Wildlife Health Australia

Diseases of concern in wild Australian crocodiles

Fact sheet

Introductory statement

Australia has two species of crocodile: the freshwater crocodile (*Crocodylus johnstoni*) and the estuarine or saltwater crocodile (*Crocodylus porosus*). Australian crocodile farming is a multi-million dollar industry (Crocodile Farmers Association of the Northern Territory and Northern Territory Government 2014). Farmed crocodiles have been affected by a number of different disease agents including poxvirus, pentastomes, *Streptococcus agalactiae, Dermatophilus* and *Chlamydia* (Buenviaje et al. 1998; Ladds 2009). Little is known about the prevalence and impacts of these, and other diseases, on Australia's wild crocodile populations. This fact sheet focuses on those diseases that have been identified in wild crocodiles and also examines diseases that have been recognised in farmed animals with the potential to spill over and affect the wild populations.

World and Australian distribution and epidemiology

Disease agents reported from wild Australian crocodiles include:

- **leeches**
- **nematodes** (*Capillaria crocodilus* and *Dujardinascaris*) (Webb et al. 1982; Webb and Manolis 1983)
- **pentastomes** (Riley et al. 1990)
- ***Dermatophilus* sp**. (Buenviaje et al. 1998)
- ***Chlamydia* sp.** (Jerrett et al. 2008)
- **Trauma** was also reported as a significant cause of morbidity in wild crocodiles (Webb and Manolis 1983)
- **Poxvirus, herpesvirus** and ***Streptococcus agalactiae*** have only been reported from captive crocodiles in Australia (Buenviaje et al. 2000; Shilton et al. 2016).

Nematodes *Capillaria crocodilus* (syn. *Paratrichosoma crocodilus*) and *Dujardinascaris* (syn. *Gedoelstascaris*) have a worldwide distribution. *Capillaria crocodilus* has been described from the skin of both freshwater and estuarine crocodiles. They are slender, thread-like nematodes that lay bioperculate, unembryonated eggs (Ashford and Muller 1978). *Dujardinascaris* are large nematodes that produce oval, thin shelled eggs. Fish, frogs and other aquatic species are the intermediate hosts (Sprent 1977).

Pentastomes have a worldwide distribution. They are large elongate, 0.5-12 cm, often tongue-shaped parasites. The cuticle is transversely striated and the anterior end is thick and flattened with two pairs of strong hooked claws. The adults live in the lungs of the crocodile definitive host. The egg, (130 µm diameter) when passed in the faeces or saliva, contains a larva with two or three pairs of rudimentary clawed legs. After ingestion by the fish intermediate host the egg hatches in the intestine, bores through the intestinal wall and encysts in a suitable organ. The larva undergoes several ecdyses and becomes a nymph. This is infective for the crocodile when it eats the fish (Jacobson 2007). Additional information on pentastomes in crocodiles can be found in the WHA fact sheet "Pentastomiasis in Australian Reptiles".

***Dermatophilus* spp**. consist of Gram-positive tapering bacteria that branch at right angles. Any septa that form give rise to as many as eight parallel rows of coccoid cells (zoospores), each of which has a tuft of up to six flagella. Zoospores measure 0.7 to 1.2 µm x 0.8 to 1.6 µm. *Dermatophilus* is spread by direct contact and mechanical transfer by insect vectors. Experimental transmission produced typical lesions after three days (Buenviaje et al. 2000).

***Chlamydia* spp.** are obligate intracellular bacterial parasites that consist either of the non-infectious reticulate body or the infectious elementary body. *Chlamydia* infections have been recorded from Nile crocodiles (*Crocodylus niloticus*) in Zimbabwe and South Africa (Australian Quarantine and Inspection Service 2000). Older crocodiles can carry *Chlamydia* while suffering no or only mild clinical signs. They can act as a reservoir for younger animals, which develop more severe disease if infected.

Poxviruses are large, 220-450 nm, enveloped, ovoid to brick shaped DNA viruses. Poxvirus has a worldwide distribution. Incubation was reported to range from nine days to four weeks (Australian Quarantine and Inspection Service 2000).

Herpesviruses are icosahedral, enveloped DNA viruses with a diameter of 120 to 200 nm. They are fragile viruses that do not survive well outside the body. Transmission requires close contact. Herpesvirus infection was initially identified in the skin of a farm hatched estuarine crocodile from the Northern Territory with poxvirus infection (McCowan et al. 2004). More recently two novel herpesviruses, crocodyline herpesvirus 1 (CrHV – 1) and crocodyline herpesvirus 2 (CrHV -2) were identified from farmed estuarine crocodiles in the NT suffering from a range of syndromes. Both CrHV – 1 and CrHV – 2 were found in crocodiles with conjunctivitis/pharyngitis syndrome, while CrHV – 2 was found in crocodiles with systemic lymphoid proliferation with nonsuppurative encephalitis and lymphonodular skin lesions (Hyndman et al. 2015; Shilton et al. 2016).

Streptococcus agalactiae is a group B *Streptococcus.* There is one report of necrotising fasciitis which occurred in captive raised male juvenile estuarine crocodiles in the NT, over a three month period between November 2005 and January 2006 (Bishop et al. 2007).

Clinical signs, diagnosis, pathology and laboratory diagnostic specimens and procedures

Diagnosis is made through a combination of clinical signs, gross and histological necropsy findings, culture, faecal examination and PCR.

Clinical signs associated with **leeches** have not been described.

Capillaria crocodilus infections produce characteristic black tracks arranged in a serpentine pattern in the abdominal scales. The keratinised and cellular layers of the epidermis contain numerous cystic spaces filled with operculate eggs and adult parasites (Buenviaje et al. 1998).

Dujardinascaris has been reported to be associated with gastric ulcers, anorexia and weight loss. Ulcers contain a fibrino-haemorrhagic exudate, necrotic cellular debris, occasional parasite eggs and a mononuclear cell accumulation (Ladds 2009).

Signs of **pentastome** infection are related to mechanical damage caused by the parasites in the respiratory tract. These include respiratory haemorrhage, interstitial pneumonia, bronchiectasis, excessive mucous production and anaemia (Jacobson 2007; Ladds 2009).

To diagnose **nematode** and **pentastome** infections, submit fresh faeces for direct examination or faecal flotation.

Dermatophilus infections cause focal brown spots primarily on the abdomen, but these can also appear on the neck, tail and feet (Buenviaje et al. 1997). These brown foci correspond to areas of nodular hyperkeratosis containing keratin, inflammatory cells, necrotic cell debris and characteristic branching filaments.

For ***Dermatophilus*** diagnosis, submit visible lesions in formalin for histological evaluation. *Dermatophilus* filaments can be detected on sections stained with haematoxylin and eosin or particularly with periodic acid-Schiff stain (PAS). Fresh tissue can be used to culture *Dermatophilus* on blood agar (Buenviaje et al. 2000).

Clinical signs of ***Chlamydia*** infections include a fibrinous to mucopurulent conjunctivitis and pharyngitis with swelling of the eyelids, including the nictitating membrane. Infections cause diffuse erosions or ulceration of the pharynx with a pale diphtheritic membrane or pale mucosal plaques. Microscopically lesions are characterised by epithelial hyperplasia, erosion and intraepithelial granulocyte and lymphocyte infiltration (Ladds 2009).

For *Chlamydia* diagnosis submit a range of tissues in formalin for histological evaluation and fresh/frozen tissues for PCR testing. Aluminium shafted dacron swabs can be used to swab the conjunctiva and pharynx of live affected animals and then submitted for PCR testing. Swabs can be kept refrigerated or frozen (Jerrett et al. 2008).

Poxvirus infections cause raised and ulcerated crusty brown skin lesions in the oral cavity, on the head, eyelids, palmar surface of the feet and ventral and lateral body surfaces. Nodules are two to six millimetres in diameter. There is histological evidence of hyperkeratosis and parakeratosis with hypertrophic epithelial cells containing eosinophilic intracytoplasmic inclusion bodies that appear dumbbell shaped under electron microscopy. Morbidity is high, but mortality is low and the disease usually appears in juveniles less than two years old. Lesions usually resolve spontaneously over several months (Buenviaje et al. 2000). For diagnosis submit visible lesions in formalin for histological evaluation (Buenviaje et al. 1992).

Crocodiles suffering conjunctivitis/pharyngitis syndrome, associated with **herpesvirus** were first identified on a farm in 2006. This syndrome appeared similar to the one attributed earlier to *Chlamydia* infection. Affected crocodiles had corneal opacity and thickening, oedema and reddening of the nictitating membrane and conjunctiva with a mucopurulent exudate. Mucosal erosion or ulceration with associated fibrinocaseous exudate was present in the pharynx (Shilton et al. 2016).

Systemic lymphoid proliferation with nonsuppurative encephalitis associated with **herpesvirus** was first recognised in 2009. Affected crocodiles were in poor body condition with splenomegaly and pulmonary

oedema. Histologically there was lymphohistiocytic infiltration in the pulmonary septae, liver, pancreas, gastrointestinal submucosa, pericardium and epicardium. The brain had diffuse gliosis and perivascular lymphohistiocytic infiltration (Shilton et al. 2016).

Crocodiles with lymphonodular skin lesions associated with **herpesvirus** had multiple pale, soft, raised, well-delineated 4–20 mm foci most commonly involving the lateral abdominal scales. Similar foci were also present on the tongue and commissures of the mouth. Tonsils were enlarged. Histologically the dermis was expanded by aggregates of lymphocytes and macrophages. Oral lesions were similar to the skin lesions. Tonsils were hyperplastic and contained dense sheets of lymphocytes mixed with macrophages (Shilton et al. 2016).

Crocodiles affected by ***S. agalactiae*** exhibited lethargy, swollen limbs and skin sloughing involving either the ventral body wall or limbs. The underlying subcutaneous tissue and skeletal muscle was necrotic. Histologically this corresponded to areas of coagulation necrosis with abundant Gram-positive cocci surrounded by variable numbers of inflammatory cells. Lesions in other organs were suggestive of septicaemia and included mild mixed inflammatory cell infiltrates associated with the epicardium and multifocal acute splenic necrosis. Mixed Gram-negative rods and Gram-positive cocci were visible in internal organs (Bishop et al. 2007). For diagnosis, submit tissue for histological evaluation and bacterial culture.

Differential diagnoses

Differential diagnoses include other disease-causing agents including fungi such as *Fusarium* sp., mycobacteria and both Gram-positive and negative bacteria (Buenviaje et al. 1998).

Prevention, control and treatment

Disease prevention in wild crocodiles is generally not feasible.

A range of anthelminthic formulations including mebendazole, fenbendazole and thiabendazole have all been used to treat nematode infections (Australian Quarantine and Inspection Service 2000).

An in vitro study examining the antibacterial properties of copper sulphate, formalin and salt against *Dermatophilus* showed that only copper sulphate was effective. In treatment trials immersion of infected crocodiles for 15 minutes twice per day for four days in medicated water containing 1 ppm copper sulphate was the most effective. Formalin 0.1% added to the water did not resolve the skin lesions (Buenviaje et al. 2000).

To prevent *Chlamydia* infections in younger crocodiles, exposure to older animals should be minimised by providing separate water circulation systems and equipment. Water should be chlorinated to reduce the survival of chlamydial organisms (Jerrett et al. 2008). Treatment with oxytetracycline was reported to stop *Chlamydia* related mortalities on a crocodile farm in South Africa (Huchzermeyer et al. 1994).

Surveillance and management

Wildlife disease surveillance in Australia is coordinated by the Wildlife Health Australia. The National Wildlife Health Information System (eWHIS) captures information from a variety of sources including Australian government agencies, zoo and wildlife parks, wildlife carers, universities and members of the public. Coordinators in each of Australia's States and Territories report monthly on significant wildlife cases identified

in their jurisdictions. NOTE: access to information contained within the National Wildlife Health Information System dataset is by application. Please contact admin@wildlifehealthaustralia.com.au. There are a small number of reports of pathology in wild crocodiles in the database.

There is no targeted surveillance program for any of the diseases listed in this fact sheet.

Statistics

A report examining 797 wild freshwater crocodiles from the NT found 56.3% to be affected with traumatic scars and injuries (Webb and Manolis 1983).

The report also examined crocodiles for **parasitic infections**. Leeches were present on 9.7% of the crocodiles examined. No crocodiles with a snout vent length under 31 cm had evidence of *Capillaria crocodilus* infection, while 100% of crocodiles with a snout vent length over 80 cm had evidence of infection (Webb and Manolis 1983).

A second report of 146 wild freshwater crocodiles from the NT identified nematodes in 50 stomach samples. The most predominant species was *Dujardinascaris* sp. (96% of samples), followed by *Eustrongylides* sp. (14%), *Contracaecum* sp. (6%), *Physaloptera* sp. (2%) and *Goezia juviatilis* (2%) (Webb et al. 1982).

Dermatophilus was recorded from one wild crocodile of unrecorded species in the NT that was found dead (Buenviaje et al. 1998).

While *Chlamydia* has caused significant disease in farmed crocodiles, disease in wild crocodiles has not been reported. One report found four of 33 pooled conjunctival and cloacal swabs of clinically unaffected wild crocodiles from the NT to be *Chlamydia* positive by PCR (Jerrett et al. 2008).

There are no reports of poxvirus or herpesvirus infections in wild Australian crocodiles.

Research

There is a need for surveys to determine the prevalence of infectious disease agents in wild crocodile populations in Australia. There is also a need to ascertain the health status of wild crocodile populations in order to establish what effects, if any, these disease agents may be having on them.

Human health implications

No human health concerns are currently recognised, although it is not known if the *Chlamydia* that infects crocodiles is also capable of infecting humans.

Conclusions

Limited information is currently available concerning the health of wild crocodiles in Australia. Given the value of the Australian crocodile industry and the potential for pathogens to move from wild crocodiles to farmed crocodiles and back again, there is a clear need for more information in this area.

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To provide feedback on this fact sheet

We are interested in hearing from anyone with information on this condition in Australia, including laboratory reports, historical datasets or survey results that could be added to the National Wildlife Health Information System. If you can help, please contact us at admin@wildlifehealthaustralia.com.au.

Wildlife Health Australia would be very grateful for any feedback on this fact sheet. Please provide detailed comments or suggestions to admin@wildlifehealthaustralia.com.au. We would also like to hear from you if you have a particular area of expertise and would like to produce a fact sheet (or sheets) for the network (or update current sheets). A small amount of funding is available to facilitate this.

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