# CIRCOVIRUSES



## *AETIOLOGY*

### *Classification of the causative agent*

Circoviruses infect swine, canine, mustelid, and avian species. They are part of the *Circoviridae* family and *Circovirus* genus. They are non-enveloped, circular, single-stranded DNA viruses. Most infections in both wild and domestic species are subclinical. However, circovirus infections are responsible for severe pathology in commercial swine operations. These viruses cause a range of gastrointestinal, neurological, dermatological, and respiratory signs in their hosts, and are most apparent in young animals. They are often found in conjunction with other pathogens in many species.

### *Resistance to physical and chemical action*

Temperature: Inactivated at 80°C for 1 hour

pH: Stable at pH 3-9

Chemicals/Disinfectants: inactivated by iodine, 1% glutaraldehyde, 0.4% beta-propiolactone, or 10% sodium hypochlorite

Survival: Able to survive in the environment for extended periods of time

## *EPIDEMIOLOGY*

There are numerous circoviruses that affect both domestic and wild animal species, but only the most pertinent species are discussed in this technical card. This is not an exhaustive list of the potential species affected. In general, circoviruses appear to be species-specific. For example, there are distinct circoviruses that infect ostriches (*Struthio* spp.), finches (family *Fringilidae*), canaries (*Serinus* spp.), laughing doves (*Spilopelia senegalensis*), and ducks (family *Anatidae*).

### *Hosts*

- Beak and feather disease virus (BFDV)
    - Psittacines (*Psittaciformes*)
        - Cockatoos
            - Gang-gang cockatoos (*Callocephalon fimbriatum*)
            - Little corellas (*Cacatua sanguinea*)
            - Long-billed corellas (*Cacatua tenuirostris*)
            - Major Mitchell's cockatoos (*Cacatua leadbeateri*)
            - Sulphur-crested cockatoos (*Cacatua galerita*)
            - White cockatoos (*Cacatua alba*)
        - Parrots
            - African grey parrots (*Psittacus erithacus*)
            - Budgerigars (*Melopsittacus undulatus*)
            - Cape parrots (*Poicephalus robustus*)
            - Crimson rosellas (*Platycercus elegans*)
            - Eclectus parrots (*Eclectus roratus*)
            - Lovebirds (*Agapornis* spp.)
            - Mauritius parakeets (*Psittacula echo*)
            - Orange-bellied parrots (*Neophema chrysogaster*)
            - Rainbow lorikeets (*Trichoglossus moluccanus*)

        - Red-rumped parrots (*Psephotus haematonotus*)
        - Swift parrots (*Lathamus discolor*)
- Canary circovirus (CaCV)
    - Common canaries (*Serinus canaria*)
- Canine circovirus (DogCV)
    - Domestic canines (*Canis lupus familiaris*)
    - European badgers (*Meles meles*)
    - Red foxes (*Vulpes vulpes*)
    - Wolves (*Canis lupus*)
- Fox circovirus (FoCV)
    - Red foxes (*Vulpes vulpes*)
- Goose circovirus (GoCV)
    - Geese (*Anser* spp.)
- Gull circovirus (GuCV)
    - Kelp gulls (*Larus dominicanus*)
    - Ring-billed gulls (*Larus delawarensis*)
- Pigeon circovirus (PiCV)
    - Rock pigeons (*Columba livia*)
- Porcine circovirus 1, 2, and 3 (PCV1-3)
    - Domestic swine (*Sus scrofa domesticus*)
    - Wild boars (*Sus scrofa*)

## *Transmission*

- Avian circoviruses
    - Ingestion or inhalation of contaminated viral particles (faeces, feather dust)
    - Ingestion of crop milk (PiCV)
    - Ingestion of regurgitated food (BFDV)
    - Vertical transmission
- DogCV
    - Faecal-oral route
- Porcine circoviruses
    - Ingestion or inhalation of excreta, including faeces, urine, saliva, and ocular, nasal, and bronchial secretions
    - Vertical transmission

## *Sources*

- Avian circoviruses
    - Feather dust
    - Faeces
    - Regurgitated food (BFDV)
    - Crop milk (PiCV)
- DogCV
    - Faeces
- Porcine circoviruses
    - Excreta

## *Occurrence*

BFDV causes the most common disease of wild psittacines in Australia. The virus has been isolated from wild birds in Australia, New Zealand, and Africa. All psittacine species are thought to be susceptible to infection with BFDV. The worldwide spread of BFDV is thought to be due to the exotic bird trade. PiCV has been reported in Europe (Ireland, Germany), Australia, and North America (United States), and only has been found in pigeons. It is not often documented in wild pigeons. CaCV has been reported in canary aviaries in the United States and Italy. GuCV has been found in wild gulls from New Zealand, Canada, Netherlands, and Sweden. GoCV has been reported in farmed geese from Europe (Hungary, Germany) and Taiwan.

PCV2 has a worldwide distribution in swine operations. Reports of PCV2 in wild boar have come from Europe (Spain, Belgium, Italy, Germany, Czech Republic), the Republic of Korea, North America, and captive wild boars in Brazil. PCV3 has been found in swine operations in Germany, China, Russia, Thailand, Italy, Spain, Denmark, the Republic of Korea, Brazil, Sweden, the United States, Japan, and Poland. Recently, PCV3 was reported in wild boars in Italy.

DogCV has been found in domestic dogs in Europe (Italy, Germany), China, Taiwan, Argentina, and the United States. It has also been detected in wild canids in Italy.

**For more recent, detailed information on the occurrence of this disease worldwide, see the OIE World Animal Health Information System - Wild (WAHIS-Wild) Interface [http://www.oie.int/wahis_2/public/wahidwild.php/Index].**

## *DIAGNOSIS*

Circoviruses can cause their hosts to become immunocompromised; animals often present with secondary co-infections.

The majority of BFVD infections occur in psittacines less than 3 years of age. The incubation period of the virus can last from 3 weeks to 1 year. While GoCV has only been found in captive geese, a large percentage have antibodies to GoCV and wild geese may be at risk for infection if there is mixing of wild and captive geese. If there are large die-offs of gulls in the wild, GuCV should be among the differential diagnoses. PiCV mostly affects squabs less than one year old.

There is a collection of diseases associated with PCV2, known as porcine circovirus-associated disease (PCVAD). The collection of diseases include PCV2 systemic disease (PCV2-SD), reproductive failure, interstitial pneumonia, and porcine dermatitis and nephropathy syndrome (PDNS). PCV2-SD used to be known as postweaning multisystemic wasting syndrome (PMWS). PCV3 has also been associated with PDNS and reproductive failure. Swine may be co-infected with porcine reproductive and respiratory syndrome (PRRS) or porcine parvovirus. The incubation period of PCV2 is approximately 2 weeks; most pathology occurs in pigs who are 2-4 months old. In domestic swine, PCV2-associated reproductive failure has mostly been reported in new swine operations with new gilts. PCV1 is not pathogenic in swine.

Dogs infected with DogCV have also been found to have canine parvovirus-2 (CPV-2) and canine distemper virus (CDV).

### *Clinical diagnosis*

Most BFDV infections are subclinical or mild. Clinical signs of BFDV infection include feather loss, abnormal feather growth and development, and a non-regenerative anaemia. The beak may become shiny, overgrown, broken, or delaminated. Feathers may become constricted, clubbed, or stunted; mature feathers may have blood in the shaft. Other clinical signs include stunted growth and wasting, with immunosuppression resulting in secondary infections such as salmonellosis and aspergillosis. CaCV causes high mortality rates in young canaries. The abdomen becomes large and translucent, and the gallbladder becomes congested and is visible through skin. Clinical disease is also known as “black spot disease”. It may also cause lethargy, anorexia, and feather loss. PiCV results in ill thrift, diarrhoea, and upper gastrointestinal signs.

Pigs with PCV2-SD present with clinical signs of weight loss, palor, jaundice, anaemia, diarrhoea, inguinal lymphadenopathy and fever (40-41°C). The disease can result in death or develop into a chronic disease characterised by ill thrift. Generally, the only clinical sign associated with PCV2-SI is growth retardation. In sows, PCV2-RD is characterised by late-term abortions and stillbirths. PDNS causes renal failure, anorexia, stiff gait, depression, and prostration. Cutaneous lesions include reddish-purple macules and papules on the perineum and hindlimbs, which may spread over the entire body.

Red foxes infected with FoCV have been observed with central nervous system signs, including encephalitis. Other canids infected with the virus have presented with diarrhoea with or without frank blood, anorexia, and vomiting.

### *Lesions*

- BFDV
    - Palatine necrosis of beaks
    - Leukopoenia
    - Basophilic and botryoid intracytoplasmic inclusion bodies in follicular epithelium (pathognomonic for the virus)
    - Inclusions in cloacal bursa epithelium and macrophages due to phagocytosis
        - Inclusions are characterised as semicircles, circles, or paracrystalline arrays of 14-16 nm viral particles
    - Necrosis and inflammation in dystrophic feathers
    - Lymphocyte depletion
- CaCV
    - Necrosis
        - Bursa of Fabricius
        - Epithelium of developing feathers
        - Oral mucosa
    - Presence of viral particles in several organs (e.g. lymph nodes)
- PiCV
    - Botryoid, basophilic intracytoplasmic inclusions in lymphoid tissue, particularly in the bursa of Fabricius
    - Same inclusions as for BFDV along with necrosis or histiocytosis
    - Atrophy of bursa of Fabricius
- DogCV
    - Necrotising vasculitis
    - Granulomatous inflammation of Peyer's patches and intestinal crypts
    - Lymphadenitis
    - Lymphoid necrosis
- Porcine circoviruses
    - PCV2-associated reproductive failure (foetal lesions)
        - Congestion of liver
        - Myocardial discoloration
        - Fibrosing or necrotising myocarditis
        - Lymphocytic or lymphohistiocytic myocarditis
        - Presence of PCV2 virions in heart
    - PCV2-SD
        - Lymphocyte depletion with histiocytic infiltration of lymphoid tissues
            - May include multinucleated giant cells and botryoid intracytoplasmic inclusion bodies
        - Large, pale lymph nodes
        - Small thymus
        - Splenic infarcts
        - Lymphohistiocytic interstitial pneumonia
        - Granulomatous bronchointerstitial pneumonia with bronchiolitis and bronchiolar fibrosis
        - Atrophic and icteric liver
        - Enlarged kidneys with diffuse, white foci of lymphohistiocytic infiltration
        - Multifocal lymphohistiocytic myocarditis
    - PDNS
        - Kidneys
            - Firm, swollen, and pale kidneys
            - Vasculitis and cortical petechiae
            - Oedema of renal pelvis
            - Necrotising and fibrinous glomerulonephritis

            - Interstitial nephritis and renal tubular necrosis
        - Skin
            - Dermal haemorrhage
            - Epidermal necrosis
            - Leukocytoclastic necrotising vasculitis of dermal and hypodermal capillaries and arterioles
        - Enlarged lymph nodes
        - Mild lymphocyte depletion with histiocytic infiltration of lymphoid tissues

## *Differential diagnoses*

- BFDV
    - Endocrinopathy
    - Feather folliculitis
    - Metabolic imbalance
    - Nutritional deficiency
    - Polyomavirus
    - Behavioral/stressed-induced feather-picking
- DogCV in dogs or wolves
    - Canine adenovirus
    - Canine coronavirus
    - Canine distemper virus
    - Canine hepatitis virus
    - Canine influenza virus
    - Canine parvovirus
- DogCV or FoCV in red foxes
    - Canine adenovirus
    - Canine distemper virus
    - *Neospora caninum*
    - Rabies
    - Tick-borne encephalitis virus (TBEV)
    - *Toxoplasma gondii*
- PCV2
    - Piglets
        - Chronic respiratory disease
        - Glässer's disease
        - Porcine reproductive and respiratory syndrome (PRRS)
        - Porcine intestinal adenomatosis
        - Salmonellosis
    - Sows and gilts
        - Leptospirosis
        - Porcine parvovirus
        - Porcine reproductive and respiratory syndrome (PRRS)
        - Pseudorabies
- PDNS
    - Skin and kidney lesions
        - *Actinobacillus suis*
        - African swine fever
        - Classical swine fever
        - Septicaemic salmonellosis
        - Swine erysipelas
        - Porcine stress syndrome

## *Laboratory diagnosis*

**Samples**

*For isolation of agent*

- Avian circoviruses
    - Whole blood
    - Feathers (newly-erupted preferred)
    - Trachea
    - Intestines
    - Spleen
    - Lymph nodes
    - Lungs
- DogCV
    - Lymph nodes
    - Spleen
    - Intestines
- PCV2
    - Serum
    - Bronchoalveolar lavage
    - Kidney

*Serological tests*

- Serum

**Procedures**

*Identification of the agent*

- Avian circoviruses
    - Dot-blot hybridization
    - Polymerase chain reaction (PCR)
- DogCV
    - PCR
- PCV2
    - PCR
    - Real-time quantitative polymerase chain reaction (qPCR)
    - Viral isolation (VI) using porcine kidney, bronchoalveolar lavage, or serum

*Serological tests*

- BFDV
    - Enzyme-linked immunosorbent assay (ELISA)
    - Haemagglutination (HA) and haemagglutination inhibition (HI)
    - Immunohistochemistry (IHC)
    - Western blot
- PCV2
    - Antibody capture enzyme-linked immunosorbent assay (ELISA)
    - Immunoperoxidase monolayer assay (IPMA)
    - Indirect fluorescent antibody (IFA)

## *PREVENTION AND CONTROL*

### *Sanitary prophylaxis*

- In captive facilities, utilise proper sanitation protocols in order to prevent circovirus transmission between wild and domestic species
- Avian circoviruses

    - Quarantine and screen birds for avian circoviruses before introducing them to captive populations
    - Utilise proper housing facilities and fencing to minimise contact between wild and captive avian species, especially on goose farms
    - Do not release pet psittacines into the wild to prevent the potential spread of BFDV to wild bird populations
- PCV2
    - Maintain fencing or enclosed housing on swine operations to prevent interaction of wild and domestic pigs

### *Medical prophylaxis*

- Currently, no avian or dog circovirus vaccines are available
- PCV2 commercial vaccines are available for use in piglets, gilts, and sows; in piglets, the vaccines are administered at ≥3-4 weeks of age
    - An inactivated, oil-based adjuvant vaccine is available for use in gilts and sows at 2 mL/dose and in piglets at 0.5 mL/dose
    - 3 vaccines, available for use in piglets, are derived from a PCV capsid protein (open reading frame 2 protein) expressed in a baculovirus.
    - A chimaeric PCV1/2 vaccine is available for use in piglets

## *POTENTIAL IMPACTS OF DISEASE AGENT BEYOND CLINICAL ILLNESS*

### *Risks to public health*

- There is no known risk of animal circovirus infection in humans

### *Risks to agriculture*

- PCV2 is a threat to the commercial swine industry as well as wild boar game facilities
- Circoviruses are a risk to farmed geese and racing pigeons

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The OIE will periodically update the OIE Technical Disease Cards. Please send relevant new references and proposed modifications to the OIE Science Department (scientific.dept@oie.int). Last updated 2020. Written by Samantha Gieger and Erin Furmaga with assistance from the USGS National Wildlife Health Center.