidelines for treatment. It plays a particularly important role in the diagnosis of tumours, which appear to be increasingly common in reptiles in human care (Fig. 4). Submission of representative organ samples or organ spectra is recommended in order to determine a cause of death – especially in case in which multiple animals are affected.

Fig. 4: Soft tissue sarcoma of the skin in a bearded dragon. Histology and cytology are recommended to help determine the aetiology.

A clinical history is important and in many cases decisive for the interpretation of histological and cytological results. In addition to species, gender and age of the patient, it should also contain information on tests already performed, clinical distribution, localisation and duration as well as the type of sampe. Clinical photos of the altered areas and a differential diagnosis list are also helpful. This allows the pathologist to understand the clinical picture and discuss differential diagnoses and the relevance of the results.

In reptile practice, many patients are presented for which the list of differential diagnoses can be significantly reduced with the aid of **cytology** or for which immediate treatment is possible after diagnosis. This is of great advantage, as many patients with advanced signs of disease are presented that require rapid and consequent intervention. Cytology is a typical “instant method”, i.e. a result can be obtained immediately after collection. Since no embedding is necessary, the result is available one day earlier than for histological examination even if samples are sent to the laboratory. All materials for which it is technically possible to produce evaluable smears can be cytologically examined. These may include, for example, preparations of skin, carapace, masses, organs, secretions, excretions, or exudates. The sampling method depends on the specific conditions such as localisation, expected yield/material quantity, and consistency. When making cytological preparations, the aim is to achieve a sample thickness of one cell layer (monolayer). The preparations are air-dried and not treated any further before staining.
Cytology in reptiles is used to differentiate inflammatory and degenerative from neoplastic processes and to analyse pathogenic structures. Extensive experience is needed for the evaluation of the preparations. In routine diagnostics, preparations of skin lesions and changes in the carapace as well as lavages and liver aspirates are most commonly examined.

Laboratory tests for diseases of important organ systems

Below, some important disease complexes and problems are briefly described that can occur in different reptiles in practice. The text focuses on species that are commonly kept in captivity (tortoises and aquatic turtles, lizards and snakes) and is divided according to important organ systems. It specifically offers information on possible helpful laboratory diagnostic tests. More detailed information on important pathogens that can be detected in reptiles is listed in Table 3 above.

1. Upper respiratory tract (nasal discharge, rhinitis, upper respiratory tract disease (URTD))

Diseases of the upper respiratory tract are often accompanied by nasal discharge. Swelling of the head region, conjunctivitis and changes around the ears may also be associated with diseases of the upper respiratory tract. Dyspnoea may be caused by disease in this area, but may also indicate further changes in the lower respiratory tract. There are many causes of upper respiratory tract disease. Non-infectious causes include poor husbandry, including keeping the animal too cold, too dry and/or too dusty. Mistakes in feeding the animals can also lead to changes in the upper respiratory tract, the eyes or also the ears. This includes, for example, vitamin A deficiency, which is a problem especially in aquatic turtles (but hypervitaminosis A can cause severe skin problems especially in tortoises). There are several pathogens that cause changes in this area. Mixed infections are common.

Table 4: Laboratory testing in reptiles with upper respiratory tract disease – possible parameters and samples. Priority samples underlined where applicable.

BLOOD TESTS			
Parameters	**Species**	**Samples**	**Comments**
CBC, differential	All	Heparin blood (include a blood smear)	Can offer information on presence of inflammation
Blood chemistry: Total protein, albumin, globulins	All	Heparin plasma, serum	Electrophoresis, shifts following inflammation and infection
INFECTIOUS AGENTS			
Pathogens	**Species**	**Samples**	**Comments**
Viruses			
Arenaviruses/IBD	Boas and pythons	Dry oesophageal swab, blood, tissues (brain, liver, lung, pancreas, kidney)	PCR, inclusion bodies in blood smears or liver biopsies. See also: CNS signs
Herpesviruses	Chelonians	Dry oral swab, lesions, tongue, lung, brain	PCR. See also: upper digestive tract
Nidoviruses	Snakes, mostly pythons, skinks (*Tiliqua* spp.)	Dry oral swab, tracheal/nasal lavage, tissues (esp. lung)	PCR. See also: lower respiratory tract
Picornaviruses (torchiviruses, Virus „X“)	Tortoises	Dry oral and cloacal swab, tissues	PCR, virus isolation. See also: kidney disease
Ranaviruses	All	Dry oral and cloacal swab, whole blood, lesions, tissues	PCR. See also: upper digestive tract, skin (lizards)
Bacteria			
Mycoplasma	Esp. tortoises, also turtles, snakes	Nasal flush, dry oral swab, nasal mucosa, lesions	PCR. Important cause of disease in terrestrial tortoises. Significance in other reptiles less well understood.
Aerobic bacteria	All	Nasal flush, lesions	Bacterial culture. Interpretation can be challenging, should always be done in conjunction with clinical signs
Fungi			
Moulds	All	Nasal flush, lesions	Fungal culture. Interpretation can be challenging, should always be done in conjunction with clinical signs.
Parasites			
Intranuclear coccidia (TINC)	Chelonians	Nasal flush, cloacal swab, tissues	PCR. Most common in tropical tortoises. Systemic disease, various organ systems can be affected.

2. Lower respiratory tract (pneumonia)

Fig. 5: Tracheal lavage sample taken from a ball python. Tracheal lavage samples can be examined cytologically. They can be used to detect inflammation, changes in the respiratory tract, and possible involvement of bacteria or fungi. Lavage samples can also be used for further diagnosis of infectious agents, e.g. ferlaviruses or nidoviruses.

Pneumonia is relatively common in reptiles living in captivity, in part due to the anatomy of the reptilian respiratory tract (no diaphragm, relatively simple lung structure, air sacs in some species). Pneumonia is frequently caused or promoted by poor husbandry, such as low temperatures, draught, poor hygiene, or insufficient ventilation. Inflammation is often chronic and the cause can be difficult to determine. Affected animals can remain without noticeable clinical signs for extended periods of time, so that reptiles with noticeable pneumonia are often already seriously ill. Lifting the head while breathing (especially in snakes) can be a sign of dyspnoea. In chelonians, increased movements of the limbs in time with the breathing may be visible. Mucus or fluid (including blood) in the oral cavity can be a sign of inflammation of the lungs. However, disorders of other systems and space-occupying processes in the body cavity (e.g. laying activity, especially in chelonians, obesity, constipation, tumours) can also lead to dyspnoea. Traumata should also be clarified as a possible cause. In addition, there are several viruses and parasites that can lead to changes in the lungs (Table 5). Bacteria and fungi may also be involved in pneumonia, although these are usually facultative pathogens. Diagnostically, imaging techniques play an important role. Furthermore, tracheal lavage samples (Fig. 5) can provide important information. Turbidity and flocculation in the lavage fluid already indicate inflammation in this area. Tracheal lavage samples can be examined cytologically (smears should best be freshly prepared in practice after centrifugation). This way, inflammation, changes in the respiratory tract and possible involvement of bacteria or fungi in the course of the disease can be detected. Lavage samples can also be used for further diagnosis of pathogens (Table 5).

Table 5: Laboratory testing in reptiles with lower respiratory tract disease – possible parameters and samples. Priority samples underlined where applicable.

BLOOD TESTS			
Parameters	**Species**	**Samples**	**Comments**
CBC, differential	All	Heparin blood (include a blood smear)	Can offer information on presence of inflammation
Blood chemistry: Total protein, albumin, globulins	All	Heparin plasma, serum	Electrophoresis, shifts following inflammation and infection
INFECTIOUS AGENTS			
Pathogens	**Species**	**Samples**	**Comments**
Viruses			
Adenoviruses	Snakes, lizards, chelonians (less common)	Dry cloacal swab, liver, intestine	PCR. Sometimes found in collections with therapy resistant pneumonias. See also: gastrointestinal tract and liver
Arenaviruses/IBD	Boas and pythons	Dry oesophageal swab, whole blood, brain, liver, pancreas, kidney	PCR, cytology/histology for inclusions in blood smears or biopsies of the liver or oesophageal tonsils. See also: CNS
Ferlaviruses (paramyxoviruses)	Snakes, rarely lizards and chelonians	Tracheal lavage, dry oral (and cloacal) swabs, lung, intestine, pancreas, brain	PCR. See also: CNS. Especially common in viperids, colubrids. Can also infect others
Herpesviruses	Most common in various chelonian spp.	Dry oral swab, lesions, tongue, lung, brain	PCR. See also: upper gastrointestinal tract
Nidoviruses	Pythons, rarely in boas. Related virus found in skinks *(Tiliqua* spp.) and turtles in Australia	Dry oral swab, tracheal lavage, lung, oral mucosa	PCR. Common in pythons
Ranaviruses	All	Dry oral swabs, whole blood, lesions, liver, tongue, intestine, skin, kidney	PCR. See also: upper gastrointestinal tract, skin (lizards)
Reoviruses	Esp. snakes, lizards; rare in chelonians	Dry oral swabs, intestine, liver, brain, tongue, lung	PCR, virus isolation. Relatively common, may play a role in multifactorial disease. See also: CNS
Sunshinevirus	Pythons	Tracheal lavage, dry oral swab, brain, lung, kidney	PCR. See also: CNS

Bacteria			
Chlamydia	All	Tracheal lavage, dry oral swabs, lesions, lung, liver, heart	PCR. Can affect a wide variety of organs
Mycobacteria	All	Lesions	Cytology, histology, (PCR)
Mycoplasma	Esp. tortoises, possibly aquatic turtles, snakes	Nasal lavage, dry oral swabs, nasal mucosa, lesions	PCR. More common as an upper respiratory pathogen
Aerobic bacteria	All	Tracheal lavage, lesions	Culture. Interpretation can be difficult, should always be done in conjunction with clinical signs
Fungi			
Moulds	All	Tracheal lavage, lesions	Culture. Interpretation can be difficult, should always be done in conjunction with clinical signs
Parasites			
Intranuclear coccidia (TINC)	Chelonians	Nasal lavage, dry cloacal swabs, liver, intestine, kidney, pancreas, others	PCR. Especially in tropical tortoises. Systemic disease, various organ systems can be affected
Lung worms (*Rhabdias* spp., others)	Snakes, lizards	Faeces, sputum, lung, intestinal content	Flotation
Pentastomides	Esp. snakes, lizards (wild-caught)	Faeces, sputum, lung	Flotation, adult stages can also be found in the lung using diagnostic imaging techniques. Zoonotic

3. Upper gastrointestinal tract (stomatitis, glossitis, peridontitis, oesophagitis)

Changes in the upper gastrointestinal tract are regularly observed in various reptiles and can be caused by different infectious and non-infectious agents. Affected animals are often lethargic and anorectic. Poor husbandry conditions and inappropriate food frequently play a major role in the development of diseases in this region. Food which is too soft or contains too much sugar (e.g. a high content of fruit) can lead to the development of peridontitis, which is regularly observed in bearded dragons. Oral traumata can be caused by biting between animals in the terrarium or also by feeder animals. Masses can be caused by granulomatous inflammation, gout (see kidney), but also by tumours. Here, a cytological examination or biopsy can contribute to the diagnosis. Possible infectious agents involved are listed in Table 6.

Table 6: Laboratory testing in reptiles with upper gastrointestinal tract disease – possible parameters and samples. Priority samples underlined where applicable.

BLOOD TESTS			
Parameters	**Species**	**Samples**	**Comments**
CBC, differential	All	Heparin blood (include a blood smear)	Can offer information on presence of inflammation
Blood chemistry: Total protein, albumin, globulins, possibly kidney parameters	All	Heparin plasma, serum	Depending on the clinical signs
INFECTIOUS AGENTS			
Pathogen	**Species**	**Samples**	**Comments**
Viruses			
Arenaviruses/IBD	Boas, pythons	Dry oesophageal swab, whole blood, liver, blood smear (for cytology), <u>brain,</u> pancreas, kidney	PCR, inclusions in blood smear or liver biopsy. See also: CNS
Herpesviruses	Chelonians, rarely lizards and snakes	Dry oral swab, lesions, <u>tongue,</u> liver, brain	PCR
Nidoviruses	Pythons, rarely in boas. Related virus found in skinks (*Tiliqua* spp.)	Dry oral swab, tracheal lavage, <u>lung,</u> oral mucosa	PCR. V.a. Mostly affects the respiratory tract, but infected animals may also develop stomatitis

Ranaviruses	All	Dry oral swab, liver, whole blood, lesions, tongue, intestine, skin, kidney	PCR. See also: liver, skin (lizards)
Reoviruses	Chelonians	Dry oral swab, intestine, liver, brain, tongue, lung	PCR
Sunshinevirus	Pythons	Dry oral and cloacal swabs, brain, lung, kidney	PCR. See also: CNS
Bacteria			
Chlamydia	All	Dry oral swab, lesions, lung, liver, heart	PCR. Can affect a wide variety of organs
Mycoplasma	Esp. tortoises, possibly aquatic turtles, snakes	Nasal lavage, dry oral swab, nasal mucosa, lesions	PCR. See also: upper respiratory tract
Fungi			
Metarhizium (Chamaeleomyces) spp.	Lizards, esp. chameleons	Dry oral and cloacal swabs, liver, lesions	Culture, histology

4. Lower gastrointestinal tract (obstipation, diarrhoea, vomiting, regurgitation, anorexia)

There are many causes of disorders of the gastrointestinal tract in reptiles. Inadequate husbandry conditions, especially poor hygiene and temperatures that are too low, can lead to disorders in this region. Improper nutrition as well as spoiled food and stress (especially in animals captured in the wild) can lead to a refusal to eat or to regurgitation. Malnutrition, e.g. calcium deficiency, can also affect digestion. Quite frequently, foreign bodies are found in the gastrointestinal tract, especially in lizards and snakes. Among others, the terrarium substrate plays an important role here. Animals can take up sandy or stony ground with the food which then leads to obstipation. Space-occupying processes in the coelom can cause gastrointestinal effects including anorexia and obstipation. Tumorous lesions of the intestine are described frequently. Adenocarcinomas of the large intestine of snakes are most often diagnosed. Anorexia can also be caused by various systemic diseases and does not have to be associated with a primary disorder of the gastrointestinal tract. Physiological anorexia occurs in female animals before egg deposition. Species that brumate (hibernate), e.g. Mediterranean tortoises or bearded dragons *(Pogona vitticeps)*, physiologically stop feeding when days grow shorter and ambient temperatures are lower. Some species from temperate zones, e.g. Russian tortoises *(Testudo horsfieldii)* also aestivate at high ambient temperatures. Diagnostically, imaging techniques can be particularly useful in case of foreign objects and space-occupying processes. In addition, a faecal examination (native and by means of flotation) and possible further examinations are advisable (Fig. 6). For some parasites, a gastric lavage sample is best suited for diagnosis (Table 7).

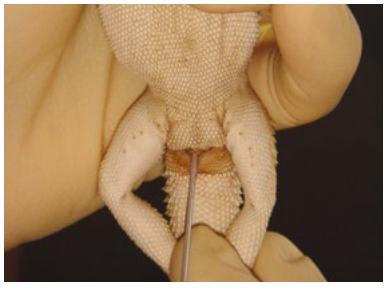

Fig. 6: Cloacal swab collection in a bearded dragon. Cloacal swabs can be used to detect various infectious agents, e.g. adenoviruses. They can also be examined parasitologically (direct smear), but are usually less sensitive than faecal samples for the detection of endoparasites.

Table 7: Laboratory testing in reptiles with lower gastrointestinal tract disease – possible parameters and samples. Priority samples underlined where applicable.

BLOOD VALUES			
Parameters	**Species**	**Samples**	**Comments**
Haematocrit	All	Heparin blood	Increased in dehydration; anaemia possible in chronic liver disease
CBC, differential	All	Heparin blood + blood smear	Possible indicator for inflammation
Blood chemistry: Glucose, total protein, albumin, liver and kidney parameters	All	Heparin plasma, serum	
INFECTIOUS AGENTS			
Pathogen	**Species**	**Samples**	**Comments**
Viruses			
Adenoviruses	Lizards, snakes, possibly chelonians	Dry cloacal swab, liver, intestine	PCR. Very common esp. in bearded dragons

Arenaviruses/IBD	Boas, pythons	Dry oesophageal swab, whole blood, liver, brain, pancreas, kidney	PCR, inclusions in blood smears or liver biopsies. See also: CNS
Herpesviruses	Chelonians, rarely lizards and snakes	Dry oral swab, lesions, tongue, liver, brain	PCR. Mostly upper gastrointestinal tract affected
Ranaviruses	All	Dry oral swab, liver, whole blood, lesions, tongue, intestine, skin, kidney	PCR. See also: liver, skin (lizards)
Reoviruses	Chelonians, possibly lizards and snakes	Dry oral and cloacal swabs, intestine, liver, brain, tongue, lung	PCR
Bacteria			
Chlamydia	All	Dry oral swab, lesions, lung, liver, heart	PCR. Can affect a wide variety of organs
Fungi			
Yeasts *(Candida* spp.)	Esp. chelonians	Faeces, lesions, intestinal content	Culture. Involved in diarrhoea in cases with dysbiosis
Parasites			
Various intestinal parasites	All	Faeces, intestinal content	Cloacal swab less sensitive
Cryptosporidia	Esp. lizards, snakes	Faeces (lizards), stomach lavage (snakes), stomach (snakes), intestine (lizards)	Direct smear, stain, ELISA, PCR. Cryptosporidia are also found in prey animals. It is therefore important to differentiate the species in positive cases (PCR)
Coccidia (e.g. *Isospora* spp.)	Esp. lizards	Faeces, intestinal content	Flotation
Entamoeba invadens	Esp. snakes, lizards	Faeces, intestine	Direct smear, histology
Intranuclear coccidia (TINC)	Chelonians	Nasal lavage, dry cloacal swab, liver, intestine, kidney, pancreas, others	PCR. Especially in tropical tortoises. Systemic disease, various organ systems can be affected
Oxyurids	Esp. chelonians	Faeces, intestinal content	Flotation. Only causes problems in cases with massive burdens
Protozoa, e.g. hexamites, balantidia	Chelonians	Faeces – fresh, direct smear, unstained, intestinal content, possibly kidney	In cases with massive burdens: Digestive disorders, enteritis
Strongylides (e.g. *Kalicephalus* spp.)	Esp. snakes	Faeces, intestinal content	
Spirometra	Snakes	Faeces, lesion/growth, skin	

5. Liver

Hepatic diseases regularly occur in reptiles and can be accompanied by very different and unspecific clinical signs. Liver function in reptiles is similar to that in mammals and birds, but it is sometimes very dependent on physiological conditions (e.g. brumation, laying activity in female animals) and environmental factors (e.g. temperature). For most reptiles, biliverdin is the end product of haemoglobin degradation. Acute liver diseases often manifest in sudden depression, lethargy and anorexia. Anamnestic data are often unspecific, but questions about several affected animals or contact with animals not belonging to the population can indicate infectious causes. Animals with acute liver disease may have a good nutritional status, normal weight and good muscling. Some suffer from diarrhoea. Urates and plasma may have a green discolouration due to increased levels of biliverdin. Animals that regurgitate generally have a poor prognosis. Mucous membranes may be pale, reddish or yellowish in colour, the eyes may be closed in affected animals. Chronic liver diseases are characterised by a slowly increasing loss of appetite with a progressive reduction of activity. Animals show reduced fertility, reduced weight gain or slow weight loss. Affected reptiles that brumate often develop post hibernation anorexia. Colour and consistency of the faeces may be changed. Animals are usually in poor physical condition, the limbs are often limp, the animals are poorly muscled. Diarrhoea is rare as the animals are generally anorectic. Clinical problems are often seen after stress (e.g. brumation, mating, or other diseases). Ascites can occur.

For the diagnosis of liver diseases there are several test methods available. During faecal analysis (and urinalysis), diarrhoea and urates with yellow to green discolouration may possibly be detected. Faecal examination for parasites is advisable. Imaging techniques can indicate changes in the liver including swelling, granulomas, abscesses or tumours. Liver biopsies or cytological preparations are very helpful in the diagnosis of hepatic diseases and can also

be used for prognosis and the evaluation of therapeutic success. They can be obtained percutaneously, surgically, endoscopically or ultrasound-guided. In addition, such samples can also be examined microbiologically.
Many different noxae such as toxins, infections, tumours and metabolic disorders should be considered as possible aetiological causes of liver diseases. The latter are most common in reptiles and particularly manifest as fatty liver, which is mainly caused by poor husbandry (malnutrition, lack of exercise). Pesticides, some medication (e.g. metronidazole, itraconazole, benzimidazole, ivermectin), plant toxins, and mycotoxins can also damage the liver. There are some infectious agents, including viruses, bacteria, fungi and parasites, that can cause hepatic diseases. Bacteria are mainly opportunistic pathogens that infect the liver as part of a multifactorial disorder. Some infectious agents that frequently affect the liver are listed in Table 8.
Liver tumours repeatedly occur in reptiles. Hepatocellular adenomas are rare, while bile duct adenomas are more common. Hepatocellular carcinomas and bile duct carcinomas have been described and are sometimes very aggressive. Metastases of other primary tumours are also found in the liver. Diagnosis of a liver tumour is best made histologically after taking liver biopsies.

Table 8: Laboratory testing in reptiles with hepatic disease – possible parameters and samples. Priority samples underlined where applicable.

BLOOD VALUES			
Parameters	**Species**	**Samples**	**Comments**
Haematocrit	All	Heparin blood	Increased in dehydration; possible anaemia in chronic liver diseases
CBC	All	Heparin blood + blood smear	Number of leukocytes can be increased in acute hepatitis, may be normal or slightly elevated in cases with chronic liver disease
Differential	All	Heparin blood + blood smear	Heterophilia in acute hepatitis, possible monocytosis in chronic cases, possible eosinophilia in cases with parasite infestation
Blood chemistry: ALT, AST, (CK), LDH, GLDH, bile acids, TP, Alb, cholesterol, triglycerides	All	Heparin plasma, serum	Few liver specific parameters – should be evaluated overall and in conjunction with clinical signs
INFECTIOUS AGENTS			
Pathogens	**Species**	**Samples**	**Comments**
Viruses			
Adenoviruses	Lizards, snakes, possibly chelonians	Dry cloacal swab, liver, intestine	PCR. Very common e.g. in bearded dragons
Arenaviruses/IBD	Boas, pythons	Dry oesophageal swab, whole blood, blood smears, liver, brain, pancreas, kidney	PCR, inclusions in blood smears or liver biopsies. See also: CNS
Herpesviruses	Chelonians	Dry oral swabs, lesions, tongue, liver, brain	PCR. See also: stomatitis. Hepatitis mostly described in aquatic turtles. Rare in lizards and snakes
Ranaviruses	All	Dry oral swabs, whole blood, lesions, liver, tongue, intestine, skin, kidney	PCR. See also: stomatitis (chelonians), skin (lizards)
Reoviruses	Snakes, lizards, rarely chelonians	Dry oral swabs, dry cloacal swabs, intestine, liver, brain, tongue, lung	PCR. See also: upper GI tract and lower respiratory tract
Bacteria and fungi			
Bacteria and moulds, yeasts	All	Liver, lesions	Culture. Interpretation best in conjunction with histology
Chlamydia	All	Tracheal lavage, dry oral swab, lesions, lung, liver, heart	PCR. Can affect a variety of organs
Metarhizium (Chamaeleomyces) granulomatis	Chameleons	Oral and cloacal swab, liver, lesions	Culture
Metarhizium (Chamaeleomyces) viridis	Lizards	Oral and cloacal swab, liver, lesions	Culture

Mycobacteria	All	Lesions	Cytology, histology, (PCR)
Nannizziopsis and *Paranannizziopsis* spp.	Lizards	Skin, lesions, liver	Culture. See also: skin
Parasites			
Choleoeimeria spp.	Lizards, snakes	Faeces, gall bladder	Flotation, histology
Entamoeba invadens	Esp. snakes, lizards	Faeces, intestine	Direct smear, histology
Intranuclear coccidia (TINC)	Chelonians	Nasal lavage, cloacal swab, intestine, liver, pancreas, others	PCR. Most common in tropical terrestrial tortoises. Systemic disease that can affect a variety of organ systems
Helminths, e.g. various nematodes	All	Faeces, intestine, lesions	Parasites that wander through the body can affect internal organs
Protozoa, e.g. hexamites, balantidia	Chelonians	Faeces – fresh, unstained direct smear, intestinal content, liver	Can cause liver disease in cases with severe burdens. See also: kidneys
Spirometra	Snakes	Faeces, intestinal content, lesions, skin	

6. Nervous system

There are many different causes for changes in the CNS in reptiles. Clinical signs are most frequently observed in snakes. Affected animals usually show postural disorders, opisthotonus, tremors, or seizures. When assessing changes in posture, a distinction should also be made between physiological and non-physiological behaviour. Some snake species, for example, can physiologically take a supine position (e.g. as defensive behaviour, advanced gestation). There are some metabolic disorders that can affect the CNS. The most common are probably hypocalcaemias caused by insufficient calcium or a poor Ca:P ratio in the food, vitamin D deficiency, lack of UV light, or liver or kidney disease. This can lead to changes in the locomotor system as well as to disorders of neuromuscular transmission, resulting in tremor or paralysis. In fish-eating reptiles (e.g. garter snakes), thiamine deficiency can occur as a result of thiaminases in the food.

In all species, traumata can lead to neurological disorders. Additionally, there are some toxins that can cause neurological signs. For example, some reptile species are sensitive to different insecticides. Although species from temperate zones can tolerate low temperatures during brumation, frostbite can possibly damage the nerves and thus, for example, lead to blindness. Other causes of CNS signs include septicaemia and fungaemia, which occasionally occur in animals with a weakened immune system. Severe hepatic dysfunction as part of a hepatoencephalic syndrome can also lead to corresponding signs. Furthermore, some infectious agents may be a primary cause of CNS disease. For the diagnosis of CNS disorders, in addition to a detailed anamnesis and clinical examination, various further diagnostic tests may also be necessary. A selection of possible laboratory tests is listed in Table 9. For some CNS diseases, an exact diagnosis is only possible on the basis of a histological examination of the brain, so that in these cases a diagnosis by exclusion is the only option in a living animal. This is, for example, the case in acanthamoebic infections in snakes and granulomatous changes in the brain caused by fungi or bacteria (e.g. mycobacteria).

Table 9: Laboratory testing in reptiles with CNS disease – possible parameters and samples. Priority samples underlined where applicable

BLOOD VALUES			
Parameters	**Species**	**Samples**	**Comments**
CBC, differential	All	Heparin blood + blood smear	Possible indicators of inflammation
Blood chemistry: Ca, Ca:P ratio, possibly liver parameters	All	Heparin plasma, serum	Depending on case history
INFECTIOUS AGENTS			
Pathogens	**Species**	**Samples**	**Comments**
Viruses			
Adenoviruses	Lizards	Dry cloacal swabs, liver, intestine	PCR. Very common e.g. in bearded dragons. Liver and intestine most often affected, CNS signs also described
Arenaviruses/IBD	Boas, pythons	Dry oesophageal swab, whole blood, blood smear, liver, <u>brain,</u> pancreas, kidney	PCR, inclusions in blood smears or liver biopsies.

Ferlaviruses (Paramyxoviruses)	Esp. snakes	Tracheal lavage, lung, intestine, pancreas, brain	PCR. See also: lower respiratory tract
Herpesviruses	Chelonians, rare in lizards, snakes	Dry oral swab, lesions, tongue, liver, brain	PCR. See also: upper gastrointestinal tract
Reoviruses	Snakes	Dry oral and cloacal swab, intestine, liver, brain, tongue, lung	PCR
Sunshinevirus	Pythons	Dry oral and cloacal swab, brain, lung, kidney	PCR
Bacteria			
Mycobacteria	All	Lesions	Cytology, histology, (PCR)
Parasites			
Acanthamoeba	Snakes	Faeces, brain, lesions, intestinal content	Histology. Apathogenic in the intestine. CNS form can only be diagnosed post mortem

7. Skin/carapace

Skin lesions that are commonly presented in practice are generally not primarily infectious. These include burns caused by contact with heat lamps or heating pads that are too warm, as well as various traumata such as bite injuries caused by feeder animals or conspecifics. In some species, such as water dragons or very agile snakes, rostral trauma regularly occurs due to repeated contact with the terrarium walls. Moulting disorders can be caused by many different factors such as incorrect ambient temperatures, keeping animals too dry or too moist, and malnutrition. Too much humidity in the terrarium can also lead to so-called blister disease, a primarily sterile dermatitis, in snakes. Bacterial dermatitis can result from keeping animals under poor hygienic conditions. The bacteria involved are usually part of the normal intestinal or environmental flora. This can lead to septicaemic cutaneous ulcerative disease (SCUD) in aquatic turtles. Septicaemia can lead to petechial bleeding under the skin and reddening of the skin. As a primary pathogenic bacterium, *Devriesea agamarum* causes dermatitis, mainly in spiny-tailed lizards *(Uromastyx* spp.) but also in other species, especially around the mouth. Various fungi can be secondarily involved in dermatitis (Fig. 7). However, some primarily pathogenic species of the family Onygenaceae (*Nannizziopsis* and *Paranannizziopsis* spp. in lizards, *Ophidiomyces ophiodiico*la in snakes) have been described and numbers of cases involving these pathogens appear to be increasing. In other species, it is advisable to histologically relate skin lesions to detected fungal infections.

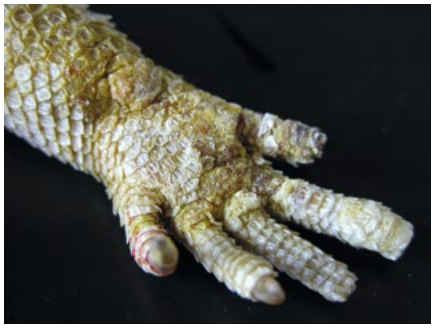

Fig. 7: Fungal infection of the skin of the foot of a bearded dragon. A mycological examination is recommended to detect the fungi and to diagnose the species. Histopathology is recommended to clarify the role of the fungi in the disease and to verify the findings.

Vitamin A plays a special role in the skin. Hypovitaminosis A can lead to metaplastic hyperplasia and thus to disorders of mucous membranes and moulting. In aquatic turtles, hypovitaminosis A often leads to the formation of auricular abscesses after obstruction of the Eustachian tube. However, hypervitaminosis A (often iatrogenic) also leads to skin disorders, especially in tortoises, in which extensive detachment of the epidermis can occur. Skin tumours of different rigin are relatively frequent in reptiles. Papillomatous skin changes are regularly described in different reptile species. In most cases, their aetiology is unclear, although various viruses (herpes-, irido-, papilloma-, reovirus) have been discussed as possible causes. Lizards also regularly have melanocytic tumours (Fig. 8), while snakes most often have sarcomas of different histogenesis.

Ectoparasites are regularly detected in reptiles. Mites (especially *Ophionyssus natricis*) are common in snakes and lizards. Ticks are mainly found in animals captured in the wild.

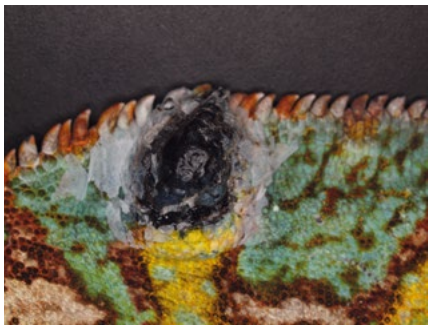

Abb. 8: Cutaneous melanophoroma in a veiled chameleon. Diagnosis can be made by histopathological or cytological examination.

Table 10: Laboratory testing in reptiles with lesions of the skin and carapace – possible parameters and samples. Priority samples underlined where applicable.

BLOOD VALUES			
Parameters	**Species**	**Samples**	**Comments**
CBC, differential	All	Heparin blood + blood smear	Possible indicators of inflammation
INFECTIOUS AGENTS			
Pathogens	**Species**	**Samples**	**Comments**
Viruses			
Arenaviruses/IBD	Boas, pythons	Dry oesophageal swab, whole blood, blood smears, liver, brain, pancreas, kidney	PCR. Inclusions in blood smears or liver biopsies. See also: CNS
Herpesviruses	Chelonians, rarely lizards and snakes	Dry oral swabs, lesions, tongue, liver, brain	PCR. Most commonly associated with upper gastrointestinal tract lesions. Papillomatous lesions in sea turtles and others
Invertebrate iridoviruses	Lizards	Skin, liver	PCR. Esp. in prey insects
Picornaviruses (torchiviruses, virus „x“)	Tortoises	Dry oral swabs, tongue, oesophagus, intestine, trachea, kidney, others	PCR. Softening of the carapace in juvenile tortoises
Ranaviruses	Lizards, possibly others	Dry oral swabs, skin, lesions, liver, tongue, intestine, kidney	PCR. See also: upper gastrointestinal tract and liver
Reoviruses	Lizards	Skin, intestine, liver, brain, tongue, lung	PCR. Has been associated with papillomas in some cases
Bacteria			
Devriesea agamarum	Lizards, esp. *Uromastyx* spp.	Skin, oral swab, lesions	Culture. Bearded dragons can be inapparent carriers
Aerobic bacteria	All	Skin, lesions	Culture. Mostly secondary pathogens
Mycobacteria	All	Lesions	Cytology, histology, (PCR)
Fungi			
Nannizziopsis and *Paranannizziopsis* spp. (CANV, yellow fungus disease)	Lizards	Skin, lesions, liver	Culture, histology
Ophidiomyces ophiodiicola	Snakes	Skin, lesions	PCR, histology, culture
Metarhizium (Chamaeleomyces) spp.	Chameleons	Skin, oral swabs, liver, lesions	Culture, histology and cytology
Moulds	All	Skin, lesions	Culture, histology. Histology or cytology necessary to interpret clinical relevance

8. Kidney/bladder/urinary tract

Renal diseases are common in reptiles, especially in older animals, and are usually associated with husbandry and nutritional problems. When keeping reptiles, sufficient access to fresh water and humidity are particularly important. For many species, clean bathing facilities are also necessary for fluid balance. As terrestrial reptiles mainly excrete uric acid, renal dysfunction and malnutrition can lead to renal gout. There are different manifestations here, with joint and visceral gout often occurring at the same time. A very high protein diet can play a role in the development of gout. In species that have a urinary bladder (e.g. tortoises), bladder stones can form. Bacterial or fungal infections usually occur secondarily after damage to the kidneys or the immune system. Intoxication can lead to renal damage. Diagnosis of renal insufficiency can be made with the help of clinical chemistries often in connection with imaging techniques. A kidney biopsy with histological examination can help in the diagnosis. Bladder stones are normally visualised by imaging techniques.

Table 11: Laboratory testing in reptiles with urinary tract disease – possible parameters and samples. Priority samples underlined where applicable.

BLOOD VALUES			
Parameters	**Species**	**Samples**	**Comments**
Haematocrit	All	Heparin blood	Increased in dehydrated animals, chronic renal disease can be associated with anaemia
CBC, differential	All	Heparin blood + blood smear	Possible indicators of inflammation
Blood chemistry: uric acid, urea, Ca, PO4, Na, K	All	Heparin plasma, serum	

INFECTIOUS AGENTS			
Pathogens	**Species**	**Samples**	**Comments**
Viruses			
Picornaviruses (torchi-viruses, virus „x“)	Tortoises	Dry oral swabs, tongue, oe-sophagus, intestine, trachea, kidney, others	PCR. See also: upper respiratory tract, skin/ carapace
Parasites			
Intranuclear coccidia (TINC)	Chelonians	Nasal lavage, dry cloacal swab, liver, intestine, kidney, pancreas, others	PCR. Most common in tropical tortoises. Systemic disease that can affect a variety of organ systems
Hexamita parva	Chelonians	Urine, kidney	Esp. in young and weakened animals

9. Genitals (egg binding, cloacal prolapse)

Depending on the species, reptiles are ovipar, ovovivipar or vivipar. A common problem in female animals is preovulatory or postovulatory egg binding. This is often due to non-infectious causes. They particularly include problems with the design of the terrarium, such as a lack of egg deposition sites, disturbances and other stress factors. Furthermore, space-occupying processes in the coelom as well as in the fallopian tubes or the cloaca can lead to corresponding disorders. The need for calcium is particularly high during the development of eggs/embryos and during oviposition, so that calcium deficiency during oviposition can cause acute problems. Bacteria and fungi can infect the genitals, usually secondarily following injuries or immunosuppression. In addition, animals with prolapse of the cloaca are regularly presented in the reptile practice. Various organs can prolapse. These include parts of the genitals (oviduct in female animals, penis or hemipenes in male animals), the urinary tract (especially the bladder, if present) and the distal sections of the intestine. Possible causes are metabolic disorders (especially calcium deficiency, metabolic bone disease), space-occupying processes in the abdominal cavity (e.g. egg binding, obstipation, high endoparasite load) as well as exhaustion. Traumata can also play a role here. Laboratory tests that can help in the clarification of clinical problems of the genitals are listed in Table 12.

Table 12: Laboratory testing in reptiles with genital disease – possible parameters and samples.

BLOOD VALUES			
Parameters	**Species**	**Samples**	**Comments**
CBC, differential	All	Heparin blood + blood smear	Possible indicators of inflammation
Blood chemistry: Ca, PO4, TP, albumin, cholesterol	All	Heparin plasma, serum	Possible indicators of vitellogenesis
Infectious agents			
Pathogens	**Species**	**Samples**	**Comments**
Endoparasites	All	Faeces, intestinal content	Direct smear, flotation

10. Heart

Relatively little is known about cardiac diseases in reptiles. In most reptile species, the anatomy of the heart differs in some aspects from that in birds and mammals. Since the septum between the ventricles is not completely closed, venous and arterial blood can mix. Problems with the heart can be caused by calcifications as part of metabolic disorders. In rare cases, cardiac tamponade may occur during cardiac puncture for blood collection. Cardiac tumours and metastasis of tumours in the heart are very rare. Bacteraemia/septicaemia can lead to endocarditis or myocarditis. Diagnosis is usually made with the help of imaging techniques. Laboratory tests can indicate inflammation or muscle degeneration, but are not very specific.

Table 13: Laboratory testing in reptiles with cardiac disease – possible parameters and samples.

BLOOD VALUES			
Parameters	**Species**	**Samples**	**Comments**
Haematocrit	All	Heparin blood	
CBC, differential	All	Heparin blood + blood smear	Possible indicators of inflammation
Blood chemistry: ALT, AST, CK, K, Na, Ca, PO4	All	Heparin plasma, serum	

11. Blood (anaemia, parasites, etc.)

Blood tests in reptiles are significantly influenced by the technique, the collection of the blood sample and processing. As already mentioned, dilution with lymph may occur during blood collection, which leads to a shift in various parameters, including haematocrit.
When preparing blood smears, morphological changes may take place in the cells, making assessment difficult. Smears should be made as gently as possible.
Various factors can lead to anaemia in reptiles. Undernourishment or malnutrition as well as kidney or liver diseases can play a role here. Systemic infections can lead to shifts in the blood count and to morphological changes in the cells. There are several infectious agents that cause inclusions in different blood cells, including viruses, e.g. erythrocytic necrosis viruses (hemocytiviruses), arenaviruses/inclusion body disease (IBD), and parasites, such as *Hepatozoon* spp. The latter are mainly found in the blood of animals captured in the wild.

Table 14: Laboratory testing in reptiles with haematologic disease – possible parameters and samples. Priority samples underlined where applicable.

BLOOD VALUES			
Parameters	**Species**	**Samples**	**Comments**
Haematocrit	All	Heparin blood	
CBC, differential	All	Heparin blood + blood smear	
Blood chemistry: K, TP, albumin, possibly liver and kidney parameters	All	Heparin plasma, serum	
INFECTIOUS AGENTS			
Pathogens	**Species**	**Samples**	**Comments**
Viruses			
Arenaviruses/IBD	Boas, pythons	Dry oesophageal swab, whole blood, blood smear, liver, brain, pancreas, kidney	PCR, inclusions in blood smears or liver biopsies. See also: CNS
Erythrocytic necrosis virus (hemocytiviruses)	All, esp. wild caught animals	Whole blood, blood smear, liver	Inclusions in blood smear
Ranaviruses	All	Dry oral swabs, whole blood, lesions, liver, tongue, intestine, skin, kidney	PCR. See also: stomatitis (chelonians), skin (lizards)
Bacteria			
Bacteria	All	Whole blood, blood smear	Cytology, culture
Parasites			
Protozoa in the blood	All (esp. wild caught animals)	Whole blood, blood smear	Cytology

12. Locomotor system

Changes in the locomotor system have many causes. Different kinds of traumata play a special role here. Bite wounds from other terrarium inhabitants or feeder animals, burns from contact with lamps or heating elements and falls can occur. Metabolic disorders can also cause changes in the locomotor system. Disorders of calcium balance in the metabolic bone disease (MBD) complex lead to pathological bone fractures as well as chronic exostoses and bone remodelling, but also to movement disorders due to disorders of neuromuscular transmission (see nervous system). Gout can lead to periarticular urate deposits and also to remodelling of the joints (see kidneys). Growth disorders in young animals can lead to various deformations of the locomotor system and are often related to malnutrition (Ca deficiency, incorrect Ca:P ratio, excess protein) or low humidity and lack of UV light. Movement disorders can occur as a result of changes in the internal organs (e.g. blockages or foreign bodies, pulmonary changes or intestinal bloating in aquatic turtles with abnormal swimming position). The tail can also be damaged by various processes. In some lizard species (like lacertids or geckos), the tail is thrown off quite easily in case of danger (tail autotomy). Tumours in the locomotor system, mostly spreading from the skin to the muscles, are not rare, while primary bone tumours are very rare. In the clinical examination of reptiles with changes in the locomotor system, traumatic, developmental, metabolic, physiological, and infectious as well as neoplastic causes should be considered. Impairments in various other systems can have effects on the movement of the animals. In addition to anamnesis, clinical examination and imaging techniques, laboratory tests can be helpful in diagnosis and therapy monitoring. Cytology or histology can be of great use in clarifying the aetiology of masses.

Table 15: Laboratory testing in reptiles with disease of the locomotor system – possible parameters and samples.

BLOOD VALUES			
Parameters	**Species**	**Samples**	**Comments**
CBC, differential	All	Heparin blood + blood smear	Possible indicators of inflammation
Blood chemistry: Ca, Ca:P ratio, possibly uric acid, urea, other kidney parameters, liver parameters	All	Heparin plasma, serum	Depending on the history and clinical signs
INFECTIOUS AGENTS			
Pathogens	**Species**	**Samples**	**Comments**
Bacteria			
Aerobe and anaerobe bacteria	All	Abscess wall, lesions, bone, skin and adjacent muscle tissue	Culture, cytology
Fungi			
Moulds	All	Abscess wall, lesions, bone, skin and adjacent muscle tissue	Culture, cytology

Quarantine

Quarantine is always important before animals are introduced into an existing group. Ideally, the health status of the existing group and that of the new animals tested should be known. In reptiles, this is particularly important as clinically relevant diseases often remain unnoticed for extended periods of time, many infectious diseases can persist permanently, and some of these animals naturally have a long life expectancy.
Ideally, quarantine should consist of several parts. Initially, a detailed anamnesis is important in order to determine whether the animals were captured in the wild or if they were bred and which possible contacts existed with other animals (e.g. purchase from a private breeder, in a pet shop, or at a reptile show?). Then, a clinical examination, preferably supplemented by a blood test, is necessary. Sick animals should not be brought into a healthy population. Healthy animals should then be tested for common infectious diseases. At a minimum, this usually consists of a parasitological faecal examination (direct smear and flotation) and tests for specific infectious agents occurring in this species. For the detection of important pathogens, Laboklin offers several quarantine profiles tailored to different animal groups. Since pathogens cannot always be detected in latent or persistent infections, tests for infectious agents should be repeated after a few weeks or months. Until then, the new animals should be kept separately. The quarantine period in reptiles depends on various factors. As a general rule, for species that brumate, it is safer to keep them in quarantine for so long that the animals can be examined both before and after brumation. The longer the quarantine period and the more detailed the testing, the lower the risk of introducing pathogens into a collection. During this time, however, strict separation between animal groups is necessary, which can be challenging depending on the spatial conditions.

Brumation

Many reptiles from temperate climate zones (e.g. most Mediterranean tortoise species) brumate during the cold winter months. During this period, the animals reduce their body temperature and reduce their food intake and their movement. Brumation behaviours are induced not only by reduced external temperatures, but also by changes in light intensity and the length of the day. Brumation can be physiologically challenging for the health of a reptile, and the reduction in body temperature renders the animal unable to react to insults, e.g. infectious disease or attacks from predators. It is, however, also considered important for long term health of these animals and has been shown to contribute to successful breeding. It is important to make sure that animals are healthy before the start of brumation and to initiate any necessary treatments (e.g. for endoparasites) sufficiently early to ensure that medications are administered while the metabolism is still active. A healthy check in late summer is generally advisable, and can include blood testing (haematology and clinical chemistry), faecal examination for parasites, and testing for specific pathogens in addition to a clinical exam. Laboklin offers specific brumation profiles for tortoises for this purpose.

Suggested additional reading

Divers SJ, Stahl SJ. 2019. Mader`s Reptile and Amphibian Medicine and Surgery, 3rd Ed. Elsevier.

Mader DR, Divers SJ. 2014. Current Therapy in Reptile Medicine and Surgery. Elsevier.

Carpenter JW. 2013. Exotic Animal Formulary, 4th Ed. Saunders.

Jacobson ER. 2007. Infectious Diseases and Pathology of Reptiles. CRC Press.

Pees M. 2015. Leitsymptome bei Reptilien. Enke.

Abbreviations

, (comma)	Sample options listed with commas: please choose a sample for submission from the list
+	Sample options connected with a “+”: you must submit all of the sample materials listed
A	swab (without medium = dry swab for PCRs)
BS	blood smear
CNS	central nervous system
EB	EDTA blood
EIA/ELISA	enzyme linked immunosorbent assay
FA	faeces
GW	tissue
HB	heparin blood
HP	heparin plasma
HT	skin
IFAT	indirect fluorescent antibody test
L	liver
LSP	lung lavage
Lu	Lunge
MSP	gastric lavage
NSP	nasal flush
PCR	polymerase chain reaction
S	serum
TM	swab with medium
TSP	tracheal lavage
*	partner laboratory

Our Tests for Reptiles

Reptile Chemistry Profiles

Reptile Profile (small) **HP,S/0.2ml**
(uric acid, protein, AST, AP, Ca, PO4)

Reptile Profile (large) **HP,S/0.4ml**
(AP, GLDH, ALT, AST, bile acids, CK, protein, albumin, urea, uric acid, PO4, Ca, K, Na)

Haematology

Complete Blood Count **HB/0.5ml(+BS)**

Infectious Diseases/Serology

Herpes (TeHV-1 and TeHV-3) **HP,S/0.4ml**
(chelonian)

Paramyxovirus/ Ferlavirus* **HP,S/0.2ml**

Picornavirus **HP,S/0.2ml**
(tortoise)

Microbiology

Bacteriology (aerobic) + Mycology **TM,GW**

Bacteriology (aerobic + anaerobic) **TM,GW**

Bacteriology (aerobic culture) **TM,GW**

Detection of Anaerobes (incl. Antibiogram) **TM,GW**

Mycology (skin) **TM,HT**

Bacteriology (aerobic) + Mycology (skin) **HT**

Ectoparasites **HT**

Antibiogram (fixed price)

Extended Antibiogram

Faecal Examinations

Reptile Faecal Profile
(bacteriology incl. salmonella, mycology)

Salmonella

Endoparasites
(flotation and sedimentation)

Reptile Endoparasites
(flotation and sedimentation, Ziehl-Neelsen stain, native smear)

Baermann Test (lungworm larvae)

Slide
(Ziehl-Neelsen stain)

Giardia sp. Antigen (EIA)

Cryptosporidia Antigen (EIA)

Cryptosporidia Antigen (IFAT)

Cryptosporidia – PCR **FA,MSP**
if positive: differentiation

PCR Assays

Adenoviruses **A,GW**
(reptile)

Arenaviruses/IBD **A,EB,GW**
(boa, python)

Batrachochytrium dendrobatidis **A,GW**
(amphibian/salamander)

Batrachochytrium salamandrivorans **A,GW**
(amphibian)

Chlamydia **A,LSP,GW**
(reptile, amphibian)

Cryptosporidia **FA,MSP**
(reptile)
if positive: differentiation

Herpesviruses **A,GW**
(reptile)
if positive: differentiation
(tortoise)

Herpesvirus **GW**
(koi carp)

Intranuclear coccidians (TINC) **A,NSP,GW**
(chelonian)

Iridovirus **A,HT,L**
(lizard, feed insect)

Mycoplasma **A,NSP**
(tortoise, turtle)

Nidoviruses **A,TSP,GW**
(python, boa)

Ophidiomyces ophiodiicola **A,HT,GW**
(snake)

Paramyxoviruses/ Ferlaviruses (reptile) **A,TSP,GW**

Picornavirus (Virus “X”) **A,GW**
(tortoise)

Ranaviruses **A,GW**
(reptile, amphibian, fish)

Reovirus (reptile) **A,LSP,GW**

Salmonella **FA**
(reptile, amphibian)

Sunshinevirus (phyton) **A,GW**

Pathology

Histopathology (per clinical question)
(tumor diagnosis, dermatopathology, organ biospies up to 3 sites)

Panel of Organs (per clinical question)
(descriptive diagnosis up to 8 sites)

Cytology
(smear, puncture fluid, lavage, etc.)

PCR Profiles

Amphibian **A,GW**
(Batrachochytrium dendrobatidis, Batrachochytrium salamandrivorans, ranaviruses)

Aquatic Turtle **A, NSP**
(herpesviruses, mycoplasma, ranaviruses)

Quarantine (lizard) **A**
(adenoviruses, ranaviruses, reoviruses)

Quarantine (colubrid, viper) **A**
(adenoviruses, paramyxoviruses/ ferlaviruses, reoviruses)

Quarantine (boa, python) **A,TSP+EB**
(adenoviruses, arenaviruses, paramyxoviruses/ferlaviruses, reoviruses)

Quarantine (tortoise) **A,NSP+HP**
(herpesviruses, mycoplasma, picornavirus, ranaviruses,herpes antibodies (TeHV-1 and TeHV-3))

Respiratory (large) (tortoise) **A,NSP**
(herpesviruses, mycoplasma, picornavirus)

Respiratory (small) (tortoise, turtle) **A,NSP**
(herpesviruses, mycoplasma)

Respiratory/Neurology (boa) **A,TSP+EB**
(adenoviruses, arenaviruses, paramyxoviruses/ferlaviruses, reoviruses)

Respiratory/ Neurology (python) **A,TSP+EB**
(adenoviruses, arenaviruses, nidoviruses, paramyxoviruses/ ferlaviruses, reoviruses)

Skin (lizard) **HT**
(adenoviruses, iridovirus, ranaviruses)

Other Profiles

Brumation Check Small (tortoise) **S, HP+A**
(large reptile profile, herpesvirus Ab (TeHV-1 and TeHV-3), herpesviruses PCR, mycoplasma PCR)

Brumation Check Large (tortoise) **S, HP+HB+BS+A+FA**
(large reptile profile, complete blood count, herpesvirus Ab (TeHV-1 and TeHV-3), herpesviruses PCR, mycoplasma PCR, endoparasites)

Cell culture

Virus Isolation **GW,TM**

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