Mycobacteriosis in Australian birds

Fact sheet

Introductory statement

Multiple species of mycobacteria can cause disease in birds. The most common species, however, are Mycobacterium avium subspecies avium and M. genavense. Mycobacteria cause a slowly progressive and, in the end, fatal disease in the birds they infect. Infection in wild birds occurs sporadically. However, in certain species of captive birds and in certain collections of captive birds, infection prevalence is high. A lack of genetic diversity, insufficient hygiene, and an increased persistence of these bacteria in the environment are likely to be predisposing conditions to infection in captive birds. Although essentially eradicated with the onset of intensive raising processes in the chicken industry, the return to free-range farming of chickens may result in a re-emergence of mycobacterial infections. The role of captive birds in spill over to native Australian wild birds is not known.

Aetiology

Order (Actinomycetales), family (Mycobacteriaceae), genus (Mycobacterium).

Mycobacteria are small rod-shaped bacteria that grow inside of the host’s cells. They do not stain with the Gram’s stain or do so faintly. They are difficult to see in haematoxylin and eosin stained tissue sections and only stain with the acid fast or Ziehl-Neelsen stain. They stain red with this stain and are referred to as acid-fast organisms (reviewed in Saggese et al. 2010).

The two most common species of mycobacteria detected in diseased birds are Mycobacterium avium subspecies avium (MAA) and M. genavense (MG) and they are the focus of this fact sheet (Hoop et al. 1993; Feizabad et al. 1996; Saggese et al. 2010; Pate et al. 2011).

Other mycobacteria that have been thought to cause disease in birds include M. tuberculosis, M. bovis, M. gordonae, M. nonchromogenicum, M. fortuitum subsp. fortuitum, M. avium subsp. hominissuis, M. peregrinum, M. intermedium, M. celatum, M. avium subsp paratuberculosis, M. africanum, and M simiae. (Shitaye et al. 2009; Reviewed by Tell 2004; Shivaprasad & Palmieri 2012).
Natural hosts

*Mycobacterium avium* subsp. *avium*: MAA infects a wide range of birds. To date, an environmental source or another vertebrate host for MAA have not been found (Moravkova *et al.* 2011; Pate *et al.* 2011).

*Mycobacterium genavense*: MG infects a wide range of birds and some mammals including humans (Hoop *et al.* 1993; Manarolla *et al.* 2009; Hoefsloot *et al.* 2013). It is found in drinking water and it is likely that it may grow outside of its host under some environmental conditions. It is shed in the faeces of infected birds and humans (reviewed in Hoefsloot *et al.* 2013).

World distribution


Occurrences in Australia

Mycobacterial infections have been described predominately in avicultural collections, zoological collections, backyard chickens, and pet birds in Australia (Feizabad *et al.* 1996; Sangster & Vinette-Herrin 2012). There are only a few cases of mycobacterial infection in free-ranging wild birds. A search of the records of Wildlife Health Australia (WHA) and the Australian Registry for Wildlife Health found seven cases of mycobacteriosis in wild native birds and a search of the literature found two more likely cases. Infected birds were found in Queensland, New South Wales, Victoria, Tasmania and the Northern Territory. Mycobacterial infections have been identified in four southern cassowaries in Northern Queensland (A. Olsson, pers. comm. 2013). A search of the diagnostic submissions to the Wildlife Health and Conservation Clinic at Sydney University found one case of mycobacteriosis in a backyard chicken (Table 1).

**Table 1.** Wild Australian birds reported with mycobacteriosis

<table>
<thead>
<tr>
<th>State of Origin</th>
<th>Species</th>
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<tbody>
<tr>
<td>Northern Territory</td>
<td>Pied Imperial Pigeon (<em>Ducula spilorrhoa</em>)(^1)</td>
</tr>
<tr>
<td>Queensland</td>
<td>Laughing Kookaburra (<em>Dacelo novaeguineae</em>)(^1)</td>
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<tr>
<td></td>
<td>Cassowary (<em>Casuarius casuarius</em>)(^3)</td>
</tr>
<tr>
<td>New South Wales</td>
<td>Australian Hobby (<em>Falco longipennis</em>)(^1)</td>
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<tr>
<td></td>
<td>Pacific Black Duck (<em>Anas superciliosa</em>)(^1)</td>
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<tr>
<td></td>
<td>Dusky Moorhen (<em>Gallinula tenebrosa</em>)(^1)</td>
</tr>
<tr>
<td>Victoria</td>
<td>Nankeen kestrel (<em>Falco cenchroides</em>)(^2)</td>
</tr>
<tr>
<td>Tasmania</td>
<td>Swamp Harrier (<em>Circus approximans</em>)(^1)</td>
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<tr>
<td></td>
<td>Wedge-tailed Eagle (<em>Aquila audax</em>)(^3)</td>
</tr>
</tbody>
</table>

\(^1\) National Wildlife Health Information System (eWHIS).


\(^3\) Moore 2007; Olsson, pers. comm. 2013.
Epidemiology

An environmental source outside of the bird has not been found for MAA. Therefore, it is possible that MAA only grows in birds (Feizabad et al. 1996; Dvorska et al. 2007; Moravkova et al. 2011). In contrast, MG grows in the environment and can be shed by birds and other infected animals (reviewed in Hoefsloot et al. 2013). Once in the environment, it is likely that both organisms can persist for long periods of time. It has been postulated that mycobacterial infections in zoos result from long-term buildup of the organisms in the environment, however, in at least one case this does not appear to be true (Witte et al. 2010).

Infection with MAA or MG is likely to be the result of ingestion or inhalation of the aerosolized organism. Ingestion of contaminated soil or water is a route of exposure for all birds (Whiley et al. 2012). For birds of prey, another route of exposure would be the ingestion of infected prey species (Tell et al. 2004; Moravkova et al. 2011). MG can be found in water and inhalation of water droplets could also be a source of infection (Hoefsloot et al. 2013).

Whether exposure results in infection will depend upon the number of organisms to which the bird is exposed and the host’s immune response to infection. Many cases of mycobacteriosis occur in individual birds. These birds may be housed alone or in contact with other birds and other cases of disease may not develop (reviewed in Dalhausen 2012). However, relatively high prevalences of infections can also be seen in zoo and avicultural collections and some species of birds (Kriz et al. 2011, Saggese et al. 2008). The increased prevalence of infection in bird collections can be the result of problems with hygiene and increased exposure due to large numbers of organisms in the environment. This would be particularly the case in facilities that cannot be disinfected and have food and water sources that can be contaminated with faeces (Saggese et al. 2010). However, certain species, no matter what the environment that they are housed in, are highly susceptible to mycobacterial infections. These include the Gouldian finch (Erythrura gouldiae) (Vitali et al. 2006), canary (Serinus canaria domestica), Venezuelan siskin (Carduelis cucullata) (Manarolla et al. 2009), grey-cheeked parakeet (Brotoigeris pyrrhoptera) (Palmieri et al. 2013), white-winged duck (Asarcornis scutulata) (Saggese et al. 2007) and Mauritius pink pigeon (Columba mayeri) (Phalen & Grimes 1995). Some of these species may be genetically predisposed to infection. As an example, it has been shown that white-winged ducks are highly inbred and will become infected with mycobacteria wherever they are raised (Saggese et al. 2007). Likewise, the Mauritius pink pigeon has recovered from a significant population bottleneck and therefore would be expected to have limited genetic diversity (Phalen & Grimes 1995). A correlation between phenotype and response to disease has been demonstrated in collared-turtle doves (Streptopelia risoria). In this species, the prevalence of infection, specific lesions and the number of organisms in infected tissues correlates with the colour of the bird’s feathers suggesting that feather colour and a component of the immune system are genetically linked (Saggese et al. 2008).

Infection between birds raised out of doors and wild birds and between wild birds and domestic birds has been documented (Dvorska et al. 2007). This raises the possibility that the new trend in raising free range chickens will result in the re-emergence of mycobacterial infections in them and also increase the dissemination of this disease to wildlife (Ikonomopoulos et al. 2009; Shitaye et al. 2008).

In humans the age of the person and the immune status of the person are factors that contribute to susceptibility to infection with some mycobacteria (Hoefsloot et al. 2013). Stress and other factors impacting the immune system and age may also make birds more susceptible to infection, but this has not been proven.
**Clinical signs**

Mycobacteria can infect a wide range of tissues and thus can present with many different signs. Infections are typically slowly progressive and most birds present with a chronic wasting disease, as exhibited by pectoral muscle atrophy. By the time that many infected birds are noticed they will often be lethargic and spend more time sleeping than normal. Poor quality feathering as the result of delayed molts is also a common finding (Saggese et al. 2010; Reviewed in Dahlhausen et al. 2012; Mayahi et al. 2013).

A characteristic lesion caused by mycobacteria is the granuloma. The granuloma is a mass composed of inflammatory cells and varying numbers of mycobacteria. These masses can develop anywhere in the body, including the skin, within the beak, in the sinuses around the eye, and internal organs, particularly the liver, spleen, intestine, lung, air sacs and bone. Infection of the respiratory tract or enlargement of organs like the spleen and liver can result in difficulty breathing. Severe damage to the liver can result in the liver leaking fluid into the abdomen, collapsing air sacs and again causing birds to have difficulty breathing. These latter birds also present with abdominal distention (Saggese et al. 2010; Reviewed in Dahlhausen et al. 2012; Mayahi et al. 2013).

Infection of the intestines interferes with digestion and absorption of food and these birds are thin and may also have diarrhoea. Infection of the bone will cause some birds to be lame and rarely a bone to break spontaneously (Reviewed in Dahlhausen et al. 2012).

**Clinical pathology and other diagnostic findings**

*Haematology:* Birds with mycobacterial infections typically have an elevated white blood cell count with an increase in heterophils, lymphocytes and monocytes. White counts in excess of 50,000 cells/µl are common. These birds are typically anaemic. They may have a low total protein or an elevated total protein. Elevations of the total protein are caused by increased concentrations of gamma and beta globulins. Use of plasma electrophoresis can be used to identify these changes (Saggese et al. 2010; Reviewed in Dahlhausen et al. 2012; Mayahi et al. 2013).

*Biochemistry:* Biochemical changes seen in blood will depend on the organ infected and the severity of the disease. Albumin concentrations are expected to be low in birds that are not eating well and in birds with advanced liver disease. Aspartate aminotransferase (a liver and muscle enzyme) concentrations will be elevated with liver disease or in the case that there is muscle disease. Creatinine phosphokinase (another muscle enzyme) may also be elevated with muscle disease (Saggese et al. 2010; Reviewed in Dahlhausen et al. 2012).

*Faecal acid-fast staining:* The faecal acid-fast stain is a very insensitive means of detecting birds infected with mycobacteria because many infected birds do not shed the organism at all and others only in small numbers. However, if this test is positive, it is likely that the bird is infected with a mycobacterium (Saggese et al. 2010; Reviewed in Dahlhausen et al. 2012).

*Serology:* The detection of antibodies to mycobacterial antigens as a means of detecting infection in birds has been limited to a few studies. A compliment fixation assay, a blocking enzyme-linked immunoassay (ELISA), a direct ELISA (Phalen & Grimes 1995) and a western blot assay (Gray et al. 2008) have all been described. The most extensive study has been done in ring-neck turtle doves (*Steptopelia risoria*). In this study, a Western Blot assay was used with antigens extracted from the cell wall, cell membrane and cell cytoplasm of the mycobacteria infected these birds. This assay was found to be 100% specific for infection and to have a high
sensitivity. However, some infected birds, possibly because of stage of their disease or as the result of the nature of their immune response to infection, did not produce antibody and were negative by this assay (Gray et al. 2008). It is likely that sensitivity and specificity of serology will be depend on the species of bird being tested, the mycobacteria infecting the bird, and possibly environmental exposure to other mycobacteria species by the bird being tested.

Skin testing: The intensity of the reaction to an intradermal injection of a purified protein derivative made from MAA has been used successfully to detect infected chickens (Shitaye et al. 2008). Limited trials in other species using this method have not been successful (reviewed in Dahlhausen et al. 2012).

Polymerase chain reaction (PCR): PCR can be used to amplify mycobacterial DNA from faeces. For it to detect infection, it requires that birds have intestinal lesions and be shedding mycobacteria, which many birds are not, so this assay while specific is not sensitive (Saggese et al. 2010; Reviewed in Dahlhausen et al. 2012).

Imaging: Imaging is a useful diagnostic tool. The most common form of imaging performed in veterinary practices is radiography, but MRI’s, CTs, and ultrasonography can also be used. Many birds will have large livers and spleens. Focal soft tissue densities corresponding to granulomas in the lungs or air sacs or other spaces may also be seen radiographically. A finding that is highly suggestive of a mycobacterial infection is the presence of a local or locally extensive increase in soft tissue density in the medullary cavity of long bones with discrete round lucent areas within the soft tissue densities. Ultrasonography of the liver may demonstrate characteristic multifocal granulomatous changes or more diffuse disease. A diffuse thickening of the intestine is present in some infected birds and can be visualized using contrast radiography and if the bird is sufficiently large by ultrasonography (Reviewed in Dahlhausen et al. 2012).

Pathology

The vast majority of birds that die as the result of a mycobacterial infection have advanced pectoral muscle wasting and the absence of body fat. There may be a significant amount of fluid within the peritoneal space in some cases. Intestinal thickening may also occur but is not consistently seen. When there is diffuse disease of the intestine, thickened villi will give the mucosa (internal lining of the intestine) a cobblestone appearance. The most common lesions are liver and spleen enlargement and spleen enlargement may be massive. These organs may maintain their normal shape, or they may contain pale tan raised foci or nodules, which represent granulomas. The granulomas if present will occur on the surface and within the parenchyma of the liver and spleen. They may become large and, in some cases, may essentially replace the normal tissue. Granulomas can also be present in the lungs and air sacs and less commonly in other organ systems (Saggese et al. 2007; Saggese et al. 2008; Palmieri et al. 2013 reviewed in Shivaprasad & Palmieri 2012).

Microscopically there are two common inflammatory responses to infection. The classical tuberculosis form is characterized by granulomas with a central core of necrosis, surrounded by multinucleated giant cells, plasma cells and lymphocytes and varying degrees of fibrosis around the inflammatory cell layer. The second form is characterized by replacement of normal tissue with sheets of histiocytes and to a lesser extent other inflammatory cells. The numbers of bacteria in these lesions can vary from massive numbers to very few. Amyloidosis of the liver and less often the spleen are common sequelae to mycobacterial infections (Saggese et al. 2008; Palmieri et al. 2013; reviewed in Shivaprasad & Palmieri 2012).
Diagnosis

Diagnosis in the live bird: Physical, imaging, biochemical, and haematological findings will generally be suggestive of a mycobacterial infection, but are rarely definitive. Proof of infection requires the identification of acid-fast organisms either in faeces or in tissues. Acid-fast stains of aspirates or biopsies of granulomas or biopsies of liver or spleen will in many, but not all cases detect mycobacteria. When intestinal lesions are present, an aspirate of the intestinal lining will often demonstrate the mycobacteria (Reviewed in Dahlhausen et al. 2012).

Where available, serology (Gray et al. 2008) and PCR examination of faeces can be used to confirm infection.

Diagnosis in the dead bird by post mortem examination and histopathology: Gross post mortem findings are often suggestive of a mycobacterial infection. Microscopic detection of acid-fast organisms in tissues, however, is required for diagnosis. Even then, the species of the organism present in the tissues cannot be determined and occasionally, the number of organisms in the tissue is so few that they are not seen.

Diagnosis in the dead bird by PCR: PCR can be used to amplify DNA from infected tissues of dead birds. PCR is a highly sensitive and specific diagnostic assay. Currently, sequencing of specific regions of the mycobacterial genome is the fastest and most accurate means of determining the species of the organism infecting a bird (Saggese et al. 2010; reviewed in Turrene et al. 2007; Schrenzel 2012).

Diagnosis in the dead bird by culture: Culture is still a valuable tool in detecting mycobacterial infection in dead birds. In one study in doves infected with MAA, culture was found to be even more sensitive than PCR in detecting infection in post mortem specimens. Both MAA and MG can be difficult to culture, and it often takes many weeks before they can be detected. A description of the various culture techniques used to isolate mycobacteria is beyond the scope of this fact sheet. If interested, the reader is referred to the many manuals available that describe these procedures (Saggese et al. 2010; Shitaye et al. 2008; reviewed in Dahlhausen et al. 2012; Hoefsloot et al. 2013).

Differential diagnoses

Clinical signs in the live bird are not specific and could be caused by a range of chronic diseases including other bacterial infections, systemic fungal infections, chronic parasitic infections, malnutrition and cancer (Reviewed in Dahlhausen et al. 2012).

Treatment

There is very little evidenced-based data to guide the choice of treatment options in birds with infections with MG and MAA and to predict their outcome (Burr & Saggese 2012). A combination of azithromycin or clarithromycin, rifibutin or rifampin, and ethambutol have been used to treat infections with MG and Mycobacterium avium hominis suis, a closely related species to MAA, with variable success in people. The incomplete success of these treatments in people is likely due to the severely immunosuppressive diseases that these people generally have. Treatment in these individuals can range from a few months to years. The use of multiple drug therapy is necessary to prevent the development of drug resistance (Kasperbauer & Huit 2013; Hoefsloot et al. 2013).

The only carefully controlled treatment trial for mycobacterial infections in birds, suggests that even with prolonged treatment (150 days) with azithromycin, rifampin, and ethambutol, most birds (82%) will not be
cured of infection and naturally occurring drug resistance may interfere with treatment (Saggese et al. in press). This study also pointed out the need for pharmacokinetic studies for rifampin and ethambutol so that appropriate therapies could be developed.

Control

Control of mycobacterial infections in wild birds is not possible. Control in domestic birds raised outside that are exposed to wild birds is also not possible. Given that MG can be found in water, it is possible that any bird can become infected if exposed to sufficient numbers of organisms or is susceptible for other reasons (Hoefsloot et al. 2013).

Preventing the introduction of mycobacteria into a collection of birds by an infected bird is challenging. All incoming birds should be routinely screened by a physical examination, a complete blood count, and plasma electrophoresis. Survey radiographs can also be included in the new bird work up. More specific testing, such as acid-fast staining of the faeces and PCR testing of the faeces for mycobacterial DNA is also indicated. Extended quarantine (e.g. six months) may allow some birds in the early stages of infection to develop signs that would not be seen when they first arrive at a facility.

Mycobacteria are susceptible to a number of disinfectants but are typically admixed with organic material. Thus, the most important element of mycobacterial hygiene is to remove all organic material from the enclosure when cleaning. This is impossible in most zoo and aviary settings that are made of wood, contain wooden perches, are planted, or have soil or gravel floors.

Statistics

The number of cage birds submitted for diagnostic histopathology that are found to be infected with acid fast organisms is remarkably similar across several studies, ranging from 1.20% to 1.34% (Manarolla et al. 2009; Witte et al. 2010; Palmieri et al. 2013). In contrast, the prevalence of infection in captive populations of highly susceptible species can be high with prevalence of 54.8% being reported in a pigeon flock (Columbia livia) (Kriz et al. 2011) and 62.0% being reported in a flock of ring-neck turtle doves (Saggese et al. 2008). Little information is available on prevalence and incidence in Australian native birds.

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. Avian mycobacterial disease is included on this list. NOTE: access to information contained within the National Wildlife Health Information System dataset is by application. Please contact admin@wildlifehealthaustralia.com.au.

Research

Much is still to be learned about mycobacterial infections in birds. With current molecular techniques and new ones that will be developed, better studies on the epidemiology of these organisms will be possible. In particular, there is a need to identify environmental and animal reservoirs for them. Proper pharmacological studies need to be done in a range of birds for the common drugs used to treat MAA and MG, so that appropriate treatment protocols can be developed. Factors, such as the lack of genetic diversity, predisposing
certain species of birds to mycobacterial infections also need to be defined. The identification of mycobacterial infections in wild cassowaries is of concern and may suggest local or more regional loss of genetic diversity or underlying immunosuppressive disease. These findings also demonstrate the need for disease monitoring in this species and the identification of the mycobacteria that are causing disease in them.

**Human health implications**

MAA: Current data suggests that MAA does not cause disease in humans or does so very rarely.

MG: Causes disease in people that are severely immunosuppressed (Hoefsloot et al. 2013). Infected birds that are shedding MG could increase the risk of infection in immunosuppressed people who might be in contact with them. MG has been found in canaries and thus it is probably inappropriate for canaries to be kept in aged care facilities (be advised by your local health care professional).

It is very rare that the actual species of mycobacteria infecting a bird is known, so best practice suggests that infected birds should be either euthanased or kept in isolation from people and other birds.

The increase in free-range poultry production may increase the number of birds infected with mycobacteria and increase exposure to people working in slaughter plants and to the general public who consume chickens (Ikonomopoulos et al. 2009; Shitaye et al. 2008).

**Conclusions**

Mycobacteria are found in the environment worldwide. Therefore, it can be expected that spontaneous mycobacterial infections will continue to occur at a low level in a range of wild and captive bird species. Mycobacteria have the most significant impact on birds kept in confinement in zoos, aviaries, and captive breeding programs and in some cases have significantly impacted captive breeding programs of endangered species. It is therefore critical that re-introduction and translocation programs do not introduce infected birds into disease-free populations. A more than base-line presence of mycobacterial infections in wild birds is a cause for concern and merits investigation. Monitoring of free-range chickens for mycobacterial infections is indicated as this becomes a more common means of raising chickens and as the duration of paddock use is increased.

**References**


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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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