Newcastle Disease

Avian Paramyxovirus-1Infection, Goose Paramyxovirus Infection

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Importance

Newcastle disease is a viral disease of birds with a wide range of clinical signs from mild to severe. This disease is caused by a diverse group of viruses; the milder strains are endemic in the United States, while highly virulent strains are exotic. The highly virulent form of Newcastle disease is one of the most important poultry diseases worldwide. Chickens are particularly susceptible, and may experience morbidity and mortality rates up to 100%. Outbreaks of virulent Newcastle disease have a tremendous impact on backyard chickens in developing countries, where these birds are a significant source of protein and this disease is endemic. In developed countries, where the more virulent forms of the virus have been eradicated, trade embargoes and restrictions cause significant economic losses during outbreaks. In the United States, one epidemic in 2002-2003 resulted in the death of more than three million birds and caused industry losses estimated at $5 billion. Low pathogenicity isolates, which are common in poultry worldwide, can decrease productivity but have no impact on international trade.

Although the most significant impact of Newcastle disease is on chickens, other species can also be affected. Some pet and zoo birds become ill after infection, while other species can carry and shed virulent viruses asymptomatically. These birds, particularly illegally imported psittacines, can introduce Newcastle disease viruses to disease-free countries. Newcastle disease is also an important cause of death during the first three months of life in cormorant colonies. Since the late 1990s, novel strains have caused outbreaks among geese (a species that is usually resistant to disease) in China.

Etiology

Newcastle disease is caused by viruses in the serotype avian paramyxovirus type 1 (APMV-1). These viruses, which are called either APMV-1 or Newcastle disease viruses (NDV), are members of the genus *Avulavirus* in the family Paramyxoviridae. APMV-1 strains maintained in pigeon populations have some antigenic differences from other NDV isolates, and are sometimes called pigeon paramyxovirus type 1 (PPMV-1).

APMV-1 strains are classified into three pathotypes based on their virulence in chickens. Lentogenic strains are the least virulent, mesogenic strains are moderately virulent, and velogenic strains are the most virulent. Most strains cluster toward the two extremes of virulence, and are either lentogenic or velogenic. Velogenic viruses can be subdivided into a neurotropic form, which is typically associated with respiratory and neurologic signs, and a viscerotropic form with hemorrhagic intestinal lesions. These clinical forms overlap and are rarely clear-cut, even in specific pathogen free (SPF) chickens.

Several tests can be used to assess the virulence of an APMV-1 strain, and countries may use different criteria to define Newcastle disease. The OIE defines Newcastle disease as an infection caused by a highly virulent APMV-1 virus – an isolate that has either 1) an intracerebral pathogenicity index (ICPI) of at least 0.7 in day-old chicks, or 2) an amino acid sequence that resembles those seen in highly virulent viruses (multiple basic amino acids at the C-terminus of the F2 protein and phenylalanine at residue 117 of the F1 protein). Such viruses must be reported to the OIE and have severe repercussions for international trade. The U.S. defines “exotic Newcastle disease” (END) as the disease caused by velogenic viscerotropic strains.

APMV-1 isolates can also be separated into two clades, called class I and class II, based on the genetic relationship between viruses. The vast majority of APMV-1 strains belong to class II, which is divided into at least nine genotypes (I to IX). Class I isolates have been found mainly in wild waterfowl, and are usually of low pathogenicity.

Species Affected

Newcastle disease primarily affects birds. Some avian species become ill, while others carry these viruses asymptomatically. Infections also occur in humans, but have not been reported in other species of mammals.

APMV-1 viruses are known to infect more than 250 species of birds in 27 orders; other avian species may also be susceptible. Wild birds, particularly waterfowl (order Anseriformes), tend to carry these viruses asymptomatically. Most of the viruses found in wild birds are lentogenic; however, virulent APMV-1 has become established in some cormorant populations (*Phalacrocorax* sp.; order Pelecaniformes) and causes disease in juvenile birds.

Susceptibility to illness varies widely among poultry and pet birds. Members of the order Phasianiformes (gallinaceous birds), particularly chickens, are highly susceptible to disease. Turkeys are less likely to develop severe symptoms, and the susceptibility of game birds (pheasants, partridges, quail and guinea fowl) varies with the species. Ducks and geese usually have inapparent infections, but some isolates (in genotypes VII and VI) have caused outbreaks among geese in China since the 1990s. Clinical cases have been also been described occasionally in ducks. Outbreaks have been reported in ostriches (order Struthioniformes). Pigeons (order Columbiformes) are susceptible to disease, and lentogenic or mesogenic APMV-1 viruses (PPMV-1) are endemic in pigeon populations. Susceptibility to disease varies widely in psittacine birds (order Psittaciformes); cockatiels often die or develop neurological signs, but some species tend to carry velogenic viruses subclinically.

Some birds found in the wild or in zoos also become ill. Penguins (order Sphenisciformes) are highly susceptible to Newcastle disease, and birds often die acutely. Fatal or severe disease has been reported in some raptors (order Falconiformes) including a bearded vulture (*Gypaetus barbatus*), some species of falcons, a captive white-tailed sea eagle (*Haliaeetus albicilla)* and a wild osprey (*Pandion haliaetus*). Other raptors tend to be resistant to disease. Illness has also been reported in gulls (order Charadriiformes) owls (order Strigiformes) pelicans (order Pelecaniformes) and a Northern gannet (*Morus bassanus;* order Pelecaniformes). Susceptibility varies among passerine birds (order Passeriformes), with some species excreting virus subclinically and others developing severe clinical signs. Occasional deaths have also been reported in Corvidae (crows and ravens).

Geographic Distribution

Velogenic APMV-1 is endemic in Asia, the Middle East, Africa, Central and South America, and parts of Mexico. Virulent strains are endemic in wild cormorants in the U.S. and Canada, but commercial poultry are free of velogenic isolates. Lentogenic isolates are found in poultry throughout the world, including the U.S. Mesogenic strains may also be found, but are less common.

Transmission

APMV-1 can be transmitted by inhalation or ingestion (fecal/ oral route). Birds shed virus in both feces and respiratory secretions. Gallinaceous birds excrete APMV-1 for only 1-2 weeks, but psittacine birds often shed these viruses for several months. Some species of psittacine birds can excrete virus for more than a year. Prolonged shedding has also been reported in some members of other orders, including owls (more than four months) and cormorants (one month). Shedding can be sporadic. APMV-1 is present in all parts of the carcass, and some outbreaks in raptors have been linked to eating infected chicken, pigeon or quails. When the temperature is just above freezing (1-2ºC [34-35ºF]), this virus is reported to survive on chicken skin for up to 160 days and in bone marrow for nearly 200 days. The importance of aerosols in long distance transmission is controversial. In one study, APMV-1 was found 64 meters but not 165 meters downwind of an infected farm. The survival of aerosolized virus is probably dependent on humidity and other environmental factors, as well as the concentration of infected poultry. Some isolates can be transmitted through the egg to hatching chicks. Egg-associated transmission of highly virulent isolates is possible but uncommon, as the embryo usually dies unless the viral titer in the egg is low. Other sources of virus for newly hatched chicks are feces-contaminated eggshells and cracked or broken eggs.

APMV-1 is readily transmitted on fomites. Survival is prolonged on eggshells and especially in feces, compared to an inorganic surface (filter paper). Published information on virus survival is highly variable, probably because it is affected by the humidity, temperature, suspending agent and exposure to light. One study reported that APMV-1 survived in contaminated, uncleaned poultry houses for up to 7 days in summer, as long as 14 days in the spring, and 30 days during the winter. Another group reported virus isolation up to 16 days after depopulation of an unvaccinated flock. However, one study found that APMV-1 remained viable for up to 255 days in a henhouse, at ambient temperatures of –11ºC (12ºF) to 36ºC (97ºF). At 23-29ºC (73-84ºF), APMV-1 is reported to survive in contaminated litter for 10 to 14 days, and at 20ºC (68ºF) in soil for 22 days. Virus has also been recovered from earthworms for 4 to 18 days, and from experimentally contaminated lake water for 11 to 19 days. Flies might be able to transmit APMV-1 mechanically, but it is still uncertain whether insects can carry enough virus to infect poultry. The importance of arthropod-borne transmission may vary with the type of housing and flock management.

The epidemiology of APMV-1 is incompletely understood; however, wild birds, particularly waterfowl, may be the reservoir hosts for lentogenic viruses. These viruses could become more virulent after becoming established in poultry. Some recent outbreaks were apparently caused by velogenic viruses that emerged from local, low pathogenic isolates. Acquisition of virulence has also been reported in experimentally infected birds. Psittacine birds have introduced APMV-1 to poultry flocks in some outbreaks. Although early reports suggested that virulent

strains might be endemic in wild psittacine populations, these birds are now thought to become infected after capture. Cormorants could transmit velogenic viruses to poultry; gulls associated with cormorant colonies could also be a source of virus, and are more likely to visit farms. Lentogenic or mesogenic APMV-1 viruses are endemic in pigeon populations, and can become more virulent if they enter and cycle in poultry flocks.

Incubation period

The incubation period in poultry varies from 2 to 15 days depending on the virulence of the strain and the susceptibility of the population. In chickens infected with velogenic isolates, an incubation period of 2 to 6 days is common. Incubation periods up to 25 days have been reported in some avian species.

Clinical signs

The clinical signs vary with the pathogenicity of the isolate and the species of bird. In chickens, lentogenic strains usually cause subclinical infections or mild respiratory disease with coughing, gasping, sneezing and rales. Mesogenic strains can cause acute respiratory disease and neurologic signs in some chickens, but the mortality rate is usually low. Lentogenic or mesogenic strains can produce more severe symptoms if the flock is co-infected with other pathogens.

Velogenic strains cause severe, often fatal, disease in chickens. The clinical signs are highly variable. Most birds are lethargic and inappetent, and the feathers may be ruffled. Conjunctival reddening and edema may be an early sign. Some birds develop watery, greenish or white diarrhea, respiratory signs (including cyanosis) or swelling of the tissues of the head and neck. Neurologic signs including tremors, clonic spasms, paresis or paralysis of the wings and/or legs, torticollis (twisted neck) and circling may also be seen. Nervous signs can occur concurrently with other symptoms but are generally seen later in the course of disease. Egg laying often declines dramatically, and eggs may be misshapen, abnormally colored, and rough or thin-shelled, with watery albumen. Sudden death, with few or no symptoms, is also common. Birds that survive for two weeks usually live but may have permanent neurological damage and/or a permanent decrease in egg production.. The symptoms may be less severe in vaccinated birds.

Similar clinical signs are seen in other species of birds; however, either neurological signs or respiratory signs can predominate in some species. Newcastle disease is generally milder in turkeys than chickens, but some strains may cause significant disease. Severe clinical signs can sometimes be seen in game birds, particularly pheasants. Respiratory signs have been reported in some but not all outbreaks in pheasants. Guinea fowl sometimes become ill, but they can also carry velogenic isolates subclinically.

In psittacine birds, Newcastle disease may be acute, subacute, chronic or inapparent. The clinical signs are highly variable, but may include respiratory and/or neurologic signs, as well as diarrhea and sudden death. Respiratory signs tend to predominate in ostriches and emus, and these birds are usually less severely affected than chickens. Diarrhea, polydipsia, conjunctivitis and neurological signs are generally seen in pigeons and doves. Neurological signs, particularly talon convulsions and the inability to coordinate flight, are prominent in raptors. Sudden death may also occur. Geese and ducks are usually infected subclinically (with most strains), but illness is occasionally reported. Neurological signs, diarrhea, anorexia and sudden death may be seen in these birds. Respiratory symptoms appear to be rare in waterfowl.

In cormorant colonies, Newcastle disease is usually characterized by neurological signs, and illness is almost always limited to juveniles. Affected birds may be weak, with paresis or paralysis of one or both legs and/or wings, incoordination, tremors, torticollis and/or drooping of the head. Sick or dead birds can be found in the same nest as apparently normal nestmates. Older fledged cormorants may be seen trying to walk, fly, swim or dive. Sick or dead gulls and juvenile white pelicans have been seen near affected cormorant colonies. Sick pelicans had neurological signs similar to cormorants, such as unilateral or bilateral wing and or leg paralysis/ paresis, drooping neck, and an inability or reluctance to move; however, it has not been proven that these symptoms were caused by APMV-1. In addition to increased mortality, the only clinical signs reported in gulls were wing and/or leg paralysis or paresis.

Post Mortem Lesions

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Significant gross lesions are usually found only in birds infected with velogenic strains. The head or periorbital region may be swollen, and the interstitial tissue of the neck can be edematous, especially near the thoracic inlet. Congestion or hemorrhages may be found in the caudal pharynx and tracheal mucosa, and diphtheritic membranes sometimes occur in the oropharynx, trachea and esophagus. Petechiae and small ecchymoses may be seen in the mucosa of the proventriculus. Hemorrhages, ulcers, edema and/or necrosis often occur in the cecal tonsils and lymphoid tissues of the intestinal wall (including Peyer's patches); this lesion is particularly suggestive of Newcastle disease. Thymic and bursal hemorrhages may also be present, but can be difficult to see in older birds. The spleen may be enlarged, friable and dark red or mottled. Pancreatic necrosis and pulmonary edema can be found in some birds. The ovaries are often edematous or degenerated, and may contain hemorrhages. Some birds, particularly those that die suddenly, have few or no gross lesions. Similar lesions have been reported in geese, turkeys, pheasants and other species infected with virulent strains. In experimentally infected guinea fowl, the only

significant lesions were hemorrhages at the tip of the glands of the proventriculus and in the cecal tonsil.

In chickens infected with less virulent strains, the lesions may be limited to congestion and mucoid exudates in the respiratory tract, and opacity and thickening of the air sacs. More severe lesions can be seen in birds with secondary bacterial infections.

Morbidity and Mortality

Morbidity and mortality rates vary greatly depending on the virulence of the strain and susceptibility of the host. Lentogenic and mesogenic viruses usually kill few birds; in poultry, the mortality rate is approximately 10% for mesogenic strains and negligible with lentogenic strains. Concurrent illnesses may increase the severity of illness and result in a higher death rate. In contrast, velogenic isolates have morbidity and mortality rates up to 100% in unvaccinated chickens. The onset of disease is usually rapid, and the virus often spreads quickly, particularly in group-housed flocks. Some isolates can affect young birds more severely. Vaccinated poultry tend to have milder infections. In one epidemic mainly affecting vaccinated chickens, flock mortality rates were 30% to 90%.

Other species of birds are usually affected less severely than chickens. Velogenic isolates can kill up to 100% of experimentally infected pheasants, but some individual birds may be resistant to disease, and the mortality rate reported during outbreaks is highly variable. From 22% to 77% of the pheasants in affected flocks died during one epizootic in Denmark, but in another outbreak in the U.K., the mortality rate was less than 3% even in the most severely affected pen. In guinea fowl, the mortality rate was 21% during one outbreak, and 8-100% in experimental infected birds (depending on the strain of the virus). Mortality rates as high as 28% have been reported in ostriches in some outbreaks, but few birds died in others. Newcastle disease is rarely severe in waterfowl; however, some velogenic strains circulating in China have an average morbidity rate of 17.5% and an average mortality rate of 9% in geese.

APMV-1 (PPMV-1) is endemic in pigeons and doves in many countries. In these birds, highly virulent strains have morbidity rates as high as 70% and mortality rates that approach 40%. Velogenic strains are endemic in cormorants, but adult birds do not appear to develop clinical signs or die. The estimated mortality during several outbreaks in juvenile cormorants ranged from less than 1% to 92%. Up to 90% of juvenile white pelicans near these colonies have died in some outbreaks; however, it has not been proven that the disease in pelicans was caused by APMV-1.

Diagnosis

Clinical

Newcastle disease should be considered, especially in chicken flocks, when the morbidity and mortality rates are high, and the symptoms could be consistent with this disease. Unexpected deaths are sometimes the first sign. There are no pathognomonic gross lesions; however, some lesions may be suggestive, particularly when several carcasses are examined.

Differential diagnosis

The differential diagnosis for velogenic Newcastle disease includes other causes of septicemia, enteritis, respiratory disease and/or neurologic signs. In poultry, these diseases include fowl cholera, highly pathogenic avian influenza, laryngotracheitis, the diphtheritic form of fowl pox, psittacosis, mycoplasmosis, infectious bronchitis, aspergillosis, and management problems such as deprivation of water or feed, and poor ventilation. In pet birds, diseases to consider include psittacosis, Pacheco's disease, salmonellosis, adenovirus, and nutritional deficiencies, as well as other paramyxovirus infections. In cormorants, botulism, fowl cholera and traumatic skeletal abnormalities are among the differentials.

Laboratory tests

Newcastle disease can be diagnosed by isolating APMV-1 from affected birds. This virus is usually recovered by inoculating samples into 9-11 day old embryonated chicken eggs. Chorioallantoic fluid from the eggs is tested for hemagglutinating activity, and any agents that hemagglutinate are examined for hemagglutination inhibition (HI) with a monospecific antiserum to APMV-1. Some HI tests that use monoclonal antibodies can identify particular strains of APMV-1. APMV-1 can cross-react with some other avian paramyxoviruses, particularly APMV-3 and APMV-7, in the HI test.

The pathogenicity of the isolate can be quantified by 1) the mean death time (MDT) in chicken embryos, 2) the intracerebral pathogenicity index (ICPI) in 1-day old chicks, or 3) the intravenous pathogenicity index (IVPI) in 6-week old chickens. In the MDT assay, velogenic isolates have an MDT of less than 60 hours, mesogenic strains have an MDT of 60-89 hours, and lentogenic viruses have an MDT greater than 90 hours. The ICPI and IVPI tests are scoring systems that evaluate illness or death in chickens. The values in the ICPI test range from 0 to 2.0; the most virulent viruses approach 2.0, while lentogenic strains are usually close to 0.0. The values in the IVPI test are from 0 to 3.0; the IVPI for velogenic strains approach 3.0, while lentogenic strains and some mesogenic strains have IVPI values of zero. However, some viruses that can produce severe disease have IVPI values of zero; the ICPI test is generally preferred for this reason. Other variations of these tests are also used; some can distinguish viscerotropic (velogenic) from neurotropic strains.

Reverse-transcription polymerase chain reaction (RT-PCR), gene sequencing, restriction enzyme analysis and other molecular techniques are also used to identify APMV-1 in eggs or clinical specimens. Some of these tests can also determine the virus's pathotype. Most iso-

lates that are highly virulent for chickens have a particular sequence, 112R/K-R-Q-K/R-R116 (multiple basic amino acids) at the C-terminus of the F2 protein and phenylalanine at residue 117 of the F1 protein. The presence of this genetic sequence is enough to classify an isolate as highly virulent for the purposes of international trade. If this pattern is not present, the pathogenicity of the virus must be determined in the ICPI or other test. Rapid diagnostic tests, as well as tests using monoclonal antibodies, are optimized for more virulent viruses, and may not identify some lentogenic viruses (particularly Class I isolates).

Serological assays may be useful in some circumstances. Hemagglutination inhibition is the most commonly used serological test. Other tests include virus neutralization, hemagglutination and enzyme-linked immunosorbent assays (ELISA). Vaccination can interfere with serologic testing. In some species, immunohistochemistry may be used to detect antigens in tissues; this test is not performed routinely for diagnosis in chickens.

Samples to collect

Before collecting or sending any samples from animals with a suspected foreign animal disease, the proper authorities should be contacted. Samples should only be sent under secure conditions and to authorized laboratories to prevent the spread of the disease. Newcastle disease is zoonotic; samples should be collected and handled with all appropriate precautions.

Tracheal and cloacal swabs should be taken from live birds for virus isolation. If cloacal swabs might harm the bird, fresh feces may be collected instead. Whenever possible, samples should be taken in the early stages of disease. At necropsy, samples should be collected from the spleen, trachea, lung, intestines (particularly the cecal tonsil), intestinal contents, liver, kidneys, heart and brain. Oronasal swabs should also be taken. Samples for virus isolation should be collected from recently dead birds or moribund birds after euthanasia. Tissues may be collected separately or pooled; intestinal samples are generally processed separately. These samples should be kept cold (e.g. on wet ice), and swabs should be sent to the laboratory in transport medium. Similar tissues and feces are collected for RT-PCR and other molecular assays. Clotted blood or serum samples can be submitted for serology.

Recommended actions if highly virulent Newcastle disease is suspected

Notification of authorities

State and federal veterinarians should be informed immediately of any suspected cases of highly virulent (velogenic) Newcastle disease.

Federal: Area Veterinarians in Charge (AVIC):
http://www.aphis.usda.gov/animal_health/area_offices/

State Veterinarians:
http://www.aphis.usda.gov/vs/sregs/official.html

Control

Good biosecurity can help prevent Newcastle disease in poultry flocks. Flocks should not be allowed to contact domesticated poultry of unknown health status, any pet birds (particularly psittacines), and wild or feral birds (particularly cormorants, gulls and pigeons). Whenever possible, workers should avoid contact with birds outside the farm. Biosecurity measures include bird-proofing houses, feed and water supplies, minimizing travel on and off the facility, and disinfecting vehicles and equipment that enter the farm. Pests such as insects and mice should also be controlled. If possible, employees should shower and change into dedicated clothing for work. All in/ all out breeding (one age group per farm), with disinfection between groups, is also advisable. More detailed biosecurity guidelines can be found in the Internet Resources section of this factsheet.

Similar biosecurity measures can protect birds kept in zoos or aviaries, or as pets (see Internet Resources). Establishing an effective biosecurity program can decrease the risk that hobby or pet birds would be euthanized during a Newcastle disease outbreak. Pet birds should be bought only from suppliers who can certify that the birds have been imported legally or bred in the U.S., and are healthy. Legally imported pet birds have been quarantined and tested for velogenic strains of APMV-1. Domestically raised birds are usually closed-banded. Some species such as Amazon parrots are difficult to raise domestically; vendors who are selling large numbers of young birds of these species (particularly when they are bargain-priced) without adequate documentation should be viewed with caution. Newly acquired birds should be isolated or quarantined for at least 30 days, and they should be monitored closely for signs of illness. Avian carcasses (of any species) that could be infected with velogenic Newcastle disease should never be fed to raptors, chickens or other birds. Illegally imported psittacines should be reported, because many of them may be carrying velogenic APMV-1.

Vaccines are used in chickens, pheasants and other species. In addition, birds in aviaries, breeding farms and zoos are often vaccinated. Vaccination can protect birds from clinical signs but does not necessarily prevent virus replication and shedding. Sentinel chickens are sometimes used to monitor vaccinated flocks.

Outbreaks are eradicated with quarantines and movement controls, depopulation of all infected and exposed birds, and thorough cleaning and disinfection of the premises. Effective disinfectants include chlorhexidine, sodium hypochlorite (6%), phenolic disinfectants and oxidizing agents (e.g. Virkon®). APMV-1 can also be inactivated by heat (56°C [133°F] for 3 hours or 60°C [140°F] for 30 min), acid (pH 3), ether and formalin; the efficacy of formalin varies with the temperature. Whether flies are competent vectors for APMV-1 is still uncertain, but fly control is prudent on and near infected farms. Before eradication begins, the facilities should be treated

with insecticides that can kill adult flies. Insect control should be continued until disinfection is complete. Farms must generally remain empty for a few weeks before re-stocking; the specific time may vary with the climate, season and other factors. During some eradication programs, government agencies may collect and test birds that die suddenly in any facility. This measure can be helpful in recognizing new cases.

Public Health

Velogenic strains of APMV-1 can cause conjunctivitis in humans, usually when the person has been exposed to large quantities of virus. Laboratory workers and vaccination crews are affected most often. Poultry workers are rarely infected, and handling or consuming poultry products does not appear to be a risk. The conjunctivitis usually resolves rapidly without treatment, but APMV-1 is shed in the ocular discharges for 4 to 7 days. All direct or indirect contact with birds should be avoided during this time.

Mild, self-limiting influenza-like disease with fever, headache and malaise has also been reported in humans; in some cases, it is uncertain whether the illness was caused by APMV-1 or misdiagnosed by cross-reactions in serologic tests. A recent report, confirmed by virus isolation, suggests that APMV-1 could cause serious opportunistic infections in people who are immunosuppressed. A patient developed fatal pneumonia 18 days after receiving a peripheral blood stem cell transplant. There was no history of contact with poultry, and the isolate was most closely related to APMV-1 viruses from pigeons.

Internet Resources

California Department of Food and Agriculture.
Newcastle Disease Information
http://www.cdfa.ca.gov/ahfss/Animal_Health/Newcastle_Disease_Info.html

The Merck Veterinary Manual
http://www.merckvetmanual.com/mvm/index.jsp

United States Animal Health Association.
Foreign Animal Diseases
http://www.vet.uga.edu/vpp/gray_book02/fad/index.php

United States Department of Agriculture (USDA).
Biosecurity for the Birds
http://www.aphis.usda.gov/animal_health/birdbiosecurity/

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

OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals
http://www.oie.int/eng/normes/mmanual/a_summry.htm

OIE Terrestrial Animal Health Code
http://www.oie.int/eng/normes/mcode/A_summry.htm

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