Salmonellosis in Wildlife: Diagnosis, Prevention, and Treatment Options for the Zoo Veterinary Technician and Wildlife Rehabilitator

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Abstract: Salmonellosis is a common worldwide disease that can affect all animals, including humans. The primary mode of transmission is through direct oral ingestion of contaminated feces or through contaminated food sources. *Salmonellae* are small, straight, Gram–negative rods whose many serotypes fall into two main categories: those highly adapted to a specific host and those with broad host ranges. The incidence of salmonellosis has increased with the intensification of livestock production where animals are abnormally crowded and stressed. Under these conditions fecal contamination of skin or food supplies can occur. Although these situations rarely occur in natural settings, it is important to note that zoos and rehabilitation facilities can render similar stressful situations. Clinical salmonellosis manifests as primary enteritis and colitis, generalized infection (septicemia), or abortion, and can occur in all stages from peracute to chronic. A positive diagnosis of salmonellosis is based on a fecal culture of the bacteria and observed clinical signs. *Salmonella* spp. can be spread from wildlife to humans by improper handling of infected animals and is considered a Class 4 nosocomial pathogen. Conversely, there are documented cases in Antarctica and Africa where increasing ecotourism has resulted in higher incidences of salmonellosis in native wildlife. Clinically ill animals can be treated cautiously with an antibiotic and receive supportive care but, in severe cases, the prognosis is guarded. Use of the existing list of recommended husbandry and hygienic actions, along with the ability to detect the signs, will decrease the spread of salmonellosis in wildlife facilities and zoos to those animals under care as well as to the practitioners.

INTRODUCTION

An article from the Associated Press (AP) states; "More than 210,000 Americans were sickened between 2000 and 2004 with salmonella, and at least 89 died. Most infections came from contaminated food—but up to 5 percent have been linked to pets, especially such reptiles as iguanas and turtles. And last year, at least 30 people in 10 states were sickened with a drug–resistant form linked to hamsters and other rodent *pocket pets*." (Ebrahim and Solomon 2006). So what is salmonellosis? Should caretakers of wildlife worry about the disease spreading throughout a wildlife rehabilitation facility, affecting animals under care, or contracting the disease themselves? Salmonellosis is caused by many species of *Salmonella* and characterized clinically by one or more of three major syndromes: septicemia, acute enteritis, and chronic enteritis. The disease is seen worldwide and can affect all animals although incidences have increased with intensification of livestock production. Salmonellosis is also zoonotic which is further illustrated by the AP article previously referenced (Ebrahim and Solomon 2006). This paper will explore how salmonellosis specifically affects wildlife species, how the zoo veterinary technician and wildlife rehabilitator can recognize clinical signs, and how to treat and isolate animals so that the disease does not spread to other patients under care, including the caretakers.

Salmonellae bacteria are small, straight, Gram–negative rods, measuring 0.7–1.5 x 2.0–5.0 µm (0.0007–0.0015 x 0.002–0.005 mm). Most strains are motile, but nonmotile forms also occur. They are facultatively anaerobic and grow well on non–selective media, although enriched media can improve the sensitivity of isolation procedures. Differentiation of the genus *Salmonella* into species or serotypes is based on biochemical and serologic reactions. Based on host specificity, serotypes fall into two categories: those highly adapted to specific host species, like *typhi* and *paratyphi* in humans, *pullorum* in birds, and *dublin* in cattle and those with broad host ranges. Serotypes may vary markedly in virulence in various hosts, and only about fifty are regularly incriminated in disease (Williams and Barker 2001).

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As a nosocomial infection, *Salmonella* is classified under the most dangerous class, Class 4. Pathogens in this class can be spread by air, produce highly infectious bodily fluids, and includes *Shigella*, as well as the viruses that cause canine parvovirus, canine infectious hepatitis, and rabies (Limon 2006).

The usual route of infection is oral. The organism multiplies in the host intestine and causes enteritis. Penetration of bacteria into the lamina propria likely contributes to gut damage and diarrhea. The inflammatory response is initiated and Salmonellae are engulfed by phagocyctic cells although the bacteria can survive and multiply in these cells. Septicemia may follow with subsequent localization in the brain and meninges, gravid uterus, distal aspects of the limbs, and tips of the ears and tails, which can result, respectively, in meningoencephalitis, abortion, osteitis, and dry gangrene of the feet, tail, or ears. The organism also frequently localizes in the gallbladder and mesenteric lymph nodes, and survivors intermittently shed the organism in their feces (Wobeser 2006).

Wildlife Species Affected

As mentioned above, *Salmonella* species are well–recognized pathogens in many animals including humans, livestock, wild mammals, birds, reptiles, and insects. Among wild animals, Salmonellae are most frequently isolated from birds, but they also occur in mammals and reptiles. Many serotypes of *Salmonella* are also human pathogens and salmonellosis is considered the most widespread zoonotic disease in the world (Martin 1984; Williams and Barker 2001).

Salmonella's main mode of transmission between animals is through contaminated feces. Many infectious agents are shed in droppings, and vast numbers of infectious particles may be present per gram of feces. However, in most natural conditions, direct transfer from fresh feces is unlikely except in situations where animals are abnormally crowded and fecal contamination of skin or food supplies occurs. For example, *Salmonella* infections of passerine birds increase greatly at bird feeders and feeding stations (Wobeser 2006). The prevalence of infection varies among species and countries, but is much higher in a confinement livestock industry setting where animals are stressed owing to deprivation of feed, transportation, crowding, unclean conditions, and the administration of some drugs. One important consideration to note concerning wildlife is although these situations rarely occur naturally, rehabilitation facilities and zoos can duplicate these stressful situations—thereby leading to a higher incidence of salmonellosis.

Clinical Signs and Laboratory Identification

Clinical salmonellosis may manifest as primary enteritis and colitis, generalized infection (bacteria infecting and replicating in blood), or abortion. The disease occurs in all stages from peracute to chronic, although the clinical picture varies greatly depending on the serotype and host species. The primary site of infection is the intestines. After ingestion, the bacteria attach to and invade the enterocytes on the surface of the gut. If sufficient damage is done to the enteric lining, full–blown enteritis ensues. The organism must invade and survive in macrophages and reach regional lymph nodes, from which they enter the bloodstream via lymphatic tissue in order to persist. Septicemic salmonellosis may produce widespread hemorrhage on serous membranes, enlargement of the spleen and lymph nodes, edema and congestion of organs such as the lung, and sometimes multifocal hepatic necrosis. Microscopic lesions in septicemia can include microvascular thrombosis in any tissue, necrosis and inflammation in liver, spleen, and lymph nodes, and focal granulomas in various organs (Williams and Barker 2001).

Commonly reported signs in avian species include ruffled feathers, head droop, diarrhea, and severe lethargy; chronically infected birds often appear severely emaciated. Sick birds may also seizure. Types of lesions found in infected birds are highly variable; in acute cases, obvious lesions may be completely absent. Otherwise, livers become swollen and crumbly with small reddened or pale spots. Paratyphoid nodules may develop in the liver and extend into the body cavity. Infected songbirds often have yellow, cheesy nodules on the mucosal surface of the esophagus (USGS 2006). Since all species of birds should be considered susceptible to *Salmonella*, all birds admitted to a wildlife rehabilitation facility or zoo should be watched closely, cages should be cleaned sufficiently, and observable signs recorded for possible isolation from other animals.

A diagnosis of salmonellosis is based on bacterial culture and clinical signs. In living animals, fecal cultures are used. In one study, fecal samples from 212 selected marine mammals, marine birds, and raptors were cultured for *Salmonella* spp. upon arrival at wildlife rehabilitation centers in California from May 1999 through July 2000. *Salmonella* spp. were cultured from nine (4%) animals, and seven serotypes were isolated (Smith et al 2002). In dead animals, specimens for culture should be taken from the small intestine, colon, lymph nodes, spleen, or liver. Isolation of *Salmonella* using solely an intestinal specimen is not sufficient for

a diagnosis of salmonellosis since many animals are carriers (USGS 2006).

Zoonotic Concern

Salmonella spp. can be spread from wildlife to humans in different ways. Reptile–associated salmonellosis is a well–described phenomenon, especially among children. The increasing popularity of keeping reptiles and other exotic animals as pets presents a public health risk, as such animals are commonly carriers of *Salmonella* and thereby can infect humans directly or indirectly. Some infections to humans have also occurred through animals in the wild. In one 1999 case that occurred in Norway, a waterborne outbreak of *S. typhimurium* infections was linked to a dead gull that had contaminated a reservoir from which the water was used untreated (Kruse et al 2004). Another example in Massachusetts linked confirmed cases of *Salmonella* in fifth–graders to owl pellets. The report by the Massachusetts Department of Health showed that failure to sanitize a cafeteria table after dissecting owl pellets led to 40 cases of *Salmonella* (Scott 2006). In general, however, the probability of humans and domestic animals contracting the infection from wild mammals is low (Williams and Barker 2001).

On the other hand, documented cases of transmission of *Salmonella* from humans to wildlife are increasing. The prevalence of *Salmonella* spp. infections among human–habituated gorillas during tours in Mgahinga National Park, Uganda, doubled during the last four years (Nizeyi et al 2001). In Antarctica, where the number of human visitors is increasing rapidly, cases of salmonellosis have been documented in Gentoo penguins *(Pygoscelis papua)*, macaroni penguins *(Eudyptes chrysolophus)*, gray–headed albatrosses *(Thalassarche chrysostoma)*, black–browed albatrosses *(Thalassarche melanophrys)*, and Antarctic fur seals *(Arctocephalus gazella)* from 1995 to 2000, indicating a high genetic adaptation of the bacteria to the environment or a recent introduction of *Salmonella* into the area (Palmgren et al 2000).

Control, Prevention, and Treatment

Control of *Salmonella* infection in the wild is not feasible. To the extent that environmental contamination with sewage, manure, or effluent from slaughterhouses contributes to the occurrence of *Salmonella* in wildlife, improved sanitation is probably the best way to reduce the prevalence among wild mammals of serotypes infective for domestic animals and humans. In urban/wild interfaces, animal feeders should be cleaned with 10 percent bleach and water solution, rinsed well, and dried to prevent spread, especially among wild passerines. Addition of more feeders may reduce crowding and minimize opportunity for interaction and contamination, and birdseed should be stored in rodent–proof containers (USGS 2006).

In captive situations, a high standard of husbandry and hygiene, with attention to rodent control and fecal contamination by birds, should minimize the risk of disease. Vaccines are not practical for non-domestic species. Clinically ill animals at zoos and wildlife rehabilitation centers can be started on an antibiotic based on the Gram stain of the organism, as well as the infection location. During treatment it is important that the medication be finished as directed. Otherwise, the bacteria may become resistant to antibiotics (Limon 2006). Supportive care, such as fluid therapy, should also be performed if necessary. However, in severe cases, the prognosis is guarded (Williams and Barker 2001).

Since identification of the specific serotype is time–consuming, expensive, and treatment is limited, the emphasis for wildlife rehabilitation and zoo facilities should be practicing a high standard of husbandry—including good hygiene and disinfection—to decrease the spread of *Salmonella* and other diseases. Several studies that document the incidence of *Salmonella* in animals at petting zoos illustrate this point. One study of thirty Swiss petting zoos, performed during the summer of 2003, found only two samples of *Salmonella* spp. out of 423 fecal samples (ranging from pigs to poultry) and another performed by the Association of Zoos and Aquariums found only 0.6 percent prevalence of *Salmonella* spp. among 997 animals at 36 exhibits located throughout the US. The low prevalence of *Salmonella* identified in both these studies was attributed to standardized management and facility conditions, routine isolation and quarantine procedures, generally high hygiene levels, low animal stress due to exhibit permanency (e.g., lack of transport stress), and low rate of new animal introductions and animal mixing compared to temporary or recurring types of animal exhibits or production livestock settings (Butikofer et al 2005; Keen et al 2007). On a broader zoonotic scale, the National Association of State Public Health Veterinarians, Inc. instructs in its *Compendium of Measures to Prevent Disease Associated with Animals in a Public Setting* (2005) that in venues that encourage or permit the public to come in contact with animals "the recommendation to wash hands is the single most important prevention step for reducing the risk of disease transmission." Other critical recommendations are that venues include transition areas between animal areas and non–animal areas

(where food is sold) and animals are properly cared for and managed in public settings. In addition, the report recommends educating venue operators, staff, exhibitors, and visitors regarding the risk for disease transmission where animal contact is possible.

A list of actions on how to clean and disinfect areas to decrease the spread of *Salmonella* is displayed on the DuPont® (Wilmington, DE) Animal Health Solution website and refers to decreasing *Salmonella* in the poultry industry. This list includes the following actions suitable for adoption by a zoo or wildlife rehabilitation center:

- Blow down all surface dust from ceiling beams, slats, cages, nest boxes, water pipes, fan boxes, and inlets.
- Remove all litter from facility and blow or brush down loose debris.
- Clean and disinfect water systems (header tank, lines, and drinkers) with a broad–spectrum disinfectant.
- Maintain closed water and feed system to possibly infected individuals.
- Remove any residual food from feeders.
- Clean and disinfect feeder system.
- Use full immersion tanks for all equipment using correct dilutions of disinfectant.
- Administer disinfectants at higher concentration on specific target areas likely to be contaminated, such as wooden nest boxes and nest box floors.
- Concrete floors should be kept in a good state of repair.
- Beams and equipment in facilities should have minimal horizontal surfaces and ledges to reduce dust build–up.
- All alleyways and anterooms should be regularly swept out.
- Effective control of beetles, mites, coccidia, and worm eggs as potential active and/or passive mechanical vectors.
- Effective control of mice and rats.
- Store all litter, shavings, and straw to minimize moisture and contact with rodents.
- Spray litter with broad–spectrum potent disinfectant before use.
- Use cleanable waterproof boots and dedicate boots for each area of use. Use footbaths with effective broad–spectrum disinfectant, frequently replenished (at least twice weekly).
- Wash or sanitize hands on entry and exit of each enclosure and before and after handling each animal.
- Limit access and exclude unnecessary personnel; control site traffic.
- Promptly remove carcasses and correctly dispose of them.
- Ensure all enclosures are wild bird–proofed and clean up all spills promptly to discourage visitation by wild birds.
- Train volunteers and staff on *Salmonella* hygiene and transmission.

Putting these actions into place as part of the general protocol at wildlife rehabilitation facilities and zoos, while making those who care for wildlife aware of the signs of this disease, can better ensure that salmonellosis will not spread to other animals. Furthermore, animal caretakers will be better protected against contracting the disease and losing valuable work time to deal with its unpleasant consequences.

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