First confirmed U.S. case of RHD2 found in Medina County

September 25, 2018 Krysten Bennett No comments

On Sept. 19, rabbit hemorrhagic disease virus 2 (RHD2) was detected in a domestic rabbit in Medina County. This is the first confirmed case of RHD2 in the United States. It's important to remember RHD2 **does not pose a threat to humans or other animals**, but is highly fatal in rabbits.

The rabbits at this location were housed in horse stalls and ran free in those stalls. They have been on site for several years and there has been no movement of rabbits on or off the premises recently. The Ohio Department of Agriculture (ODA) will work with state and federal partners to conduct surveillance of wild rabbits near the location.

RHD is a viral disease that causes sudden death in rabbits. It can be spread through contact with infected rabbits, as well as by materials having contact with infected animals. Again, this disease does not affect people or other animals. There are two main types of RHD: RHD1 and RHD2. This is the first detection of RHD2 in the United States. Currently there are no vaccines for use in the U.S. so the best way to protect rabbits is by enhanced biosecurity practices.

The time from infection to first signs of RHD2 disease may be up to nine days. Affected rabbits may develop a fever and die within 12 to 36 hours. Infected rabbits may appear dull and be reluctant to eat;

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have congested membranes around the eyes; show nervous signs, incoordination or excitement; and paddling. Breathing may be difficult, and a blood-stained, frothy nasal discharge may be seen at death. Rabbits shed RHD2 in the urine or feces for as long as four weeks after infection. RHD virus can be spread on contaminated food, bedding, fur and water. Transmission of the RHD virus over short distances can occur by the contaminated clothing of people, biting insects, birds, rodents, wild animals, fur or vehicles.

Although RHD2 does not pose a threat to humans, other animals or the food supply, **it must be reported to state or federal authorities immediately upon diagnosis or suspicion of the disease.** If you suspect cases of the disease, have questions or need more information, please contact ODA Division of Animal Health at (614) 728-6220.

—Tony Forshey, DVM
State Veterinarian and Chief, ODA Division of Animal Health

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Biosecurity Measures for Rabbit Production

UNP-0140

What is Biosecurity?

The potential for disease outbreaks within a rabbitry poses serious threats to animal health and longevity, and the economic viability of a rabbit farm. Because an incident of disease outbreak from just one animal could have adverse effects upon an entire herd, farmers should consider implementing a series of security measures known as *biosecurity*.

Biosecurity is a system of best management practices designed to reduce the introduction of disease. Biosecurity practices are an important aspect of farm and herd health management for operations of any size.

There are two biosecurity level practices among animal production systems:

- ***Primary biosecurity*** practices include preventative screening and measures for visitors, new or returning animals, and equipment or machinery.
- ***Secondary biosecurity*** practices include a working relationship with a veterinarian limiting contact with other animals, animal identification, an isolation area for sick animals, specific handling practices, and monitoring environmental conditions.

Figure 1. It's important to keep rabbitries clean to reduce risk of disease.

Animal producers are advised to implement biosecurity measures that are best suited for their operations.

Potential Sources of Contamination

There are three general sources for health threats to a rabbitry: 1) Physical transference resulting from visitors; 2) biological transference from new, sick, or contaminated rabbits being brought onto a farm; and 3) mechanical transference resulting from equipment, supplies, or machinery being brought on to the farm from another farm or location. The best way to counter health threats is to implement a health management or biosecurity program.

Five key principles of a biosecurity program are:

#1: Isolation

- Make sure areas around a rabbitry are clean to discourage the habitation of other animals or insects that may present the threat of transference of disease.
- Maintain an isolation facility and equipment for newly acquired animals and sick animals. This practice allows you to assess the health status of new animals, and to evaluate and treat animals with health issues.

- Sanitize shoes and wash clothes after visiting another rabbitry.
- Make sure that dead animals are buried in a secure location to prevent other animals from accessing their carcasses.

#2: Traffic Control

- Keep your premise secure from unauthorized visitors. Whether innocent or intentional, visitors have the potential to harbor disease on or under their shoes, hands, clothing, or hair.
- Inspect and require authorized visitors to sanitize their footwear or wear protective footwear covers. This may require protective clothing and hair covering as well.
- Limit random traffic near animal facilities. You may want to establish sanitization methods for vehicle tires that have visited other rabbitries.
- Utilize sanitization methods for newly introduced or returning equipment and cages that may have come in contact with other rabbitries.

#3: Sanitation Maintenance

- Practice routine prevention maintenance and disinfection such as cleaning and disinfecting nest boxes in between litters, as well as cages, watering devices, and feeders following the removal of any rabbit for any reason.
- Take time to scrape off organic matter that remains attached to cages including burning off hair. Be sure to do this in a safe location removed from the rabbitry and any loose material.
- Sanitize the actual rabbitry structure as time allows.
- Wash hands, clothing, and head coverings after visiting a rabbitry.
- Sanitize the sole and outside of shoes, or wear protective footwear covers.
- Learn to utilize latex or rubber gloves when appropriate, such as when handling sick animals.
- For commercial operations, have a designated and remote location that allows you to sanitize empty rabbit transport cages prior to being set-up near your rabbitry. Ideally, cages are sanitized at several points throughout the pick-up and delivery process of marketing.
- Allow for proper drainage of urine and excessive water that may harbor diseases.
- Remove manure and other debris (hay and litter) that accumulates under the cages since they retain moisture and serve as a breeding ground for diseases, including eye or lung irritants.
- As a post clean-up measure, spread hydrated lime under the cages to reduce odor and to modify the pH balance of urine and manure so that it decomposes quicker.

Figure 2. Disease can be transported from one farm to another via foot traffic, truck and trailer tires, and transport cages that are not sanitized in between farm visits.

#4: Handling Practices

- The approach of handling healthy animals first and sickly animals last minimizes exposure and transmission of disease from contaminated to healthy animals. The same approach should be utilized for different age groups of animals. For example, handle young animals first and then older animals. Adult animals are more likely to have developed immunities or tolerances to diseases

that younger animals are more susceptible to.

#5: Observation

- Try to observe animals when they are healthy so that you will be able to quickly identify unusual behavior resulting from possible health issues.
- Become familiar with disease symptoms to insure a quick response, isolation, and treatment if rabbits become sick. Disease symptoms may include lethargic behavior, lack of appetite, diarrhea, nasal or eye discharge, gasping for air, and twisting of neck or head.

Potential Disease & Ailment Concerns

Here is a list of the most common ailments that occur among rabbits. **Note:** Rabbit owners are encouraged to consult a veterinarian for diagnosis and treatment.

- ***Sores or cankers*** inside or around the ears indicate the presence of ear mites that have established themselves within the ears of a rabbit. The rabbit will frequently shake its head and scratch at its ears. Treatment will be necessary over several days, but can be easily treated by rubbing a coating of mineral oil within the entire ear. The cage or general area may need to be dusted or sprayed with the appropriate treatment.
- ***Coccidiosis*** is a parasitic disease of the intestinal tract that results from rabbits excessively licking their dirty feet or coats, or by eating or drinking contaminated food and water. Maintaining clean cages, resting pads, and feed or water vessels are an ideal form of preventative maintenance. Symptoms can include diarrhea and rapid weight loss. If untreated, the infected animal will dehydrate and die. Young and elderly rabbits are most vulnerable. Temporarily reducing access to grain feed and increasing provision of hay is one home remedy. Another is the provision of pellets containing coccidiostats or the introduction of liquid coccidiostats into the water of the affected animal.
- ***Cold*** symptoms include occasional sneezing and nasal discharge. Colds are usually not a serious threat to the animal, but isolation is necessary to eliminate exposure to other rabbits.
- ***Conjunctivitis*** (Pinkeye) is an inflammation of the eye caused by bucks spraying urine, draughts, ammonia fumes, or a dusty atmosphere. An eye ointment available from a veterinarian can easily treat this disease.
- ***Heat stress*** symptoms include rapid panting and the rabbit lying in a prostrate position that is caused by excessive temperatures and lack of air flow. Establishing a ceiling fan or a box type fan that moderately moves area across the cage and not directly on the rabbit is a good practice during summer months. For immediate results, try placing a plastic bottle with frozen water inside the cage. Allow the rabbit to lie next to the cold bottle to help lower its body temperature.
- ***Mastitis*** is an inflammation of the milk glands that often results from injuries (scrapes or abrasions) to the teats. Symptoms include a swelling, warm feeling, and hardness of the teat or teats. A veterinarian can recommend the appropriate antibiotics.
- ***Mucoid enteritis*** occurs when there is a change in a rabbit's diet or it undergoes a stressful event. Symptoms include bloating, scouring, and rapid weight loss. This disease is very painful to rabbits and may cause them to grind their teeth and exhibit other signs of pain. Extreme diarrhea

Figure 3. Note water in background, flooding situations have the potential to bring in biohazard contaminants.

may also occur with a mucus-like consistency. Remove all pelleted feed for a few days and provide hay and abundance of water. After a few days pelleted food can be slowly reintroduced.

- ***Paralysis*** symptoms include lack of or limited movements of the hindquarters that is likely the result of an injury such as a rabbit excessively impacting the wall of its cage due to some type of external stress (predator animals), fighting with another rabbit, or being dropped. There is generally no treatment, and if paralysis continues for more than several days the animal may need to be euthanized.
- ***Pasteurellosis*** (snuffles) symptoms include a white discharge from the nose caused by excessive sneezing. Causes include excessive stress, poor ventilation, or excessive dust or ammonia vapors (from excessive accumulation of urine below cages) that irritate the trachea, sinuses, and lungs. Snuffles is a highly contagious disease and if untreated, may be incurable and even fatal.
- ***Torticollis*** (wryneck) symptoms include the head being tilted to one side, as the result of muscle spasms. Wryneck is caused by a widespread protozoal infection in the inner ear, nerves, brain, or a combination of sites. At this time there are no well-determined treatments. The animal may need to be terminated.

Conclusion

Livestock managers are encouraged to implement the three Bs of biosecurity: *be observant, be proactive*, and *be diligent*. By establishing biosecurity measures and becoming more familiar with diseases that commonly afflict rabbits, rabbit owners will be able to prevent and to work more effectively with a licensed veterinarian to diagnose and to treat diseases.

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Rabbit Hemorrhagic Disease

Viral Hemorrhagic Disease of Rabbits, Rabbit Calicivirus Disease

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Importance

Rabbit hemorrhagic disease is a serious and extremely contagious viral disease of domesticated and wild rabbits. Morbidity and mortality rates are high in unvaccinated animals; on some farms, most or all of the rabbits may die. This disease has also caused dramatic declines in some wild rabbit populations, particularly when it is first introduced. This has had a detrimental effect on some ecosystems in Europe, where wild rabbits are an important food source for certain endangered predators, such as Iberian lynx (*Lynx pardinus*). Conversely, rabbit hemorrhagic disease has been used to help control excessive numbers of wild, non-native European rabbits (*Oryctolagus cuniculus*) in Australia.

The origins of rabbit hemorrhagic disease are not completely understood. The causative virus, rabbit hemorrhagic disease virus (RHDV), may have emerged from avirulent caliciviruses that circulate asymptomatically in European rabbits. The first known outbreak occurred in China in 1984, apparently spread by Angora rabbits that had been imported from Europe. Within 9 months, this disease had killed 14 million domesticated rabbits in China. By the late 1990s, outbreaks had been reported from forty countries, and rabbit hemorrhagic disease had become endemic in a number of areas throughout the world. Other regions, including the Americas, have experienced periodic outbreaks in domesticated rabbits. However, the species of wild rabbits found in North America are not susceptible to these RHD viruses, which facilitates eradication.

A new variant called RHDV2 emerged in Europe in 2010, and has spread widely among domesticated and wild rabbits there. This virus has also been found in Australia. RHDV2 affects animals vaccinated against older RHD viruses, as well as unvaccinated rabbits. It can also cause illness in some species of hares. Whether RHDV2 could affect any wild North American lagomorphs is not yet known.

Etiology

Rabbit hemorrhagic disease is caused by rabbit hemorrhagic disease virus (RHDV), a member of the genus *Lagovirus* and family Caliciviridae. There are many strains of RHDV, and three major viral subtypes: RHDV ("classical RHDV"), the antigenic variant RHDVa, and the recently emerged virus RHDV2 (also called RHDVb). Classical RHDV and RHDVa comprise one serotype, while RHDV2 belongs to a different serotype.

Related lagoviruses, called rabbit caliciviruses, circulate in healthy rabbits. These viruses can confer varying degrees of cross-protection to RHDV. While most rabbit caliciviruses do not appear to cause any illness, two potentially pathogenic strains have been reported. One virus identified in the U.S. (proposed name "Michigan rabbit calicivirus") was isolated from an outbreak that resembled rabbit hemorrhagic disease, although an attempt to reproduce the disease in experimentally infected rabbits resulted in little or no illness. A related strain, the Ashington strain of rabbit calicivirus, was recovered from dead wild rabbits during an outbreak in Europe.

Species Affected

RHDV primarily or exclusively affects wild and domesticated European rabbits (*Oryctolagus cuniculus*). Other lagomorphs generally seem to be unaffected by classical RHDV/RHDVa. Species reported not to be susceptible to these viruses include European brown hares (*Lepus europaeus*), varying (snowshoe) hares (*Lepus americanus*), cottontails (*Sylvilagus floridanus*), black-tailed jackrabbits (*Lepus californicus)* and volcano rabbits (*Romerolagus diazzi*). However, classical RHDV was recently found in dead wild Iberian hares (*Lepus granatensis*) that had been collected during an outbreak in the 1990s. Rodents are the only animals, other than lagomorphs, known to be infected by RHDV; viral RNA was found in the internal organs of wood mice (*Apodemus sylvaticus*) and Algerian mice (*Mus spretus*) collected near warrens that contained infected wild rabbits. There has been no evidence of virus replication in any other mammals examined or tested in the laboratory, including rabbit predators, although some animals did seroconvert.

RHDV2 seems to have a broader host range among lagomorphs. In addition to

European rabbits, it is known to affect the Cape hare (*Lepus capensis* var. *mediterraneus*) and Italian hare (*Lepus corsicanus*). Epidemiological observations suggest that it probably has little or no effect on European brown hares.

Zoonotic potential

There is no indication that RHDV infects humans.

Geographic Distribution

Rabbit hemorrhagic disease is endemic in Australia, New Zealand, Cuba, parts of Asia and Africa, and most of Europe. The viral subtypes circulating in each region can differ. As of 2016, RHDV2 has been found in a number of European countries and Australia.

RHDV is not thought to be established in North America, where *O. cuniculus* does not occur in the wild. Outbreaks were reported among domesticated rabbits in the U.S. in 2000 (Iowa), 2001 (Utah, Illinois, New York), 2005 (Indiana), 2008 (Maryland) and 2010 (Minnesota). In some cases, only a single facility or household was affected. The origins of these viruses could not be traced; however, different viruses were involved in each outbreak, and they were thought to have come from outside North America. In 2011, a clinical case occurred in Canada, in one of three rabbits that had been housed indoors for more than a year. The source of this virus is also unknown, although various hypotheses (i.e., reactivation of a persistent infection, emergence from a nonpathogenic calicivirus or transmission from an unknown source on fomites or insects) have been proposed. RHDV was endemic in domesticated rabbits in Mexico from the late 1980s to 1991, but it was eventually eradicated. This disease was also reported from domesticated and wild rabbits in Uruguay in 2004; however, Uruguay ceased vaccination for this disease in 2007, and declared itself free of RHDV to the World Organization for Animal Health (OIE) in 2012.

"Michigan rabbit calicivirus" has been reported in only one outbreak, which occurred in a single Michigan (U.S.) rabbit facility in 2001.

Transmission

RHDV can be transmitted by direct contact with live or dead animals, as well as on fomites. These viruses can enter the body through the oral, nasal or conjunctival routes, although oral transmission is thought to predominate. Most or all secretions and excretions, including urine, feces and respiratory secretions, are thought to contain virus, and RHDV can remain viable in carcasses for long periods. Even rabbit fur alone can be infectious. Surviving animals can continue to shed RHDV for at least a month after they recover. Long-term persistence of viral RNA has been reported in rabbits for at least 15 weeks, but whether this represents true persistence or slow virus clearance is still uncertain. Viral antigens or infectious virus have not been detected in these animals, even in laboratory experiments where they were immunosuppressed.

RHDV is readily spread on fomites including contaminated food, bedding and water. Insects can transmit this virus long distances. Flies are very efficient mechanical vectors; infectious virus can persist in flies for up to 9 days, and only a few virions are needed to infect a rabbit by the conjunctival route. Viruses can also be deposited on vegetation in fly feces or regurgita, then eaten by a rabbit. Fleas and mosquitoes could transmit RHDV mechanically in the laboratory. Mechanical transmission has also been demonstrated in birds and mammals, which can excrete infectious RHDV in feces after eating infected rabbits.

RHDV is very resistant to inactivation when it is protected within tissues. This virus can survive for 7.5 months in tissue suspensions stored at 4°C (39°F), and for more than 3 months in dried organ homogenates at 20°C (68°F). In one study, RHDV remained viable in decomposing rabbit carcasses kept at 22°C (72°F) for up to 20 days, but there was insufficient infectious virus after 26 or 30 days to cause clinical signs in rabbits. However, virus-inoculated bovine liver left to decompose in New Zealand fields (to simulate infected carcasses) remained infectious for at least 3 months. Unprotected viruses shed in excretions are not thought to remain viable for more than a few weeks, and may lose some of their infectivity within one to two weeks. RHDV is also reported to survive exposure to pH 3.0, heat of 50°C (122°F) for an hour, and freeze-thaw cycles.

Disinfection

RHDV can be inactivated with 10% sodium hydroxide or 1-2% formalin. Other disinfectants that have been suggested include 2% One-stroke Environ® (Vestal Lab Inc., St. Louis, MO) and 0.5% sodium hypochlorite (10% household bleach). This virus resists degradation by ether or chloroform.

Incubation Period

The incubation period is reported to be 1-3 days for classical RHDV/RHDVa and 3-9 days for RHDV2 in experimentally infected rabbits.

Clinical Signs

Classical RHDV/ RHDVa

In rabbits less than 4-8 weeks of age, RHDV/ RHDVa infections are usually subclinical. However, some young rabbits may have elevated temperatures, and subclinical signs of liver disease were noted in experimentally infected 4-week-old rabbit kittens. Deaths have also been reported, though rarely. In a recent study, experimentally infected 4-week-old rabbits died rapidly if they were immunosuppressed with corticosteroids.

Peracute and acute disease are the most common syndromes in older rabbits. In peracute cases, infected rabbits develop a fever and die suddenly within 12 to 36 hours of its onset. The only clinical signs may be terminal squeals followed rapidly by collapse and death. Animals with the

acute form survive somewhat longer, with signs of dullness/ apathy, anorexia, congestion of the conjunctiva, and/or prostration. These animals may also develop neurological signs, such as incoordination, excitement, opisthotonos and paddling. Some rabbits turn and flip quickly in their cages; this can resemble convulsions or mania. There may also be respiratory signs (e.g., dyspnea, cyanosis and a terminal, bloodstained, frothy nasal discharge), lacrimation, ocular hemorrhages or epistaxis. Animals that survive longer can develop a subacute form with severe jaundice, accompanied by weight loss and lethargy, and die in a few weeks. These animals may have diarrhea or constipation and abdominal dilatation just before death. A small number of adult rabbits can have milder signs, with a higher survival rate, or are infected subclinically. Rabbits with persistent viral RNA were apparently healthy.

Iberian hares infected with classical RHDV were found dead, but had lesions consistent with a disease caused by a lagovirus (see Postmortem Lesions, below).

RHDV2

RHDV2 affects young rabbits as well as older animals; clinical cases have been reported in rabbits as young as 11 days of age. The clinical signs are similar to the illness caused by RHDV/ RHDVa; however, experimentally infected rabbits generally survived longer, and peracute or acute cases were less common. A captive Italian hare infected with RHDV2 had no clinical signs other than epistaxis before death. Wild Cape hares infected with this virus were found dead.

Michigan rabbit calicivirus

An outbreak caused by Michigan rabbit calicivirus was characterized by acute fatalities over a 3-week period. The initial signs were vulvar hemorrhages in pregnant does, and inappetence in some animals, Additional clinical signs included epistaxis, ataxia, opisthotonos, diarrhea, ocular discharge, vocalizations and death. Clinical signs were rare and mild (transient decreases in activity, inappetence) in rabbits experimentally infected with this virus.

Post Mortem Lesions

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RHDV, RHDVa and RHDV2 cause similar lesions in European rabbits. Animals that die are usually in good condition. The primary lesion is hepatic necrosis, and the most consistent post-mortem lesions are hepatic necrosis and splenomegaly. The liver may be pale, with a fine reticular pattern of necrosis outlining each lobule. In cases with extensive necrosis, the liver can be diffusely pale. It may also be yellow, gray, friable or congested. The spleen is usually black and engorged, with rounded edges. The kidneys may be very dark brown. Disseminated intravascular coagulation (DIC) is common in the terminal stages of disease, and results in hemorrhages in a variety of organs and tissues. The trachea is often hyperemic and contains frothy, bloodstained mucus. Congestion and multifocal hemorrhages may be seen in the lungs. Hemorrhages are also common in the thymus, and petechiae may be found on the serosal membranes or viscera. Infarcts may be seen in most organs. Hemorrhages are not necessarily present in rabbits euthanized before the terminal stage. Catarrhal enteritis of the small intestine and icterus may be evident in subacute cases. Congestion of the meninges has been reported.

The lesions in Cape hares infected with RHDV2 were suggestive of European brown hare syndrome (a rabbit disease caused by a different lagovirus), and included a pale liver (with microscopic lesions of massive necrosis, moderate mononuclear inflammatory infiltrate and little fatty degeneration), an enlarged spleen, and congestion of the other parenchymal organs. The lesions in a single Italian hare were severe pulmonary and tracheal edema with profuse foamy exudate, profuse hemorrhages, and congestion and slight enlargement of the liver. Iberian hares infected with classical RHDV had hemorrhagic lesions and congestion of the liver, lungs and other internal organs.

Rabbits naturally infected with Michigan rabbit calicivirus had hemorrhagic lesions, conjunctival congestion, icterus, and liver lesions consistent with rabbit hemorrhagic disease. Nonspecific signs of hepatic injury were found in the surviving animals. Experimentally infected rabbits did not develop any gross lesions, although rare hepatocellular necrosis was noted in the liver of some animals on histopathologic examination.

Diagnostic Tests

RHDV cannot be grown in cell culture (for virus isolation); however, rabbit hemorrhagic disease can be diagnosed by detecting viral nucleic acids and/or antigens in tissues, secretions/excretions and blood. Electron microscopy may also be helpful. The liver contains the highest viral titers in acute or peracute disease, and is the best organ to submit for virus identification. Viruses may also be abundant in the blood and spleen. When the course of the disease has been prolonged, RHDV (in the form of a virus-like particle) may be easier to find in the spleen than the liver.

Reverse transcription polymerase chain reaction (RT-PCR) tests are used most often for diagnosis. RT-PCR assays have been developed for all of the viral subtypes, although the availability of RHDV2 tests may vary between laboratories. Viral RNA can be found in many organs (especially the liver), as well as in blood, urine and feces. It may be detectable in some convalescent rabbits for a prolonged period. Other methods to detect viral RNA include reverse-transcription loop-mediated isothermal amplification (RT-LAMP) assays, which have been described in the literature, and *in situ* hybridization, which is mainly used in research.

Viral antigens are often detected with enzyme-linked immunosorbent assays (ELISAs), and these assays can also be used to type the virus. Other antigen detection tests include immunostaining, immunoblotting (Western blotting)

and negative-staining immunoelectron microscopy. A hemagglutination test can also be employed, but it is less sensitive and specific than other assays, and has generally been replaced by ELISAs. Nonpathogenic rabbit caliciviruses may cross-react with RHDV, depending on the specificity of the test.

Antibodies can be found in convalescent rabbits with ELISAs or hemagglutination inhibition. Nonpathogenic rabbit caliciviruses can complicate serological diagnosis.

Animal inoculation into rabbits may be used occasionally, for instance to help identify cases that have not been definitively diagnosed by other tests.

Treatment

Treatment is currently limited to supportive care. Passively acquired immunity (hyperimmune antiserum) can protect animals that have not yet developed clinical signs, but it is reported to be ineffective in symptomatic rabbits.

Control

Disease reporting

A quick response is vital for containing outbreaks in disease-free regions. Veterinarians who encounter or suspect rabbit hemorrhagic disease should follow their national and/or local guidelines for disease reporting. In the U.S., state or federal veterinary authorities should be informed immediately.

Prevention

Uninfected countries may place restrictions on the importation of live rabbits, meat and other rabbit products (e.g., Angora wool) from endemic areas. Strict quarantines are necessary if an outbreak occurs. RHDV is extremely contagious; it can be transmitted on fomites and by insects, birds and scavenging mammals. Carcasses are infectious, and must be removed immediately and disposed of safely. The virus can sometimes be eradicated by depopulation, disinfection of infected premises, surveillance and quarantines; however, eradication is generally impossible if the virus becomes established in wild rabbit populations. Infected farms should not be restocked immediately, as RHDV can persist for a time in the environment. Sentinel rabbits can be used to monitor premises for persistent viruses.

In regions where RHDV circulates in wild rabbits, domesticated rabbits are protected with biosecurity measures including separation from wild rabbits, sanitation and disinfection, and vaccination. Maintaining closed colonies can help prevent the virus from entering the premises. Where new stock is introduced, quarantining them initially is prudent.

Vaccines are now available for RHDV2 as well as RHDV/ RHDVa; there is limited or no cross-protection between these two groups of viruses. Because the production cycle is short, commercial rabbit farms may only vaccinate breeding animals if rabbit hemorrhagic disease has not been reported in the area. However, all animals should be vaccinated if an outbreak has occurred, as the likelihood of infection is high even with strict sanitation and other control measures. Vaccination may also be useful as post-exposure prophylaxis, as immunity to RHDV usually develops in approximately 7-10 days. Sentinel animals can be used to monitor vaccinated farms for RHDV.

Morbidity and Mortality

Reported morbidity rates in rabbits infected with classical RHDV/ RHDVa range from 30% to 100%, and the mortality rate is 40-100%. The highest morbidity and mortality rates occur in adult rabbits from naïve populations. Clinical cases may be sporadic in some situations where rabbits are well separated from each other (e.g., some research environments). Rabbit kittens are resistant to illness caused by classical RHDV/RHDVa, and fatalities are rare in animals < 4 weeks of age. Rabbits lose this resistance between 4 and 12 weeks of age.

Variable mortality rates ranging from 5% to 70% have been reported for RHDV2. The average mortality was 20% in experimentally infected rabbits, and in general, this virus is thought to be less virulent than classical RGDV/RHDVa. However, some severe natural outbreaks have been seen. During the initial outbreaks in Australia, which occurred in rabbits vaccinated against RHDVa, the apparent morbidity rate was 44%, with a mortality rate of 37.5%, and case fatality rate of 86%. Young rabbits do not appear to be resistant to RHDV2. Most sources state that clinical cases occur in animals 2-3 weeks of age or older, and 11-day-old kittens were affected in one outbreak. During the initial outbreaks in Spain, mortality rates as high as 50% were seen in young rabbits.

Rabbits that survive rabbit hemorrhagic disease become resistant to related strains. Exposure to nonpathogenic rabbit caliciviruses may also provide some degree of resistance, although cross-protectivity seems to vary depending on the virus. In wild *O. cuniculus* rabbits, outbreaks can be seasonal. In some populations, classical RHDV/RHDVa outbreaks have been associated with the breeding season, with the virus spreading in young rabbits as they lose their age-related protection. In Europe, classical RHDV/RHDVa caused dramatic declines in wild rabbit populations in Spain, Portugal and France, but wild rabbits in the U.K. and some other northern European countries have been less severely affected. In some areas, rabbit populations may recover, and initial high morbidity and mortality rates may be followed by sporadic, less severe outbreaks. RHDV2 has also resulted in extensive outbreaks among wild rabbits in some areas. Epidemics in wild rabbits can lead to outbreaks in domesticated rabbits.

There is relatively little information yet about the effects of RHDV2 on hares. A single case has been reported, to date, in Italian hares. Other nearby hares, including a cage-mate, were unaffected and did not

seroconvert. This suggests that this species might be relatively resistant to infection. However, fatal illness was confirmed in several wild Cape hares during an outbreak in rabbits.

Most rabbit caliciviruses are thought to infect lagomorphs subclinically, but the mortality rate was 32.5% in an outbreak caused by Michigan rabbit calicivirus. All of the affected rabbits were older than 8 weeks. In one study, this virus caused no deaths and few signs of illness in experimentally infected rabbits.

Internet Resources

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

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

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
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