

Fowl Typhoid and Pullorum Disease

Bacillary White Diarrhea
(*Pullorum Disease*)

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Importance

Fowl typhoid and pullorum disease, which are caused by two different biovars of *Salmonella enterica* subsp. *enterica* serovar Gallinarum, are among the most important diseases of poultry. Pullorum disease is usually symptomatic only in young birds, while fowl typhoid also affects growing and adult poultry. The severity of these diseases can vary, depending on several factors including the bird's breed, but mortality rates can approach 100% in highly susceptible birds. Fowl typhoid and pullorum disease are still common in some regions, although they have been eradicated from commercial poultry in many countries with highly developed poultry industries, such as the U.S., Canada, Australia and most nations in Europe. Even in these areas, however, the causative organisms may persist in backyard poultry flocks and game birds. They are particularly difficult to control in game birds, which are often reared in semi-wild production systems. Outbreaks also occur occasionally in commercial poultry, and there are some concerns that exposure might increase with the increased demand for free range birds.

Etiology

Fowl typhoid and pullorum disease are caused by two different biovars of *Salmonella enterica* subsp. *enterica* serovar Gallinarum, a Gram negative bacterial rod in *Salmonella* serogroup D (non-flagellated organisms with O antigens 1, 9 and 12) in the family Enterobacteriaceae. *S. enterica* subsp. *enterica* serovar Gallinarum biovar Gallinarum, which causes fowl typhoid, is usually abbreviated as *Salmonella* Gallinarum, and *S. enterica* subsp. *enterica* ser. Gallinarum biovar Pullorum as *Salmonella* Pullorum. Organisms that seem to have characteristics of both biovars have occasionally been reported.

Species Affected

Salmonella Pullorum and *Salmonella* Gallinarum are considered to be highly adapted to birds. They usually cause illnesses in chickens, turkeys and game birds (e.g., pheasants, quail, guinea fowl, partridges, peacocks), but clinical cases caused by one or both organisms have also been reported in ducks, geese, pigeons, various psittacines, sparrows, starlings and other birds. Isolates found in game birds include some organisms that are shared with poultry and others that seem to be maintained in game birds, such as *Salmonella* Pullorum phage type 7, which has been detected in pheasants but not poultry.

Although clinical cases do not seem to be common in wild birds, serological and/or bacteriological evidence for *Salmonella* Pullorum has been found in diverse species from terrestrial and aquatic habitats, including seabirds. Serological tests for *Salmonella* Pullorum may also detect antibodies to *Salmonella* Gallinarum and some other *Salmonella* (e.g., *Salmonella* Enteritidis); thus, some of these studies are ambiguous. One study isolated *Salmonella* Gallinarum from a gray partridge (*Perdix perdix*) with signs of fowl typhoid, as well as asymptomatic rooks (*Corvus frugilegus*) and a wood pigeon (*Columba palumbus*), near an outbreak in poultry. However, this organism was not found in rooks from another region, suggesting that wild birds might not be significant maintenance hosts for this biotype.

Infections in mammals are unusual, but a few *Salmonella* Pullorum infections have been reported in naturally or experimentally infected pigs, cattle, cats, dogs, foxes, mink, rabbits, guinea pigs, laboratory and wild rats, chinchillas and chimpanzees. Rats were infected experimentally with *Salmonella* Gallinarum.

Zoonotic potential

Salmonella Gallinarum and *Salmonella* Pullorum rarely cause clinical cases in people. In one report, these organisms accounted for only 26 out of more than 450,000 *Salmonella* isolated from humans in the U.S. between 1982 and 1992. Self-limiting enteritis is thought to be the most common presentation, although other syndromes have been reported. Their threat to immunocompromised individuals is still unclear. A urinary tract infection caused by *Salmonella* Gallinarum was reported in a kidney transplant patient in 2017, and it is possible that some infections might

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have been missed. Organisms identified only as group D *Salmonella* have occasionally been recovered from people who were infected with HIV or had other immunosuppressive conditions.

Geographic Distribution

Fowl typhoid and pullorum disease are common in some countries of Central and South America, Africa and Asia. These diseases have been eradicated from commercial poultry in many other nations with highly developed poultry industries, such as the U.S., Canada, New Zealand, Australia, Japan and most countries in Europe. Even in these countries, however, *Salmonella* Gallinarum and *Salmonella* Pullorum may persist in backyard flocks, game birds and wild birds.

Transmission

Fowl typhoid and pullorum disease can be transmitted orally (e.g., in food and water or by cannibalism) and via the respiratory tract. The causative organisms may also enter the body at other sites, such as in wounds. *Salmonella* Gallinarum and *Salmonella* Pullorum can be found in the feces of sick birds; however, they do not seem to colonize the intestinal tract in the absence of disease.

Vertical transmission is important in the epidemiology of pullorum disease. Some infected poultry become long-term asymptomatic carriers of *Salmonella* Pullorum and transmit it to their progeny in eggs. Although only a small number of eggs may be infected, horizontal transmission can amplify the outbreak after the chicks hatch. The significance of vertical transmission in fowl typhoid is less clear. Although *Salmonella* Gallinarum has been detected in eggs, vertical transmission to progeny has been difficult to reproduce experimentally. In addition, highly susceptible birds seem to clear *Salmonella* Gallinarum if they survive, and do not appear to become carriers. Nevertheless, prolonged carriage has been reproduced in chickens that were resistant to clinical signs, with these birds reported to carry the organism for at least 14 weeks.

Under optimal conditions, *Salmonella* Gallinarum and *Salmonella* Pullorum may survive for several months and possibly up to several years in the environment. However, they can be destroyed by sunlight and/or high environmental temperatures, and they may only survive for a few weeks or less at some sites. Wild birds, mammals and insects can act as mechanical or biological vectors. Red mites (*Dermanyssus gallinae*) appear to be involved in spreading fowl typhoid and may maintain these bacteria for several months. In one study, experimentally infected rats shed *Salmonella* Pullorum for up to 4 months.

Disinfection

Some authors suggest that phenol-based compounds are the most effective disinfectants under field conditions, but other agents, such as quaternary ammonium compounds and iodophors, may also be used. Additional agents

reported to be effective against *Salmonella* spp. and/or Gram negative bacteria include 1% sodium hypochlorite, formalin (e.g., 4% formaldehyde), 2% glutaraldehyde, 70% ethanol, 70% propanol, 2% peracetic acid, 3-6% hydrogen peroxide, ozone, chlorine dioxide gas, dichloride of mercury and potassium permanganate. Autoclaving (moist heat of 121°C/ 250°F for at least 15 minutes or dry heat of 170°C/ 338°F for at least 1 hour) is also effective against *Salmonella* spp.

Incubation Period

The incubation period is short, often in the range of 4 to 6 days for fowl typhoid.

Clinical Signs

Pullorum disease is mainly seen in young birds. In poultry, this disease usually affects chicks less than 3-4 weeks of age, with peak mortality around 2-3 weeks. If birds are hatched from infected eggs, some embryos may die in the egg, and dead and dying chicks can be found soon after hatching. Recently hatched birds have nonspecific signs of acute septicemia such as depression/ somnolence, weakness, loss of appetite, drooping wings, huddling, labored breathing, dehydration and ruffled feathers. Diarrhea, which is usually white and viscous, is common, and fecal pasting is frequently seen around the vent. The course of the disease can be less acute in older chicks, and arthritis affecting various joints, especially the hock, has been described in some outbreaks. In some instances, it was the most prominent sign in the affected flock. Blindness has also been reported. Birds that survive pullorum disease may be underweight and poorly feathered, and they may not mature into productive adults. Infections in poultry > 4 weeks of age are usually inapparent, although there are occasional reports of an illness similar to fowl typhoid. Decreased egg production, fertility and hatchability of eggs can be seen in inapparent carriers.

Fowl typhoid affects birds of all ages. As with pullorum disease, dead and dying chicks may be found soon after hatching. However, this disease is common in older birds. Depression, decreased appetite, weight loss, dehydration, ruffled feathers and watery to mucoid yellowish diarrhea are common clinical signs in poultry and game birds. Respiratory distress may also be seen. Egg production usually decreases, and decreased hatchability and fertility may be noted. A progressive loss of condition in birds that survive longer can lead to anemia with pale, shrunken combs and wattles. There may also be outbreaks with atypical syndromes. One outbreak in quail was characterized by decreased egg laying and high mortality, but few birds had any clinical signs.

Post Mortem Lesions

Common lesions in recently hatched birds with pullorum disease include unabsorbed yolk sacs, which sometimes have evidence of infection (e.g., creamy or

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caseous material), peritonitis, congested lungs and a dark, swollen liver. Some chicks only have signs of septicemia, with dilated subcutaneous blood vessels and a congested liver, or no specific lesions. Chicks that survive longer frequently have typhlitis with firm, cheesy material in the cecum (necrotic cecal casts) and small white or grey necrotic foci or nodules in the liver, spleen, lungs, heart and other viscera. Some nodules may resemble the tumors of Marek's disease. Liver lesions are reported to be less common in young pheasants than young chickens, but lung lesions (white or pale nodules) can be prominent in this species. Arthritis can be seen occasionally in poultry chicks; the swollen joints contain an exudate that has been described in different outbreaks as cream-colored, yellow or orange, and gelatinous or viscous. The anterior chamber of the eye contained exudates in birds with ocular lesions. Birds that die peracutely may have no gross lesions.

Birds with acute fowl typhoid typically have generalized signs of septicemia and a dark, enlarged, friable liver than often has a coppery bronze tinge. This bronze discoloration may only develop after the liver is exposed to air. Catarrhal enteritis with viscous, bile-stained, slimy intestinal contents is common, and is usually most prominent in the small intestine. Intestinal ulcerations are reported to be frequent in turkey poults but infrequently found in chickens. Necrotic foci are sometimes visible through the intestinal wall. Turkeys with fowl typhoid may have grayish lungs, and some guinea fowl have congested lungs, airsacculitis and mucus in the upper respiratory tract. The bone marrow is typically dark brown. In more chronic cases, the carcasses may be intensely anemic and wasted or emaciated, and fibrinous pericarditis is common. Focal necrosis may be detected in the heart, liver, intestines and pancreas of chronically affected birds. Similar lesions have been reported in some clinically affected adult birds with pullorum disease.

Misshapen, discolored and/or shrunken ovaries are the most consistent gross lesion in adult carriers of *Salmonella* Pullorum. Common abnormalities include nodular or regressing ovarian follicles, an inactive ovary with small, undeveloped ova, or a few misshapen, discolored, cystic and/or nodular ova among normal ovules. The affected follicles are often attached by pedunculated fibrous stalks, and the abnormal ova may contain encapsulated caseous and oily material. Caseous material may also be detected in the oviduct. In some birds, ovarian dysfunction leads to peritoneal ovulation or impaction of the oviduct, and can result in fibrinous peritonitis. Additional lesions, such as pericarditis, arthritis, or necrotic foci in the testes, have been reported in some carriers.

Diagnostic Tests

Fowl typhoid and pullorum disease can be diagnosed by isolating *Salmonella* Gallinarum or *Salmonella* Pullorum, respectively, from affected birds. At necropsy, organisms may be found in various internal organs, such as

the liver, spleen, heart, kidneys, lung, yolk sac and intestinal and/or cloacal contents. While they are most likely to be recovered from organs with lesions, organisms may also be detected in apparently normal tissues. They may also be found in cloacal swabs from sick live birds. In carriers, *Salmonella* Pullorum is most consistently recovered from the ovary and oviduct, although it may also be found at other sites. Some experts recommend pooling several tissues from internal organs (e.g., ovary, ileocecal junction, liver, spleen) in these birds. Culture is more likely to be successful in birds that have not been treated with antibiotics for approximately 2-3 weeks. *Salmonella* Gallinarum and *Salmonella* Pullorum may also be isolated from eggs, broken eggshells, embryos, feces, red mites and the environment (e.g., incubators, poultry houses); however, it is more difficult to recover organisms from these sources than from sick or recently dead birds.

Salmonella Gallinarum and *Salmonella* Pullorum can be cultured on most standard nonselective media. Most organisms can also be recovered on selective media such as MacConkey, brilliant green and xylose lysine deoxycholate agars, although a few may be inhibited by certain complex media. In particular, *Salmonella* Pullorum from pheasants may be difficult to recover in selenite F broth, and some poultry isolates have variable or delayed hydrogen sulfide production, making them difficult to recognize as *Salmonella* on certain media. For this reason, experts recommend inoculating both selective and nonselective media. To prevent the overgrowth of competing flora, selective enrichment should be used for contaminated samples such as feces, intestinal contents and environmental samples. Isolated organisms can be identified and differentiated with biochemical and serological tests and/or PCR. Specialized techniques including plasmid profile analysis, pulsed field gel electrophoresis, PCR-restriction fragment length polymorphism (RFLP), multilocus variable-number tandem-repeat analysis (MVLA) or ribotyping may be useful in epidemiological investigations.

PCR tests can also be used to identify *Salmonella* Gallinarum and *Salmonella* Pullorum directly in tissues. Some assays are reported to distinguish these two biovars. Loop-mediated isothermal amplification assays have also been published. In one outbreak, immunostaining was used to help confirm fowl typhoid in the internal organs of budgerigars.

Serology can be employed as a flock test or to help identify chronically infected birds in control programs. Field testing of chickens is possible with the rapid whole blood plate agglutination test, but this assay is unreliable in turkeys and ducks due to false positive reactions. Other serological tests that may be used in poultry include the rapid serum agglutination test, tube agglutination, microagglutination, microantiglobulin (Coombs), immunodiffusion, hemagglutination and ELISAs. Cross-reactions with other species or serovars of *Salmonella*, particularly *S. enterica* subsp. *enterica* serovar Enteritidis,

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can be an issue; however, some assays are reported to specifically recognize *Salmonella* Gallinarum and *Salmonella* Pullorum. In control programs, testing for reactors should be repeated at least twice, as a single test may not detect all carrier birds, and preferably until all birds have tested negative at least twice.

Treatment

Various antibiotics can be used to treat clinical cases, but they do not eliminate *Salmonella* Gallinarum and *Salmonella* Pullorum from the flock. Antibiotic resistance including multi-drug resistance has been reported, and it seems to be increasing in frequency.

Control

Disease reporting

Veterinarians who encounter or suspect infections with *Salmonella* Pullorum and *Salmonella* Gallinarum should follow their national and/or local guidelines for disease reporting. In the U.S., fowl typhoid and pullorum disease must be reported to state or federal authorities immediately upon diagnosis or suspicion of the disease.

Prevention

To exclude *Salmonella* Gallinarum and *Salmonella* Pullorum from a poultry flock, live birds and eggs should be purchased from stock known to be free of these organisms, or tested. Disease-free flocks should not be allowed to contact infected birds or contaminated environments, including natural bodies of water that might contain organisms. Good biosecurity is also important in excluding organisms that may be present on fomites and visitors. To the extent feasible under the production system, rodents and wild birds should be excluded from the facility and potential insect vectors and/or reservoirs, including poultry mites, should be controlled.

Infected flocks are usually quarantined in fowl typhoid- or pullorum-free countries. Repeated testing and removal of carriers can sometimes eliminate the infection from a flock. More often, the entire flock is depopulated and the premises are cleaned and disinfected before restocking. Fowl typhoid vaccines are sometimes used in chickens in endemic areas. Vaccination can protect birds from clinical signs and mortality, but it does not prevent them from becoming infected, and protection may be short-lived.

It is difficult to eliminate *Salmonella* Pullorum and *Salmonella* Gallinarum from game birds in semi-wild production systems where the birds are released into the wild and recaptured for breeding. In this case, control measures may consist of treating outbreaks and attempting to reduce the transmission of organisms between birds in hatcheries and at other sites.

Morbidity and Mortality

Pullorum disease usually causes outbreaks only in young birds, while fowl typhoid is often seen in growing

birds and adults, although chicks are also susceptible. The mortality rate for both diseases is reported to range from <1% to 100% in chickens and turkeys, with morbidity and mortality affected by the age, species and breed of the bird; flock nutrition and management; stressors including concurrent infections; and the strain of the organism. Although mortality rates for fowl typhoid or pullorum disease can approach 100% in highly susceptible poultry, mortality can be low in resistant breeds. Among the common commercial breeds of chickens, lighter breeds such as leghorns are more resistant to pullorum disease than heavier breeds, while brown egg layers are more susceptible to fowl typhoid than white egg layers. Some local or native breeds are also reported to be resistant. In outbreaks of arthritis from pullorum disease, < 5% to 40% of the birds are reported to be affected.

Fowl typhoid and pullorum disease can also be severe in birds other than poultry. Mortality rates in the range of 50% or higher have been reported in some outbreaks in game birds, while outbreaks of fowl typhoid in budgerigars (*Melopsittacus undulatus*) at 3 facilities resulted in 45-60% morbidity and 35-60% mortality in adults, and 80-90% morbidity and 65-80% mortality in young birds. Although these diseases have been described in ducks and geese, and some birds can be infected, most of the currently raised breeds of waterfowl seem to be resistant to clinical signs.

Internet Resources

The Merck Veterinary Manual
<http://www.merckvetmanual.com>

World Organization for Animal Health (OIE)
<http://www.oie.int/>

OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals
<http://www.oie.int/international-standard-setting/terrestrial-manual/access-online/>

OIE Terrestrial Animal Health Code
<http://www.oie.int/international-standard-setting/terrestrial-code/access-online/>

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