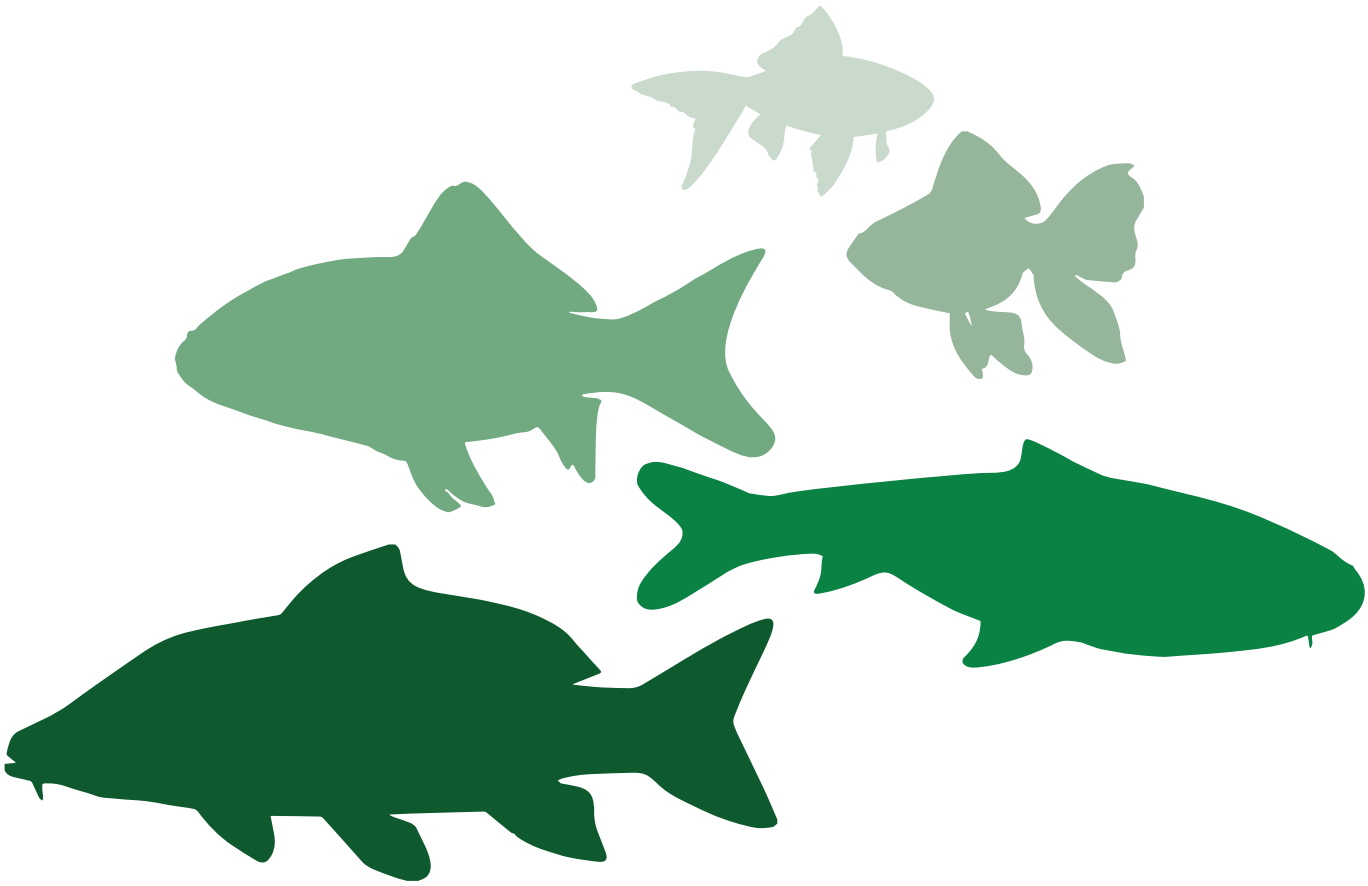
MODULE 28: SIGNIFICANT AND EMERGING VIRAL DISEASES OF CARP, KOI, AND GOLDFISH



NATIONAL VETERINARY ACCREDITATION PROGRAM

United States Department of Agriculture • Animal and Plant Health Inspection Service • Veterinary Services

Approved as one unit of supplemental training for participants in USDA's National Veterinary Accreditation Program

the Center for Food Security & Public Health
Iowa State University®

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National Veterinary Accreditation Program

Significant and Emerging Viral Diseases of Carp, Koi, and Goldfish

This informational module has been approved expressly to serve as one unit of supplemental training for participants in USDA's National Veterinary Accreditation Program. The module is intended to familiarize accredited veterinarians with animal health regulatory concepts and activities. Information in the module does not supersede the regulations. For the most up-to-date regulations and standards, please refer to the Code of Federal Regulations or contact your local Veterinary Services (VS) District Office. Completion of this module is estimated to take 60 minutes but will vary depending on your familiarity with the information presented.

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National Veterinary Accreditation Program

Significant and Emerging Viral Diseases of Carp, Koi, and Goldfish

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National Veterinary Accreditation Program

Significant and Emerging Viral Diseases of Carp, Koi, and Goldfish

Introduction

Welcome to the Significant and Emerging Viral Diseases of Carp, Koi, and Goldfish module.

In the United States, there are multiple aquaculture* industry sectors that focus on the culture, or rearing, of fish belonging to the cyprinid family, including koi carp (hereafter referred to as koi), grass carp, and goldfish. As an accredited veterinarian, you are likely to encounter a producer or hobbyist with these types of fish who will require your expertise in investigating, diagnosing, responding to, and possibly reporting a health issue. Clients may also need your assistance to meet health requirements for movement.

After completion of this module, you will be able to

- describe and differentiate two OIE-listed diseases for koi, grass carp, and goldfish—koi herpesvirus disease and spring viremia of carp;
- describe three emerging diseases of concern for these same species and industry sectors—Cyprinid herpesvirus 1, Cyprinid herpesvirus 2, and carp edema virus disease;
- understand your role as an accredited veterinarian in reporting OIE-listed diseases; and
- access additional sources of information on carp, koi, and goldfish diseases.

Fig. 28-1. A wide variety of cyprinid fish, like these koi, are produced by commercial aquaculture in the United States. *Photo source: Joe Pawlak, Blackwater Creek Koi Farms*

*Aquaculture is the propagation and/or rearing of aquatic organisms in controlled or selected environments for any commercial, recreational, or public purposes.

Web links for additional information on topics presented in this module can be found in the Resources/Web Links section of this document. Completion of this module is estimated to take 50 minutes, but will vary depending on your familiarity with the information presented.

Important Cultured Cyprinids

Koi, grass carp, and goldfish are members of the family *Cyprinidae*, a large group of freshwater fish also referred to as cyprinids. This is the largest of all fish families and includes true minnows, multiple species of Asian carp, and common carp, in addition to koi, grass carp, and goldfish.

In the United States, cyprinids produced in commercial aquaculture include ornamental fish (i.e., koi carp and goldfish), baitfish, and for vegetation control (i.e., triploid grass carp). There are many wild native cyprinids present in the United States, including minnows, shiners, chubs, and dace, as well as exotic, feral, and invasive species such as Asian carp and common carp. The selective breeding of carp and goldfish to produce the varieties sought by hobbyists today is believed to have originated in China 1,000 to 2,000 years ago. Koi, grass carp, and goldfish may be cultured, or raised, indoors or kept outdoors in ponds or tanks.

Fig. 28-2. A variety of cyprinids are present in the U.S. both as farm-raised and wild aquatic animals. *Photo sources: Koi (top left), Joe Pawlak, Blackwater Creek Koi Farms; grass carp (top right) Eric Engbretson, U.S. Fish and Wildlife Service; goldfish (bottom left), © Kate Ter Haar and licensed for reuse under Creative Commons License, via Flickr; common carp (bottom right), Ohio Department of Natural Resources*

- Koi are ornamental varieties of domesticated common carp (*Cyprinus carpio*); some references identify them as different subspecies. Koi were selectively bred for color, body shape, scale patterns, and other physical characteristics. Koi are popular pets.
- Goldfish (*Carassius auratus*) are also varied in their appearance from very plain (wild fish or those produced as baitfish) to many variations in color, shape, finnage, and scales.
- Grass carp (*Ctenopharyngodon idella*) are raised in the United States for aquatic vegetation control; however, to prevent nuisance or invasive impacts, only sterile animals may be used in free-ranging situations.
- Common carp (*Cyprinus carpio*) are bronze, greyish green, or brown in color. Common carp are an introduced wild species in the United States. They are considered an invasive pest species and as a rough sport fish by some. However, in many other countries common carp are cultured as food fish or sport fish.

Fig. 28-3. The "hood" of a redcap Oranda goldfish is a normal anatomical feature for this species. *Photo source: Denise Petty, USDA*

It is especially important when working with goldfish varieties that normal anatomical features are known from abnormal clinical presentations of disease, infectious or non-infectious. For example, the telescoping eyes of certain fancy goldfish should not be confused with exophthalmos, or the "hood" of an Oranda goldfish confused with proliferative or hyperplastic tissue.

Knowledge Review #1

Which of these fish species are selectively bred for their variations in color, finnage, and other characteristics, and are prized by hobbyists.

A. Goldfish and grass carp
B. Grass carp and common carp
C. Koi and goldfish
D. Koi and grass carp
E. Koi and common carp

Answers can be found at the end of this document.

OIE-Listed Aquatic Animal Diseases

The World Organisation for Animal Health (OIE), previously known as the Office International des Epizooties, is recognized by the World Trade Organization (WTO) as the international forum for establishing global animal health standards for trade, reporting global animal health events and disease status, and presenting guidelines and recommendations on sanitary measures relating to animal health and animal welfare.

The OIE maintains a list of animal diseases considered particularly harmful if spread internationally. Each OIE Member Nation is responsible for reporting any detection of these diseases within its territory. Upon notification, the OIE disseminates the disease outbreak information to other countries, allowing them to take necessary preventive actions, which may include trade restrictions.

Fig. 28-4. The World Organisation for Animal Health (OIE) establishes global animal health standards for trade and maintains a list of harmful animal diseases. *Graphic illustration: Dani Ausen, Iowa State University*

Cyprinidae are susceptible to several OIE-listed fish pathogens. The two most significant pathogens are the viral diseases:

- koi herpesvirus disease, and
- spring viremia of carp.

Certain cyprinid species are also susceptible to viral haemorrhagic septicemia (VHS) virus and *Aphanomyces invadans* (the causative agent of epizootic ulcerative syndrome). Both of these pathogens are also listed by the OIE. OIE-listed diseases can be found on the OIE website, and are reviewed and updated annually.

As with all OIE-listed or otherwise reportable diseases, if you suspect or diagnose one of these diseases, it is your obligation as an accredited veterinarian to immediately contact the State Animal Health Official (SAHO) and Assistant Director (AD) for your State.

The following table shows the OIE-Listed Aquatic Animal Diseases for 2017. The list is updated annually.

Table 1: OIE-Listed Aquatic Animal Diseases, 2017

OIE-Listed Aquatic Animal Diseases, 2017			
FINFISH	**MOLLUSKS**	**CRUSTACEANS**	**AMPHIBIANS**
Epizootic haematopoietic necrosis disease	Infection with abalone herpesvirus	Acute hepatopancreatic necrosis disease	Infection with *Batrachochytrium dendrobatidis*
Infection with *Aphanomyces invadans* (epizootic ulcerative syndrome)	Infection with *Bonamia ostreae*	Crayfish plague (*Aphanomyces astaci)*	Infection with ranavirus
Infection with *Gyrodactylus salaris*	Infection with *Bonamia exitiosa*	Infection with yellow head virus	Infection with *Batrachochytrium salamandrivorans*
Infection with HPR-deleted or HPR0 infectious salmon anaemia virus	Infection with *Marteilia refringens*	Infectious hypodermal and hematopoietic necrosis	
Infection with salmonid alphavirus	Infection with *Perkinsus marinus*	Infectious myonecrosis	
Infectious hematopoietic necrosis	Infection with *Perkinsus olseni*	Necrotizing hepatopancreatitis	
Koi herpesvirus disease	Infection with *Xenohaliotis californiensis*	Taura syndrome	
Red sea bream iridoviral disease		White spot disease	
Spring viremia of carp		White tail disease	
Viral haemorrhagic septicemia			
Source: OIE Aquatic Animal Health Code, Chapter 1.3 Diseases listed by the OIE available at: *http://www.oie.int/international-standard-setting/aquatic-code/access-online/*			

Koi Herpesvirus Disease

Causative Agent and Host Range

Koi herpesvirus disease (KHVD) is caused by Cyprinid herpesvirus 3 (CyHV-3), commonly known as koi herpesvirus (KHV). CyHV-3 is a DNA virus that belongs to the family *Alloherpesviridae* in the genus *Cyprinivirus*. KHVD is found in most countries that have wild and farm-raised carp, including the United States.

This disease can cause significant morbidity and mortality rates in koi and common carp *(Cyprinus carpio)*. Other cyprinids, including goldfish and grass carp, are resistant to disease caused by KHV through natural exposure routes. However, experimental exposure of common carp x goldfish hybrids and crucian carp x koi carp hybrids have been reported to result in clinical disease or detection of the agent via polymerase chain reaction (PCR).

KHV should be considered if investigating a disease outbreak with KHV-compatible signs in hybrids of common carp and koi with typically resistant species.

Clinical Signs

Clinical signs and lesions of infection with KHV may include

- lethargy and anorexia;
- uncoordinated or abnormal swimming;
- respiratory distress, (e.g., piping*) and increased opercular rate;[†]
- mottled gills with red and white patches (i.e., gill necrosis);
- bleeding gills;
- enophthalmos (sunken eyes);
- cutaneous lesions including pale patches, discolorations or hemorrhages, ulcers, and decreased mucus production (rough or sandpaper feel to skin); and
- notched "nose"—depression or notched appearance to the dorsal nares (red arrow in picture).

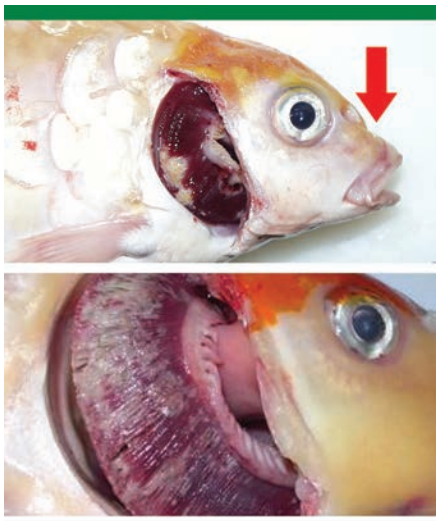

Fig. 28-5. KHVD can be grossly indistinguishable from other diseases. The top photo shows a koi with gill damage caused by KHV. The pale areas indicate dead gill tissue. The red arrow shows the "notched nose" of this infected fish. The bottom photo also shows a koi with gill necrosis, but caused by columnaris. *Photo sources: Andy Goodwin (top); Deborah Pouder (bottom)*

Clinically affected fish will tend to congregate in areas of higher oxygenation because of severe gill damage. Secondary bacterial and parasitic infections often occur and can mask the primary viral lesions. Common bacterial infections, especially columnaris disease,[‡] may be associated with clinical signs very similar to those of KHVD.

*Piping describes the behavior of finfish that swim at or near the surface of the water or near heavily oxygenated areas (e.g., waterfalls) and gulp air.

[†]The opercular rate in fish is analogous to respiratory rate in terrestrial animals.

[‡]Columnaris disease is a bacterial disease of both cultured and wild fish caused by *Flavobacterium columnare*. The disease causes skin lesions, fin erosion, gill necrosis, and high mortality that can lead to severe economic losses (Source: Declercq AM, 2013).

Transmission and Disease Expression

KHV is spread by direct contact with infected fish, contact with fluids from infected fish, and/or contact with water, mud, or other fomites or vectors that have come into contact with contaminated environments containing infected fish or that previously contained infected fish.

KHV affects fish of various ages and outbreaks have a seasonal pattern. Outbreaks typically occur during the spring and fall when water temperatures are between 60° and 82°F (16° and 28°C).

At these temperatures, morbidity and mortality rates are typically high (> 60%) and the onset of clinical signs may be sudden.

Note: Temperature is an important piece of information for this disease but should serve only as one clue for the ranking of your rule outs.

The incubation period is 7–21 days, depending on the water temperature.

- Warmer temperatures result in shorter incubation and more rapid expression of clinical disease.
- Fish can be infected at any temperature. However, fish seem most susceptible to clinical disease and mortality between 72–81°F (21–27°C).
- At lower water temperatures, fish may become infected but will not experience clinical disease until exposed to warmer temperatures.

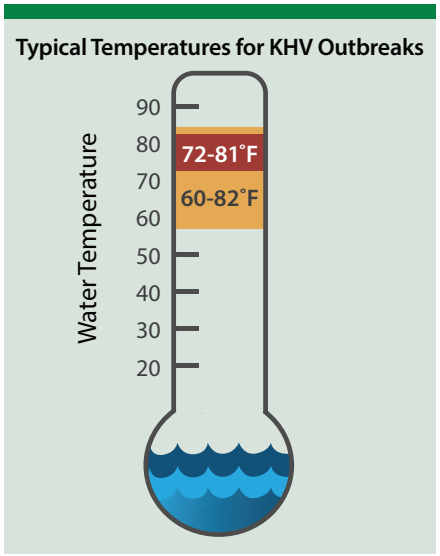

Fig. 28-6. KHV outbreaks typically occur during the spring and fall when water temperatures are between 60º and 82ºF. *Graphic illustration: Lauren Gehring, Iowa State University*

Outbreaks and losses may be minimized by increasing water temperatures, but fish that recover from KHVD will remain carriers of the virus for life and will shed the virus to other fish when the temperature is again in the optimum temperature range. These carrier fish may not show clinical signs of infection even while shedding virus.

Increasing water temperatures may be a possible solution for hobbyists, but is not ideal for producers. Accredited veterinarians need to be aware of the water temperature effects on the ability to observe symptoms of this disease, and perform their duties in an ethical manner.

Diagnosis

Morbidity and mortality events with consistent clinical signs and conducive water temperatures should prompt a presumptive diagnosis and follow-up testing for confirmation. Diagnosis of KHVD is based on clinical signs, combined with detection of the viral DNA via PCR or virus isolation via culture. Histopathology may also be useful.

In cases of an acute infection, PCR is the most practical and rapid method of diagnosis. Gill, kidney, and spleen tissues are suggested tissues for sampling. However, other suspect tissues, such as gut or brain, of infected fish may also be used. Culture of KHV is usually only successful if samples from clinically diseased, but not dead, fish are carefully collected and promptly cultured.

PCR methods are more reliable than cell culture, but diagnosticians must consider that PCR may detect latent KHV infections in fish dying from other diseases. Consult with the receiving laboratory regarding the preferred samples, sample preservation, and shipment methods. Interpreting results may also require assistance from aquatic animal health professionals with experience with KHVD.

The most concerning and difficult aspect in the diagnosis of KHVD is the ability to detect carrier fish. Detection of KHV antibodies is currently the only method of determining previous exposure to the virus if viral DNA is not detectable via PCR assays.

Serological tests (ELISA and virus neutralization) can be used to test for previous exposure in fish that have survived KHVD. This can be useful to understand the likely carrier status of clinically normal individuals or groups.

False negative serology results may occur early in the course of exposure as positive titers may take several weeks to develop. Conversely, survivors of an outbreak may lose viral load and titers over time, resulting in negative serology even though the animals are infected carriers.

Reporting

KHV is an OIE-listed pathogen, and all suspect or confirmed detections of the virus must be reported to your Assistant Director (AD) and State Animal Health Official (SAHO). Because KHV is already known to occur in koi and wild carp populations in the United States, it is on the list of diseases routinely monitored by APHIS and the States. States report outbreaks through the National Animal Health Reporting System (NAHRS). APHIS compiles this information and reports to OIE as required.

Koi herpesvirus must be reported to your Assistant Director and State Animal Health Official

More specifics on disease reporting for fish may be found in *NVAP Module 14: Evaluation of Aquatic Animals for Detection of Reportable Diseases and Pathogens*.

Prevention and Response

Koi herpesvirus is vulnerable to environmental conditions such as drying, detergents, and alcohol because of the outer lipid layer of the virion. However, it may reside outside the fish host in the environment, protected in a slime layer, for several days to weeks and remain infectious for naïve susceptible species. Methods to prevent KHV include avoiding exposure to the virus, good husbandry, and biosecurity practices.

To avoid disease problems, aquaculture facilities and hobbyists should source their fish carefully from producers who can demonstrate, through testing records, that their fish are free of this virus. To assist farms that wish to attain KHV-free status, you should consult with your local Assistant Director for guidance.

Aquaculture facilities should have biosecurity plans to limit the risk of introduction of this disease. Hobbyists should practice good biosecurity when participating in shows (e.g., keep their fish and equipment separate from others).

At the hobbyist level, quarantine of new fish is recommended for a minimum of 4–6 weeks at permissive temperatures. Quarantine should be combined with blood testing to aid in detection of carrier fish. The best recommendation for the prevention of KHVD is to avoid mixing susceptible species from multiple and/or unknown sources.

More specifics on biosecurity may be found in *NVAP Module 15: Preventing Disease Introduction and Spread in Aquaculture*.

Occurrences of KHV must be reported to your Assistant Director; however, the response to KHVD is not regulated at the Federal level.

Decisions on appropriate action should be made by individual producers or hobbyists in consultation with their veterinarian or their facility aquatic animal health team as well as the State regulatory authorities. Decisions should be based on business objectives and on actions needed to limit spread of disease to non-exposed animals.

Fig. 28-7. Additional information on disinfection and biosecurity plans can be found in NVAP Module 15. *Graphic illustration: Andrew Kingsbury, Iowa State University*

Hobbyists with private koi collections may choose to keep survivors but should be aware that these fish may be carriers of the virus and could infect uninfected fish they come in contact with, or could serve as a source of infection through contaminated water or fomites, such as during fish introductions or at exhibitions or shows. Facilities recovering from an infection of KHVD should use disinfectants with known efficacy for the virus.

Additional information on disinfection may be found in the summary table found later in this module as well as in *NVAP Module 15: Preventing Disease Introduction and Spread in Aquaculture*.

Spring Viremia of Carp

Causative Agent and Host Range

Spring viremia of carp (SVC), sometimes called infectious dropsy* of carp, is a viral disease caused by spring viremia of carp virus (SVCV) (more recently named carp sprivivirus), a bullet-shaped RNA virus, (family: *Rhabdoviridae*; genus: *Sprivivirus*). Spring viremia of carp can affect common carp, koi, goldfish, grass carp, bighead carp, silver carp, crucian carp, tench, sheatfish, and orfe (ide, *Leuciscus idus*).

There are a number of other fish species from which SVCV has been isolated or detected through immunohistochemistry or PCR. There have also been some species that have been infected experimentally through unnatural infection routes. These are not included here, but you may find more information about them in *Chapter 2.3.9. Spring Viraemia of Carp of the OIE Manual of Diagnostic Tests for Aquatic Animals* at *http://www.oie.int/index.php?id=2439&L=0&htmfile=chapitre_svc.htm*.

*Dropsy is the buildup of fluid inside the body cavity or tissues of a fish.

Fig. 28-8. Both fish pictured show clinical lesions of spring viremia of carp. The koi on the top has congestion and hemorrhages in the fins and skin. The grass carp on the bottom has petechial hemorrhages on the ventral and lateral body surface, as well as a swollen and hemorrhagic vent. *Photo sources: Kathleen Hartman (top) and Andy Goodwin (bottom)*

Clinical Signs and Lesions

Clinical signs and lesions of spring viremia of carp infection may include

- decreased respiratory rate;
- loss of equilibrium (fish lie on their side at the bottom of the tank or pond, swim up when startled and then return to the bottom);
- congregation in areas of slow water flow or near pond banks;

- pale gills;
- petechial hemorrhages in the gills, skin (ventral body surface), eyes, and fins;
- protruding vent with thick, mucoid (white to yellowish) fecal casts;
- abdominal distension;
- exophthalmia (protruding eyes);
- hemorrhages in the wall of the gas bladder and other internal organs;
- enlarged spleen; and
- mucoid intestinal content.

Transmission and Disease Expression

The virus enters fish through the gills. Replication occurs in the gills, and then the virus spreads to other internal organs. The virus is then shed from infected individuals through feces.

Blood-sucking parasites, including leeches and the fish louse *Argulus* sp., have been implicated in spreading the disease. Mechanical transmission by aquatic animals, birds, and other animals, as well as equipment, may occur because the virus is able to survive for some time in water and mud and may survive passage through the gut. The virus can also survive drying and freezing (for one month at -4°F [-20°C]).

Young fish are most susceptible to infection, and mortality can reach 70% in yearling carp. Adult fish can also be clinically affected but to a lesser degree. However, most disease events and virus isolations in feral carp in North America have been adult fish.

Morbidity and mortality rates are most severe when water temperatures are cooler, 50–72°F (10–22°C) and are often seen during times of transitioning weather, such as the spring when water temperatures are increasing.

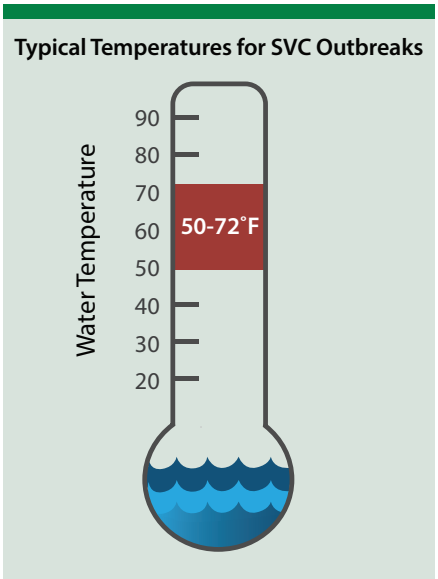

Fig. 28-9. Morbidity and mortality rates are most severe for SVC when water temperatures are cooler. *Graphic illustration: Lauren Gehring, Iowa State University*

Infected fish that survive may develop immunity. However, surviving fish that recover also may continue to shed virus and remain carriers for an undetermined length of time. The length of time that the virus may persist in surviving fish has not been reported.

Accredited veterinarians need to be aware of water temperature effects on the ability to observe symptoms of this disease and carrier status, and perform their duties in an ethical manner.

Note: Temperature is an important piece of information for this disease but should serve only as one clue for the ranking of your rule outs.

Diagnosis

Diagnosis is generally based on the isolation of SVCV in cell culture, followed by identification. PCR-based methods can be used for screening in some situations. Moribund or freshly dead fish are the best candidates for diagnostics. Suspect cases of SVC should be reported to your SAHO and AD, who will determine the appropriate laboratory for testing. If the disease is suspected in domestic stocks, a Foreign Animal Disease (FAD) investigation will likely be initiated. Samples collected as part of a FAD investigation are tested at the National Veterinary Services Laboratories (NVSL) in Ames, IA.

If both KHVD and SVC are suspected, testing may be conducted at a State or private laboratory. Check with the testing laboratory for instructions on tissue collection, preservation, and shipment. Confirmation testing at the NVSL is required on all suspected spring viremia of carp cases. If testing laboratory personnel suspect that they have isolated SVCV in cell culture or have suspect PCR findings, they need to contact the NVSL immediately.

Reporting

Spring viremia of carp is an OIE-listed disease and all suspect or confirmed detections of the disease must be reported to your AD and SAHO.

SVC is considered to be a foreign animal disease for the United States in commercially produced animals. SVC is known to occur in susceptible wild feral fish populations.

Once confirmed, outbreaks of spring viremia of carp in commercially produced stocks are reported to the OIE by APHIS immediately. More specifics on reporting can be found in *NVAP Module 14: Evaluation of Aquatic Animals for Detection of Reportable Diseases and Pathogens*.

Spring viremia of carp must be reported to your Assistant Director and State Animal Health Official

Prevention and Response

While SVC has been present in Europe and Asia for many years, it has only been periodically detected in the United States in feral common carp and farmed koi. The source and epidemiology of the virus in the occurrences of SVC in the United States are not well-defined.

In 2002, SVC was detected in feral common carp in Wisconsin and farmed koi in North Carolina; there was no epidemiologic link between these two cases. The disease was detected again in farmed koi in Washington and Missouri in 2004. As in the 2002 event, there was no epidemiologic link between these two cases. The virus was isolated from asymptomatic fish collected in 2003 and 2008 as part of U.S. Fish and Wildlife Service wild fish health surveys in Ohio and Wisconsin. Two different disease outbreaks occurred in feral carp in Minnesota in 2007 and 2011.

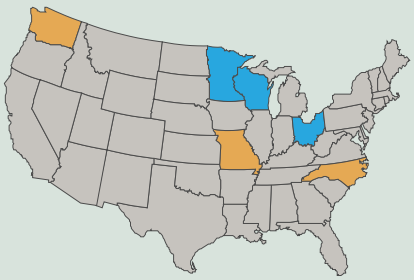

Fig. 28-10. Spring viremia of carp has been periodically detected in feral (blue) and farmed (orange) cyprinds. *Graphic illustration: Lauren Gehring, Iowa State University*

When SVCV has occurred in farm-raised fish in the United States, affected and exposed animals have been depopulated. Farm-raised susceptible populations in the United States are currently considered to be free of SVC.

USDA-APHIS-VS has SVC import health requirements for susceptible fish species entering the United States. APHIS defines SVC susceptible species to include the following:

- Common carp *(Cyprinus carpio)*;
- Grass carp *(Ctenopharyngodon idellus)*;
- Silver carp *(Hypophthalmichthys molitrix)*;
- Bighead carp *(Aristichthys nobilis)*;
- Crucian carp *(Carassius carassius)*;
- Goldfish *(Carassius auratus)*;
- Tench *(Tinca tinca)*; and
- Sheatfish *(Silurus glanis)*.

APHIS SVC import requirements can be found at *https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-and-animal-product-import-information/import-live-animals/sa_marine_life/ct_marine_import_fish*.

Aquaculture facilities and hobbyists should strictly adhere to import requirements and source their animals with care from SVC-free facilities to prevent disease introduction. In addition, they should develop and implement strict biosecurity for their establishments. Hobbyists should practice strict biosecurity for their animals when participating in shows.

SVC is a disease that requires a response at the State and Federal level. If diagnosed in a private facility, USDA-APHIS-VS and State regulators will work with the affected establishment and their veterinarian or facility health team to respond.

Table 2. Comparison of Koi Herpesvirus Disease and Spring Viremia of Carp

	Koi Herpesvirus Disease (KHVD)	Spring Viremia of Carp (SVC)
Synonyms	Cyprinid herpesvirus 3 (CyHV-3); carp nephritis and gill necrosis virus (CNGV)	Infectious dropsy of carp
Viral Agent	Cyprinid herpesvirus 3 DNA virus	Carp sprivivirus RNA virus
Species Affected	Common carp; koi; crucian carp x koi carp and common carp x goldfish hybrids	Common carp; koi; goldfish; grass carp; bighead carp; silver carp; crucian carp; tench; sheatfish; orfe
Optimal Water Temperature for Occurrence of Clinical Disease	60–82°F (16–28°C)	50–72°F (10–22°C)
Transmission	Direct contact; fecal material; infected water or mud; equipment; vectors	Direct contact; fecal material; infected water or mud; equipment; vectors
Age Susceptibility	All ages susceptible	Young more susceptible than mature
Clinical Signs: Behavioral	Lethargy; anorexia; uncoordinated or abnormal swimming; swim close to the surface or near heavily oxygenated areas; respiratory distress or increased opercular rate	Loss of equilibrium (lie on bottom of tank or pond and swim up when startled); congregate in areas of slow water flow; decreased respiratory rate
Clinical Signs: External	Gill necrosis; bleeding gills; sunken eyes; notched nose; cutaneous lesions (pale patches, discolorations or hemorrhages, ulcers, and decreased mucus production)	Pale gills; petechial hemorrhages of gill, skin, eye, and fin; protruding vent with mucoid fecal casts; abdominal distension; protruding eyes
Clinical Signs: Internal	Few; variable signs	Pinpoint hemorrhages of many organs including swim bladder; enlarged spleen; mucoid intestinal content
Testing Methods	Virus isolation, PCR, ELISA	Virus isolation and PCR
Carrier States	Yes	Yes
Regulatory Status	REPORTABLE with no mandatory consequences	FEDERALLY REPORTABLE with response required; import regulations in place
Treatment	None: water temperature may be used to limit the occurrence of clinical disease and minimize losses; however, animals remain carriers for life	None
Prevention/Control	Depopulate infected stocks or treat surviving fish as lifetime carriers; practice good biosecurity, including quarantine and testing; purchase fish from known reputable source; keep susceptible species separated	Depopulate infected stocks; practice good biosecurity, including quarantine; purchase fish from known reputable source; keep susceptible species separated
Disinfection	Chlorine (200 ppm for 1 hour); quaternary ammonium compounds (500 ppm for 1 hour)	Chlorine (500 ppm for 10 minutes); ozone; gamma or UV radiation; pH <4.0 or >10.0; heat 60°C for 15 min

Knowledge Review #2

Which of the following viral diseases of cyprinid fish are reportable to the OIE?

- **A.** Koi herpesvirus disease and spring viremia of carp
- **B.** Koi herpesvirus disease and carp edema virus disease
- **C.** Carp edema virus disease, spring viremia of carp, and koi herpesvirus disease
- **D.** Carp pox and goldfish hematopoietic necrosis virus
- **E.** Koi herpesvirus disease and carp pox

Answers can be found at the end of this document.

Emerging Pathogens of Koi and Goldfish in the United States

Cyprinid Herpesvirus 1

Host Range

Disease from Cyprinid herpesvirus 1 (CyHV-1) is also called koi pox, carp pox, herpesviral epidermal proliferation in carp, or herpesvirus septicemia in carp. This virus and the disease it causes was first recognized and described in the late 1500s. It occurs worldwide (including the United States) in koi, common carp, common carp hybrids, and grass carp.

Clinical Signs

Clinical signs and lesions of CyHV-1 may include the following:

- Mortality in juvenile koi (<2 months); mortality in adult fish is rare.
- Proliferative skin lesions manifested as focal, raised, translucent to white plaques (often described as appearing like melted candle wax) in older fish at cool water temperatures (often seen in spring) when temperatures are (<68°F [<20°C]). **Note:** Temperature is an important piece of information for this disease but should serve only as one clue for the ranking of your rule outs.
  - The plaques are fragile and can sometimes be gently removed by rubbing, differentiating them from tumors or parasitic infections that could be similar in appearance.
  - Skin damage can lead to secondary bacterial infections.
  - Large lesions can lead to scarring (detrimental to koi show fish).

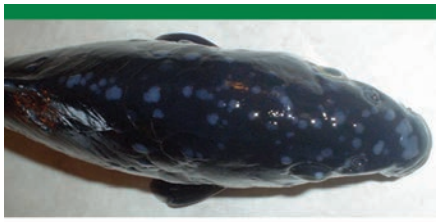

Fig. 28-11. Focal, translucent plaques may be seen with carp pox infections. *Photo source: Kathleen Hartman*

Transmission and Disease Expression

The virus is widespread in susceptible populations. Like most herpesviruses (including koi herpesvirus disease [CyHV-3] and goldfish herpesvirus [CyHV-2]), CyHV-1 can exist for many years in a latent state in an infected host. Then, when the host is stressed or environmental conditions (e.g., water temperatures) are right, it can express itself as disease in the host or be shed without obvious evidence of disease. This allows the disease to spread by direct contact or through contact with the contaminated water.

CyHV-1 tends to be expressed as disease in colder temperatures (<68°F [20°C]). Warmer water temperatures tend to help fish recover and the skin lesions to heal, but they still remain carriers.

Producers with affected animals should be aware of carrier status of animals and consult with their veterinarian or facility aquatic animal health team to limit spread of disease to unexposed animals within or outside of their facility. Accredited veterinarians need to be aware of water temperature effects when observing symptoms of this disease, and perform their duties in an ethical manner.

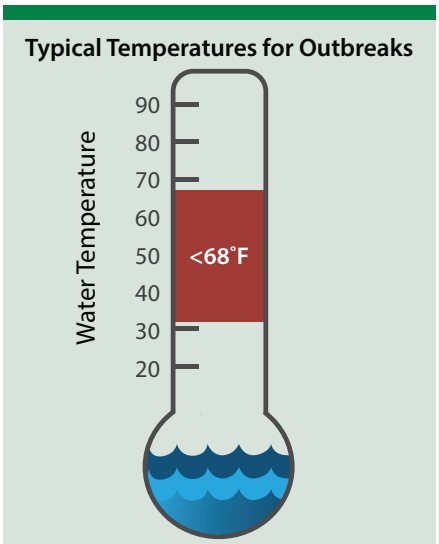

Fig. 28-12. CyHV-1 tends to be expressed as disease in colder temperatures. *Graphic illustration: Lauren Gehring, Iowa State University*

Diagnosis

While the disease can be definitively diagnosed via virus isolation, it is important to realize that virus isolation often is not successful for CyHV-1 because of the low susceptibility of cell cultures and rapid inactivation of virus particles post mortem. The use of PCR on skin tissue is an alternative diagnostic method. Often, case history and clinical signs are enough to make the diagnosis. Histopathology also can be helpful. There are no reliable methods currently available to detect carriers. Consult with your laboratory regarding the preferred diagnostic samples and sample preservation and shipment methods.

Reporting

CyHV-1 is not a reportable virus at the Federal level. However, you should always check with your SAHO or other local regulatory authorities regarding their requirements.

Prevention and Response

Because this disease is widespread and there are no reliable testing methods to identify carriers, control focuses on good biosecurity and husbandry practices. Obtaining healthy fish from reliable sources that employ good biosecurity and health management themselves is always a good practice. Managing parasite and temperature stress can limit expression of the disease and its spread. Vigilance in monitoring animals can lessen the impact of the disease if water temperatures can be gradually increased once lesions are noticed.

Cyprinid Herpesvirus 2

Causative Agent and Host Range

Cyprinid herpesvirus 2 (CyHV-2) is also called goldfish hematopoietic necrosis virus and goldfish herpesvirus (GHV). This herpesvirus affects goldfish in all types of operations and is distributed worldwide, including within the United States. It has also been reported to affect Prussian carp (*Carassius gibelio*), a commercially important cultured species in China. Some believe that modern day goldfish were derived from Prussian carp. Originally the virus was named goldfish hematopoietic necrosis virus, and as the name suggests, this virus attacks blood cell-producing tissues in the head and kidney.

Fig. 28-13. Gross lesions of CyHV-2 may include extensive pale patches on the gills. *Photo source: Keith Way, Centre for Environment, Fisheries and Aquaculture Science (CEFAS)*

Clinical Signs

Clinical signs and lesions of CyHV-2 may include

- anorexia, lethargy, and increased respiration;
- anemia characterized by pale gills and pale tissues;
- patchy gill necrosis;
- loss of mucus surface layer, making the skin feel “rough”;
- pale, enlarged kidney, spleen, and liver;
- mottled spleen; and
- ascites.

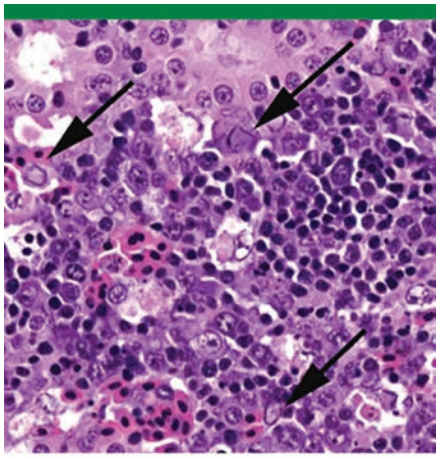

Fig. 28-14. Nuclei of hematopoietic tissue are enlarged by an intranuclear viral inclusion (arrows). *Photo source: The Joint Pathology Center*

Transmission and Disease Expression

Transmission of goldfish hematopoietic necrosis virus (GHV) is by direct contact with infected fish or contaminated environments. The disease is widespread in goldfish populations and, as with the other cyprinid herpesviruses, can remain latent. Disease outbreaks are sporadic and are triggered by stress and low water temperatures. Fish that survive outbreaks are carriers.

Diagnosis

Clinical signs and case history provide a presumptive diagnosis. Severe necrosis of hematopoietic tissues also is suggestive. As with other herpesviruses, intranuclear inclusion bodies may be evident in affected cells. Definitive diagnosis is by identification of viral DNA by conventional or TaqMan PCR. Virus isolation is extremely difficult and is not considered a useful diagnostic method. Consult with your laboratory regarding the preferred samples and sample preservation and shipment methods.

Reporting

CyHV-2 is not a reportable virus at the Federal level. However, you should always check with your SAHO or other local regulatory authorities regarding their requirements.

Prevention and Response

Like CyHV-1, this disease is widespread in goldfish populations, with many fish likely to be inapparently infected. There is evidence that the virus may be vertically transmitted within eggs. The disease caused by this virus can be prevented if stress and water temperatures in the 70°F range can be avoided. Outbreaks often occur when fish are warmed from cooler temperatures into the low to mid 70°F. However, as with the other temperature-dependent diseases, you should not rule out a case occurring at a temperature outside the preferred range.

Outbreaks can be treated by elevating temperatures into the low to mid 80°F range in systems where water temperatures can be manipulated. However, affected animals remain carriers. Producers with affected animals should be aware of carrier status of animals and consult with their accredited veterinarian or facility aquatic animal health team to limit spread of disease to unexposed animals within or outside of their facility. Good biosecurity and management practices designed to maximize population health and limit disease risk are very important to avoid economic impact from this disease.

Knowledge Review #3

Which statement best characterizes the relationship between cyprinid herpesviruses (CyHV-1 [carp pox], CyHV-2 [GHV], and CyHV-3 [KHVD]) and temperature increases above those permissive for the disease?

A. Increasing temperatures above those permissive for the disease eliminates the virus from the affected animals and the environment.

B. Increasing temperatures above those permissive for the disease eliminates the virus from the environment, but not the affected animal.

C. Decreasing temperatures below those permissive for the disease eliminates the virus from the affected animal, but not from the environment.

D. Increasing temperatures above those permissive for clinical disease may limit the expression of clinical signs in infected animals but the animals remain infected as carriers, and the environment may remain contaminated.

E. Decreasing temperatures below those permissive for the disease eliminates the virus from the affected animals and the environment.

Answers can be found at the end of this document.

Carp Edema Virus Disease

Causative Agent and Host Range

Carp edema virus is a large DNA virus and is thought to belong to the family *Poxviridae*. The virus can cause disease in wild and cultured common carp varieties, including koi. Disease caused by this virus was first seen in Japan in the mid-1970s. Since then, outbreaks have been documented in North America, Europe, and the United Kingdom.

Clinical Signs

Clinical signs and lesions of carp edema virus disease (CEVD), also called koi sleepy disease, may include the following:

- Lethargy and unresponsiveness;
  - Juveniles may hang just under the surface of the water; adult fish may lie motionless on the bottom of their pond or tank.

- **Note:** Individuals from both groups may respond to tapping on the tank or other stimulation by swimming momentarily and then returning to their previous position. This clinical sign is not pathognomonic for CEVD. A video of this behavior is available at *http://aast.cfsph.iastate.edu/AQDZ/aqdz0380.htm*.

- Anorexia;
- Erosive or hemorrhagic skin lesions with edematous swelling of the underlying tissues;
- Enophthalmos (sunken eyes);
- Pale, swollen gills; and
- Patchy areas of gill discolorations or necrosis.

Fig. 28-15. Fish with CEVD may have enophthalmos (sunken eye) as seen on this koi carp (top). A koi with normal eyes is shown on the bottom. *Photo sources: Blue Ridge Fish Hatchery (top); ©Stefan Schweihofer and licensed for reuse under Creative Commons Public Domain, via Pixabay (bottom)*

Transmission and Disease Expression

Disease often occurs in juvenile koi when they have been stressed due to movement from earthen nursery ponds to concrete-lined ponds for grading. Outbreaks also occur after the addition of infected fish into a population that has not previously been exposed to the pathogen. One study showed that mortality may begin in naïve koi or common carp at 6–16 days post exposure by immersion. This study also suggested that transmission occurred via contaminated water, so affected fish likely shed the virus from skin and gill lesions. The length of time that the virus can survive in water and the possibility of vertical transmission are unknown.

Diagnosis

In addition to a case history and clinical signs consistent with the disease, examination of wet mounts of the gills is helpful. Affected fish show a proliferation of gill epithelial cells and thickening of the gill filament. In early stages of the disease, this thickening occurs at the tips of the gill filaments, creating a "club-like" appearance. As the disease progresses, the epithelial proliferation and thickening may involve the length of the gill filament. Unfortunately, this lesion can also be caused by other issues like poor water quality. Observation of gill hyperplasia and hypertrophy, pox-like inclusion bodies, and necrosis of the skin with edema of underlying tissues on histopathologic examination is suggestive of CEVD.

Transmission electron microscopy can also be used to demonstrate these same microscopic lesions as well as to confirm the inclusions contain pox-like particles. Validated PCR tests are available and can provide a definitive diagnosis. The virus has not been grown in cell culture. Consult with your laboratory regarding the preferred samples and sample preservation and shipment methods.

Reporting

CEVD is not a reportable virus at the Federal level. However, you should always check with State or other local regulatory authorities regarding their requirements.

Prevention and Response

Advise clients to only source fish from trusted suppliers as well as to question suppliers about any unexplained mortality events, and ask if they test for CEVD before acquiring susceptible species. Make sure your clients use good biosecurity practices at their facilities. Advise quarantine and testing of new additions of fish and use of good husbandry practices to keep fish healthy and limit stress (e.g., good water quality, good nutrition, proper stocking rates and densities, etc.). Your clients should monitor fish populations for signs of disease, isolate and test sick fish, and remove dead fish from ponds as soon as possible to limit disease transmission.

Fig. 28-16. Advise clients to practice good biosecurity. *Photo source: Kathleen Hartman*

If CEVD occurs at a facility, preventative depopulation is recommended.

Knowledge Review #4

You are investigating a report of increased mortality at a koi farm. Sick fish are observed lying on their sides on the bottom of their tank. However, when brushed by another fish or otherwise startled, they right themselves and swim normally for a short time before falling to the bottom of the tank once more. Affected fish have pale, swollen gills with patchy areas of necrosis. You prepare wet mounts of the gills and see thickened gill filaments, many of which have a club-like appearance. What disease do you suspect?

- **A.** Carp pox (cyprinid herpesvirus 1)
- **B.** Spring viremia of carp
- **C.** Goldfish herpesvirus (cyprinid herpesvirus 2)
- **D.** Carp edema virus disease
- **E.** Koi herpesvirus disease

Answers can be found at the end of this document.

Table 3: Summary of Cyprinid Species Affected by Select Diseases

	Common carp	Koi	Grass carp	Goldfish	Reportable
Koi herpesvirus disease	●	●			Federal and State
Spring viremia of carp	●	●	●	●	
Cyprinid herpesvirus 1 (carp pox)	●	●	●		Check with State and local regulatory authorities
Cyprinid herpesvirus 2 (goldfish herpesvirus)				●	
Carp edema virus disease	●	●			

Knowledge Review #5

You are investigating a mortality event (due to a disease outbreak) in a facility that contains both koi and goldfish. The temperature has recently dropped from 82°F to 76°F due to a "cold snap". Only koi are affected. Clinical signs include increased opercular rate, piping at the surface, patchy red and white areas on the gills, and sunken eyes. What is your primary rule out?

- **A.** Spring viremia of carp
- **B.** Carp pox
- **C.** Koi herpesvirus
- **D.** Carp edema virus disease
- **E.** Goldfish herpesvirus

Answers can be found at the end of this document.

Summary

Cyprinids are an important aquaculture species within the United States. These species are susceptible to a variety of reportable, monitored, and emerging diseases. Accredited veterinarians should be aware of these diseases, as many resemble common diseases. If you suspect any of the diseases discussed in this module, contact your Assistant Director as well as your State Animal Health Official.

Now that you have completed this module, you will be able to

- describe and differentiate two OIE-listed diseases for koi, grass carp, and goldfish—koi herpesvirus disease and spring viremia of carp;
- describe three emerging diseases of concern for these same species and industry sectors—Cyprinid herpesvirus 1, Cyprinid herpesvirus 2, and carp edema virus disease;
- understand your role as an accredited veterinarian in reporting OIE-listed diseases; and
- access additional resources on carp, koi, and goldfish diseases.

Fig. 28-17. Cyprinids are popular pets. *Photo source: Joe Pawlak, Blackwater Creek Koi Farms*

Resources/Web Links

Additional information and resources related to topics discussed in this module are listed below.

State and Federal Contacts

Assistant Directors/District Offices
https://www.aphis.usda.gov/animal_health/downloads/sprs_contact/field_office_contact_info.pdf

State Animal Health Officials
http://www.usaha.org/upload/STATE_ANIMAL_HEALTH_OFFICIALS.pdf

State Aquaculture Coordinators
http://www.nasac.net/

National Veterinary Services Laboratories
https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/lab-info-services/sa_diagnostic_tests/ct_diagnostic_tests

Aquatic Disease Diagnostic Laboratories: Aqua VetMed search directory
http://www.aquavetmed.info/

Cyprinid Background Information

Watson CA, Hill JE, Pouder DB. Species profile: koi and goldfish. Southern Regional Aquaculture Center (SRAC) Publication No. 7201. September 2004. Available at: *http://www2.ca.uky.edu/wkrec/GoldfishKoi.pdf*. Accessed July 19, 2016.

Reportable/Notifiable Diseases

National Animal Health Reporting System (NAHRS)
https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/monitoring-and-surveillance/sa_disease_reporting/ct_usda_aphis_animal_health/!ut/p/z1/hVHLcoJAEPwajzizC-GRGxBKTIxWBFT2kmIBgQqyFBIp_z5oHlWJEf-c2O93TPdPAYAOsig5FFrWFqKKyr0Omvs6JPUFdIbOJ80DQdI3pk6upiC8U1mfAbKHYxPJwtli5KpqOH_hznVhT-gwL71VYcq28vtWfHmVJcfvPxyjPxFn8FoQWhl7ie2X0NG3DLhrXWwAb1iHwBuNz3lkjYm9SumlR7F4ci7SCoRL-PrE_BOE-u4SCAkW2IYCtWkmMtcUgwtlqI0SiTOdcopoSjfUXARHs8WhkKzf07GyAmelYJ_pm1WXNYzYE26T-Zu0Gb83_XfetvX-foQj7LpunAmRlek4Frv_CLnYt7D5g6t3QVAdpbel3vnbvNSPcpl9AJLhBXQ!/dz/d5/L2dBISEvZ0FBIS9nQSEh/?urile=wcm%3Apath%3A%2Faphis_content_library%2Fsa_our_focus%2Fsa_animal_health%2Fsa_monitoring_and_surveillance%2Fsa_disease_reporting%2Fct_usda_aphis_animal_health

NAHRS Reportable Disease Lists
https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/monitoring-and-surveillance/sa_disease_reporting/ct_disease_list

OIE-listed Diseases for Aquatic Animal Species
http://www.oie.int/index.php?id=171&L=0&htmfile=chapitre_diseases_listed.htm

World Organisation for Animal Health (OIE). Aquatic Animal Health Code
http://www.oie.int/international-standard-setting/aquatic-code/access-online/

World Organisation for Animal Health (OIE) Manual of Diagnostic Tests for Aquatic Animals
http://www.oie.int/international-standard-setting/aquatic-manual/access-online/

Koi Herpesvirus Disease

Goodwin A. Herpesviruses in fish. Southern Regional Aquaculture Center (SRAC). Publication No. 4710. May 2012. Available at: *http://fisheries.tamu.edu/files/2013/09/SRAC-Publication-No.-4710-Herpesviruses-in-Fish.pdf*. Accessed July 19, 2016.

Hartman KH, Yanong RPE, Pounder DB et al. Koi herpesvirus disease (KHVD). University of Florida IFAS Extension, Electronic Data Information Source (EDIS). Publication #VM-149/VM113. August 2016.Available at: *https://edis.ifas.ufl.edu/vm113*. Accessed July 19, 2016.

Spring Viremia of Carp

Petty BD, Francis-Floyd R, Yanong RPE. Spring viremia of carp. University of Florida IFAS Extension, EDIS. Publication #VM-149/VM106. May 2016. Available at: *http://edis.ifas.ufl.edu/vm106*. Accessed July 19, 2016.

Chapter 2.3.9. Spring Viraemia of Carp. OIE Manual of Diagnostic Tests for Aquatic Animals *http://www.oie.int/index.php?id=2439&L=0&htmfile=chapitre_svc.htm*.

USDA-APHIS-VS. USDA Guide Sheet for Live Finfish Imports—SVC Import Requirements *https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-and-animal-product-import-information/import-live-animals/sa_marine_life/ct_marine_import_fish*

Other Cyprinid Pathogens

Declercq AM, Haesebrouck F, Van den Broeck W et al. Columnaris disease in fish: a review with emphasis on bacterium-host interactions. Vet Res. 2013;44(1):27. Available at *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3648355/*. Accessed October 6, 2016.

Haenen O, Way K, Gorgoglione B, et al. Novel viral infections threatening cyprinid fish. Bull Eur Assoc Fish Pathol. 2016;36(1):11–23. Available at: *http://www.wageningenur.nl/upload_mm/a/d/9/09ef4407-2c6a-4652-858d-23bce1a62de7_Haenen%20etal%202016%20BullEurAssFishPath%20%20viral%20infections%20Cyprinid%20fish.pdf*. Accessed July 19, 2016.

Hesami S, Viaanna P, Steckler N et al. Carp edema virus disease (CEVD)/koi sleepy disease (KSD). University of Florida IFAS Extension. EDIS Publication #FA189. October 2015. Available at: *https://edis.ifas.ufl.edu/fa189*. Accessed July 19, 2016.

Lewisch E, Gorgoglione B, Way K, et al. Carp edema virus/koi sleepy disease: an emerging disease in Central-East Europe. Transbound Emerg Dis. 2015;62(1):6–12. Available at: *http://onlinelibrary.wiley.com/doi/10.1111/tbed.12293/full*. Accessed July 19, 2016.

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The content of this module has been reviewed and approved by USDA-APHIS Legislative and Public Affairs.

Knowledge Review Answers

Knowledge Review #1

Which of these fish species are selectively bred for their variations in color, finnage, and other characteristics, and are prized by hobbyists.

- **A.** Goldfish and grass carp
- **B.** Grass carp and common carp
- **C.** Koi and goldfish
- **D.** Koi and grass carp
- **E.** Koi and common carp

The correct answer is C. Koi and goldfish.

Knowledge Review #2

Which of the following viral diseases of cyprinid fish are reportable to the OIE?

- **A.** Koi herpesvirus disease and spring viremia of carp
- **B.** Koi herpesvirus disease and carp edema virus disease
- **C.** Carp edema virus disease, spring viremia of carp, and koi herpesvirus disease
- **D.** Carp pox and goldfish hematopoietic necrosis virus
- **E.** Koi herpesvirus disease and carp pox

The correct answer is A. Koi herpesvirus disease and spring viremia of carp. Both diseases are OIE-listed diseases.

Knowledge Review #3

Which statement best characterizes the relationship between cyprinid herpesviruses (CyHV-1 [carp pox], CyHV-2 [GHV], and CyHV-3 [KHVD]) and temperature increases above those permissive for the disease?

- **A.** Increasing temperatures above those permissive for the disease eliminates the virus from the affected animals and the environment.
- **B.** Increasing temperatures above those permissive for the disease eliminates the virus from the environment, but not the affected animal.
- **C.** Decreasing temperatures below those permissive for the disease eliminates the virus from the affected animal, but not from the environment.
- **D.** Increasing temperatures above those permissive for clinical disease may limit the expression of clinical signs in infected animals but the animals remain infected as carriers, and the environment may remain contaminated.
- **E.** Decreasing temperatures below those permissive for the disease eliminates the virus from the affected animals and the environment.

The correct answer is D. Increasing temperatures mitigate clinical disease expression, but do not eliminate the virus.

Knowledge Review #4

You are investigating a report of increased mortality at a koi farm. Sick fish are observed lying on their sides on the bottom of their tank. However, when brushed by another fish or otherwise startled, they right themselves and swim normally for a short time before falling to the bottom of the tank once more. Affected fish have pale, swollen gills with patchy areas of necrosis. You prepare wet mounts of the gills and see thickened gill filaments, many of which have a club-like appearance. What disease do you suspect?

- **A.** Carp pox (cyprinid herpesvirus 1)
- **B.** Spring viremia of carp
- **C.** Goldfish herpesvirus (cyprinid herpesvirus 2)
- **D.** Carp edema virus disease
- **E.** Koi herpesvirus disease

The correct answer is D. Carp edema virus disease. The clinical signs, behavior, and gill lesions described are typical for this disease.

Knowledge Review #5

You are investigating a mortality event (due to a disease outbreak) in a facility that contains both koi and goldfish. The temperature has recently dropped from 82°F to 76°F due to a "cold snap". Only koi are affected. Clinical signs include increased opercular rate, piping at the surface, patchy red and white areas on the gills, and sunken eyes. What is your primary rule out?

- **A.** Spring viremia of carp
- **B.** Carp pox
- **C.** Koi herpesvirus
- **D.** Carp edema virus disease
- **E.** Goldfish herpesvirus

The correct answer is C. Koi herpesvirus. KHV only clinically affects koi and common carp (or possibly hybrids of these species with typically resistant species). Outbreaks often occur in the spring and fall. The described clinical signs are all consistent with this disease.