

Newcastle Disease

*Avian Paramyxovirus-1 Infection,
Goose Paramyxovirus Infection,
Ranikhet disease*

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OIE Collaborating Centre for
• Diagnosis of Animal Disease and
Vaccine Evaluation in the Americas
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Importance

Newcastle disease is a viral disease of birds caused by avian paramyxovirus 1 (APMV-1). For official control purposes, this disease is currently defined as the most severe form of the illness, which is caused only by certain viral strains. Many less virulent strains of APMV-1 also circulate among domesticated and wild birds. These viruses usually cause much milder clinical signs or infect birds asymptotically. However, they can sometimes evolve to become the highly virulent strains that cause Newcastle disease.

Newcastle disease is considered to be one of the most important poultry diseases in the world. Chickens are particularly susceptible, and may experience morbidity and mortality rates up to 100%. Outbreaks can 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 highly virulent APMV-1 strains have usually been eradicated from poultry, trade embargoes and restrictions cause significant economic losses during outbreaks. Newcastle disease can also affect other commercial poultry, game birds, ratites, and various pet, hobby and zoo birds. Some of these birds become ill, while others carry and shed virulent viruses asymptotically. Subclinically infected birds, particularly illegally imported psittacines, can introduce Newcastle disease into countries where it does not usually exist.

A number of recent studies have examined the epidemiology of APMV-1 in wild birds. Although these birds are mainly infected with low pathogenicity strains of APMV-1, highly virulent strains circulate in some cormorant populations in North America. Outbreaks occur periodically in cormorants, with severe illness and deaths in young birds. Viruses from cormorants can also infect nearby gulls, and could spread to other wild or domesticated birds. Strains of APMV-1 maintained in wild (and domesticated) Columbiformes may also be a concern, although these particular viruses generally tend to cause serious disease only in pigeons and doves. Recently, several papers described sporadic infections with virulent APMV-1 viruses in various wild birds throughout the world. The significance of this finding is still uncertain.

Etiology

Avian paramyxoviruses belong to the genus *Avulavirus* in the family Paramyxoviridae. Twelve serotypes of these viruses (APMV-1 through APMV-12) have been identified in birds. The viruses that cause Newcastle disease belong to avian paramyxovirus type 1 (APMV-1), and are also called Newcastle disease viruses (NDV). APMV-1 strains maintained in Columbiformes (pigeons and doves) have some antigenic differences from other isolates, and are often called pigeon paramyxovirus type 1 (PPMV-1).

APMV-1 viruses have been classified into three or more 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. Some authors also identify an “asymptomatic enteric” group, while others consider these to be lentogenic viruses. Velogenic viruses can be subdivided into two groups: strains that cause a neurotropic form, typically associated with respiratory and neurological signs, and strains that cause a viscerotropic form with hemorrhagic intestinal lesions. However, these clinical forms are not necessarily clear-cut and can overlap.

The World Organization for Animal Health (OIE) has defined Newcastle disease as an infection caused by highly virulent APMV-1 viruses – isolates that have either an intracerebral pathogenicity index (ICPI) of at least 0.7 in day-old chicks, or amino acid sequences in the viral fusion (F) protein that resemble those seen in previously isolated, highly virulent viruses. Such viruses must be reported to the OIE and have severe repercussions for international trade. This definition has been widely adopted by many countries, although other definitions were sometimes used in the past. For example, the term “Newcastle disease” has also been used for the illness caused by any APMV-1 strain (including lentogenic viruses), and the U.S. formerly defined

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“exotic Newcastle disease” as the disease caused only by velogenic viscerotropic strains.

Two different classification systems have been used to divide APMV-1 into genotypes for epidemiological purposes, although a unified system was recently proposed. For this reason, an APMV-1 isolate can have more than one designation. One system, as well as the unified system, separates APMV-1 isolates into two clades, called class I and class II. Each of these classes is further divided into genotypes. The vast majority of APMV-1 strains belong to class II, which contains both highly virulent and nonpathogenic strains. Class I isolates have been found mainly in wild waterfowl and some live bird markets, and are usually of low pathogenicity. Some virulent APMV-1 genotypes are particularly significant, as they have spread widely and have been identified as possible panzootic viruses.

Species Affected

APMV-1 viruses are known to infect more than 250 species of birds in 27 orders; other avian species are also likely to be susceptible.

Wild birds

The epidemiology of APMV-1 is incompletely understood; however, the vast majority of the viruses found in wild birds have been lentogenic. Some species, particularly aquatic birds such as waterfowl, may be reservoir hosts for these viruses. Lentogenic viruses appear to be capable of developing into the velogenic viruses that cause Newcastle disease. The circulation of lentogenic APMV-1 viruses around the world is still under investigation; however, there is evidence that some viruses can spread between continents or hemispheres in wild birds, as well as in poultry. Strains of viruses that seem to originate from live vaccines (i.e., low virulence isolates) have also been found in wild birds in some locations.

In North America, virulent APMV-1 viruses have become established in some cormorant (*Phalacrocorax* sp.) populations. These viruses can also infect gulls, and there is a risk that they could spread to poultry. Other velogenic APMV-1 strains have been found sporadically in wild birds in other parts of the world. Reports have described infections in diverse avian species, including shorebirds, waterfowl, passerines and wild pheasants. Some of these birds seem to have been infected by contact with poultry during local outbreaks. In other cases, authors have speculated that wild birds might transmit virulent viruses during migration, or even act as reservoirs for some genotypes. In the past, velogenic APMV-1 viruses were thought to be endemic in wild psittacine populations; however, it now appears that their high prevalence in imported psittacines is the result of infections spreading subclinically among these birds after capture.

Domesticated birds

Lentogenic, mesogenic and velogenic APMV-1 viruses have been reported to infect domesticated birds and a number of captive wild species. Poultry and some other birds are important in maintaining these viruses. However, some species are more likely to develop Newcastle disease than others. Chickens are highly susceptible to velogenic strains and usually become severely ill if they are infected. Turkeys develop less severe signs than chickens, and the susceptibility of other gallinaceous game birds (pheasants, partridges, peacocks, quail and guinea fowl) is variable. Infections are usually inapparent in ducks and geese; however, some isolates have caused outbreaks among geese in China since the 1990s. Outbreaks have also been reported recently among ducks in China, although the pathogenicity of these viruses remains to be completely investigated. One isolate caused severe signs in intramuscularly inoculated ducks, but the signs were much milder when the virus was administered by a more natural (oronasal) route. Newcastle disease has also been reported in ratites and various species of zoo, pet and hobby birds, such as owls, raptors, penguins and corvids. It is reported to be an important cause of illness among captive falcons in the Middle East. Among psittacine birds, cockatiels (*Nymphicus hollandicus*) are reported to be highly susceptible, but illnesses have also been reported in conures (*Aratinga* spp.), some parrots and experimentally infected budgerigars (*Melopsittacus undulates*).

Pigeon Paramyxovirus 1

PPMV-1 circulates in domesticated pigeons and some populations of wild pigeons and doves. While these viruses mainly affect Columbiformes, occasional outbreaks or clinical cases have been documented in other species including captive game birds (pheasants, partridges), chickens and turkeys. PPMV-1 viruses may cause only mild signs initially in poultry, but can become more virulent as they continue to circulate. PPMV-1 viruses have also been isolated from other birds, including passerine birds, waterfowl and raptors.

Mammals

Naturally occurring APMV-1 infections were once thought to be rare or nonexistent in mammals. However, one virus was isolated from a calf in the 1950s, and more recently, lentogenic viruses were detected in two healthy sheep, and isolated multiple times from pigs in China. Several isolates from pigs shared high homology with vaccine strains used in poultry. These viruses may have spread to pigs from nearby poultry, or from piglets treated for diarrhea with Newcastle disease vaccines, a practice employed in some parts of China. The significance of APMV-1 infections in mammals, if any, is uncertain, but additional isolations seem likely as more surveillance is conducted.

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Experimental infections with APMV-1 viruses have been reported in cattle, nonhuman primates, rabbits, ferrets and small mammals (guinea pigs, hamsters).

Zoonotic potential

Newcastle disease viruses can infect humans, although this seems to occur only after exposure to particularly high concentrations of virus.

Geographic Distribution

Velogenic APMV-1 viruses are endemic among poultry in much of Asia, Africa and the Middle East, and some countries in Central and South America. Virulent strains are maintained in wild cormorants in the U.S. and Canada, but commercial poultry are free of velogenic isolates. Lentogenic isolates occur in poultry and wild birds throughout the world.

Transmission

APMV-1 can be transmitted by inhalation or ingestion, and birds shed these viruses in both feces and respiratory secretions. Gallinaceous birds are thought to excrete APMV-1 for 1-2 weeks, but psittacine birds often shed these viruses for several months, and sometimes 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. While aerosol transmission can occur between nearby birds, its importance in long distance transmission is controversial. In one study, APMV-1 was detected 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 on the concentration of infected poultry.

APMV-1 is present in all parts of the carcass, and can persist for some time at cold temperatures. When the temperature is just above freezing (1-2°C [34-35°F]), this virus was reported to survive on chicken skin for up to 160 days and in bone marrow for nearly 200 days. Some Newcastle disease outbreaks in raptors have been linked to eating infected birds, and in 1984, a PPMV-1 outbreak among chickens in the U.K. was caused by chicken feed contaminated by infected pigeons. Some APMV-1 isolates can also 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. Flies may be able to transmit APMV-1 mechanically.

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 the persistence of these viruses is highly variable, probably because it can be affected by many factors such as humidity, temperature, the suspending agent and exposure

to light, as well as the technique used to detect the viruses. 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 -11°C (12°F) to 36°C (97°F). At 23-29°C (73-84°F), APMV-1 is reported to survive in contaminated litter for 10 to 14 days, and at 20°C (68°F) 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.

Disinfection

Effective disinfectants for APMV-1 include sodium hypochlorite, phenolic disinfectants, glutaraldehyde, chlorhexidine and oxidizing agents (e.g. Virkon®). Quaternary ammonium compounds may be effective if used in the presence of sodium carbonate. APMV-1 can also be inactivated by heat of 56°C (133°F) for 3 hours, or 60°C (140°F) for 30 minutes, and is susceptible to acid (pH 3), ether and formalin. The effectiveness of formalin varies with the temperature.

Incubation Period

The incubation period for APMV-1 infections in poultry ranges from 2 to 15 days, and is commonly 2-6 days in chickens infected with velogenic isolates. Incubation periods up to 25 days have been reported in some other avian species. In pigeons, PPMV-1 causes clinical signs after 4 to 14 days, with some authors reporting incubation periods as long as 3-4 weeks.

Clinical Signs

APMV-1 viruses can cause varying clinical signs, depending on the pathogenicity of the isolate and the species of bird. Lentogenic strains usually infect chickens subclinically or cause mild respiratory disease, with signs such as coughing, gasping, sneezing and rales. Illnesses caused by mesogenic strains can be more severe in this species. There may be respiratory signs, decreased egg production, and in some cases, neurological signs, but the mortality rate is usually low. With both lentogenic and mesogenic viruses, the illness can be more severe if the flock is co-infected with other pathogens.

Velogenic strains cause severe, often fatal, illnesses in chickens, but the clinical signs can be highly variable. Early signs may include lethargy, inappetence, ruffled feathers, and conjunctival reddening and edema. Some birds develop watery, greenish or white diarrhea, respiratory signs (including cyanosis) or swelling of the tissues of the head and neck. 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 preceding clinical signs, is also seen frequently.

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Neurological signs (e.g., tremors, clonic spasms, paresis or paralysis of the wings and/or legs, torticollis, circling) are common in some outbreaks. CNS signs can occur concurrently with other signs of illness, but are generally seen later in the course of the disease, and the birds may be bright and alert. Surviving chickens may have permanent neurological damage and/or a permanent decrease in egg production. Clinical signs caused by velogenic APMV-1 viruses are sometimes reported in vaccinated flocks, but these signs may be less severe.

Similar clinical signs occur in other birds; either neurological signs or respiratory signs may be more prominent in some species. Newcastle disease is generally milder in turkeys than chickens, but some strains can cause significant disease. Game birds sometimes become severely ill. Neurological signs, diarrhea and/or respiratory signs, as well as nonspecific signs of illness, have been reported in pheasants. Guinea fowl may develop clinical signs, but they can also carry velogenic isolates subclinically. Respiratory signs tend to predominate in ostriches and emus, and these birds are usually less severely affected than chickens. Geese and ducks are usually infected subclinically, even with velogenic strains of APMV-1, although there are reports of clinical cases or outbreaks. Reported clinical signs in waterfowl include nonspecific signs such as anorexia, neurological signs, diarrhea, ocular and nasal discharges, decreased egg production, and sudden death.

In psittacine birds, Newcastle disease may be acute, subacute, chronic or inapparent, with highly variable signs that can include respiratory signs (including dyspnea), neurological signs, diarrhea and sudden death. Neurological signs, including talon convulsions, the inability to coordinate flight and numerous other CNS signs, are prominent in raptors. Additional signs reported in captive falcons are inappetence, regurgitation and the excretion of metallic green urates. Some falcons have only nonspecific signs, sometimes accompanied by mucoid-hemorrhagic diarrhea, before they die, and some raptors die suddenly with few or no preceding signs.

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. Neurological signs and deaths were also reported in gulls infected with this virus during some outbreaks. Sick juvenile white pelicans with neurological signs have been seen near affected cormorant colonies; however, it has not been proven that these clinical signs were caused by APMV-1.

PPMV-1 and other viruses in pigeons and doves

Outbreaks caused by PPMV-1 in pigeons vary in severity. Neurological signs with a high mortality rate are

often seen, but some strains can cause kidney disease with initial signs of polyuria, and sporadic cases of neurological disease in the flock. These signs may be preceded by severe drops in egg production. Bloody diarrhea can occur in some birds, and feather development may be abnormal if the infection occurs during molting. Strains of APMV-1 from chickens, including velogenic strains, often cause little or no disease in pigeons, although there have been reports of neurological signs.

Mammals

No clinical signs have been linked to APMV-1 infections in naturally infected mammals, as of 2015, although some of the infected pigs in China were reported to come from sick herds. Most experimentally infected mammals had few or no clinical signs. Mice showed nonspecific signs of illness and significant weight loss, without mortality.

Post Mortem Lesions [Click to view images](#)

Necropsy lesions caused by velogenic APMV-1 viruses have mainly been characterized in poultry, especially chickens. 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 are sometimes found in the caudal pharynx and tracheal mucosa, and diphtheritic membranes may 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. Some birds also have pancreatic necrosis and pulmonary edema. The ovaries are often edematous or degenerated, and may contain hemorrhages. Some birds, particularly those that die suddenly or mainly have neurological signs, have few or no gross lesions.

Similar lesions have been reported in geese, turkeys, pheasants and other birds infected with velogenic strains. In some experimentally infected guinea fowl, the only significant lesions were hemorrhages at the tip of the glands of the proventriculus and in the cecal tonsil.

Diagnostic Tests

Newcastle disease can be diagnosed by isolating APMV-1 from live or recently dead birds. Tracheal and cloacal swabs are usually taken from live birds, although fresh feces may replace cloacal swabs if collecting the latter might harm the bird. Commonly collected tissues at necropsy include spleen, lung, intestines (particularly the cecal tonsil), intestinal contents, liver, kidneys, heart and brain. The OIE also recommends collecting oronasal swabs from the carcass. APMV-1 viruses are usually isolated in embryonated chicken eggs, although cell cultures can also

be used for some viruses. In particular, some PPMV-1 strains can be isolated in cell cultures but not embryonated eggs, and both culture systems should be used when this virus is suspected. The presence of hemagglutinating activity in chorioallantoic fluid from the eggs may indicate that APMV-1 viruses are present, and these eggs can be tested with a hemagglutination inhibition (HI) assay for APMV-1. Some isolates (e.g., cormorant isolates in North America, and some velogenic viruses collected from zoo birds in Iran) do not agglutinate red blood cells. APMV-1 can cross-react with some other avian paramyxoviruses, particularly APMV-3 and APMV-7, in the HI test. A panel of monoclonal antibodies against these viruses can help resolve this issue. Reverse-transcription polymerase chain reaction (RT-PCR) assays are increasingly used to identify APMV-1 in cultures, but these tests do not necessarily detect all strains, including some that are highly virulent. Other molecular tests, such as gene sequencing and restriction enzyme analysis, may also be employed during the identification process.

The pathogenicity of an APMV-1 isolate can be quantified with several different assays. Most velogenic strains have a particular sequence, 112R/K-R-Q/K/R-K/R-R116 (multiple basic amino acids) at the C-terminus of the viral 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 live birds. The intracerebral pathogenicity index (ICPI), which evaluates illness and death in 1-day old chicks, is currently the international standard test. This test generates values from 0 to 2.0; the most virulent viruses approach 2.0, while lentogenic strains usually have a value close to 0.0. The intravenous pathogenicity index (IVPI), which evaluates virulence in 6-week old chickens, and produces values from zero (lentogenic) to 3.0, was also in the past. However, some viruses that cause severe disease in chicken flocks have IVPI values of zero, and this test has generally fallen out of favor. Another test used more often in the past is the mean death time (MDT) in chicken embryos. In this 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. Estimates of virulence for viruses isolated from birds other than chickens (e.g., PPMV-1 from pigeons) may not be accurate when assessed with these assays, including ICPI. There are no standardized tests to evaluate virulence for species other than chickens, but the OIE suggests experimental inoculation with a standard dose of virus, administered by a natural route such as oronasal inoculation.

RT-PCR tests can be used to identify APMV-1 directly in clinical specimens. Tracheal or oropharyngeal swabs are generally the preferred samples, as false negative results are less likely, but tissues and feces can also be employed. In the U.S., a separate RT-PCR test must be used to detect

cormorant isolates, as the standard assay for other velogenic APMV-1 does not recognize these viruses. Similar results have been reported for some other isolates of APMV-1. Other types of molecular tests, such as RT loop-mediated isothermal amplification assays (RT-LAMP), have been described in the literature.

Serological assays may be useful in some circumstances. Hemagglutination inhibition is used most often, but other tests such as virus neutralization, hemagglutination or enzyme-linked immunosorbent assays (ELISA) may be employed. Vaccination or previous exposure to other APMV-1 viruses (e.g., lentogenic strains) can interfere with serological testing.

Additional tests not performed routinely for diagnosis in chickens, such as immunohistochemistry and *in situ* hybridization, may occasionally be employed.

Control

Disease reporting

Veterinarians who encounter or suspect an APMV-1 infection should follow their national and/or local guidelines for disease reporting. In the U.S., state or federal authorities must be notified immediately of any suspected cases of highly virulent (velogenic) Newcastle disease.

Prevention

Good biosecurity can help protect poultry flocks from Newcastle disease. 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 are available from sources in the Internet Resources section of this factsheet.

Similar biosecurity measures can help protect birds kept in zoos or aviaries, or as pets (see Internet Resources). Pet birds should be bought only from suppliers who can certify that the birds have been imported legally or bred in the country, and are healthy. In the U.S., legally imported pet birds have been quarantined and tested for velogenic strains of APMV-1. Domestically raised birds are usually closed-banded. Vendors who are selling large numbers of young birds that belong to difficult-to-raise 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. Illegally imported psittacines should be reported,

because many of them may be carrying velogenic APMV-1. Avian carcasses (of any species) that could be infected with velogenic Newcastle disease should never be fed to raptors, chickens or other birds.

Vaccines are commonly used to protect chickens, pheasants, some exotic birds (e.g., in aviaries or zoos) and other species from Newcastle disease. Vaccines are widely used in regions where velogenic viruses circulate among poultry. Some Newcastle disease-free countries allow vaccination to protect birds from lentogenic strains. Vaccination can protect birds from clinical signs, and may decrease virus shedding and transmission; however, some viruses can spread and/or be maintained in some vaccinated flocks. Although other factors are sometimes involved in poor vaccine efficacy in the field, there have been some concerns about whether the currently available vaccines protect birds adequately against distantly related APMV-1 genotypes. Sentinel chickens are sometimes used to monitor vaccinated flocks.

Outbreaks of Newcastle are eradicated with quarantines and movement controls, depopulation of all infected and exposed birds, thorough cleaning and disinfection of the premises, and other measures (e.g., fly control) as needed. Farms must generally remain empty for a few weeks before restocking; 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.

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 healthy poultry, the mortality rate is approximately 10% for mesogenic strains and negligible with lentogenic strains. However, concurrent illnesses may increase the severity of illness and result in a higher death rate. In contrast, velogenic isolates have morbidity and mortality rates as high as 100% in unvaccinated, fully susceptible chickens. The onset of disease is usually rapid, and the virus often spreads quickly, particularly in group-housed flocks. Outbreaks are sometimes reported in vaccinated birds, with reduced morbidity and mortality rates. In one epidemic mainly affecting vaccinated chickens, flock mortality rates ranged from 30% to 90%.

Other species of birds tend to be less severely affected. 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. Affected pheasant flocks lost 22% to 77% of the birds 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. Variable mortality rates have also been reported in other species, including ostriches and guinea fowl. 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. One virus isolated from an outbreak in ducks in China caused very little mortality in experimentally infected ducks challenged by oronasal inoculation, although severe signs occurred after intramuscular inoculation.

APMV-1 (PPMV-1) is endemic in pigeons and doves in many countries. In these birds, morbidity rates may approach 70% or higher, and mortality rates may be as high as 40% to 100%, depending on the virus, composition of the flock and coinfections with other pathogens. Young birds are more severely affected, and some authors estimate that morbidity is approximately 10% in adult pigeons, with minimal mortality in the absence of coinfections. However, more virulent strains may exist. One strain was reported to cause >70% mortality in healthy, experimentally infected pigeons.

The prevalence of all APMV-1 viruses in wild birds, including lentogenic strains, is often $\leq 5\%$, although it is reported to be higher in some surveys. To date, highly pathogenic strains have been uncommon or absent in most surveys, with the exception of North American cormorants. Outbreaks in this species are reported to only affect young cormorants; adult birds do not appear to develop clinical signs or die. The estimated mortality in juvenile cormorants during several outbreaks ranged from less than 1% to 92%. Up to 90% of juvenile white pelicans near these colonies died in some outbreaks; however, it has not been proven that the disease in pelicans was caused by APMV-1. One study that tested dead birds near outbreaks in cormorants found no evidence that APMV-1 was responsible for deaths in other species, with the exception of some gulls.

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. One report, confirmed by virus isolation, suggested that APMV-1 could cause serious opportunistic infections in people who are severely 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.cdffa.ca.gov/ahfss/Animal_Health/Newcastle_Disease_Info.html

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

United States Animal Health Association. Foreign Animal Diseases
http://www.aphis.usda.gov/emergency_response/downloads/nahems/fad.pdf

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/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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