
INFECTION WITH DECAPOD IRIDESCENT VIRUS 1 (DIV1)

PATHOGEN INFORMATION**1. CAUSATIVE AGENT****1.1. Pathogen type**

Virus.

1.2. Disease name and synonyms

Infection with Decapod iridescent virus 1 (DIV1). Synonyms are infection with shrimp hemocyte iridescent virus (SHIV), infection with *Cherax quadricarinatus* iridovirus (CQIV), 'white head' disease or 'white spot' disease (of *Macrobrachium rosenbergii*).

1.3. Pathogen common names and synonyms

There are two original isolations of Decapod iridescent virus 1 (DIV1): Shrimp haemocytite iridescent virus and *Cherax quadricarinatus* iridovirus.

1.4. Taxonomic affiliation

DIV1 was assigned by the International Committee on Taxonomy of Viruses (ICTV) as the only member of the genus *Decapodiridovirus* within the *Iridoviridae* family (ICTV, 2019; Li *et al.*, 2017; Qiu *et al.*, 2018b)

1.5. Authority (first scientific description, reference)

DIV1 was first described by Xu *et al.* (2016) (as CQIV) and by Qiu *et al.* (2017) (as SHIV).

1.6. Pathogen environment (fresh, brackish, marine waters)

Fresh, brackish, and marine waters.

2. MODES OF TRANSMISSION**2.1. Routes of transmission (horizontal, vertical, indirect)**

Challenge tests with *P. vannamei* and *E. carinicauda* via *per os* and reverse gavage have demonstrated that direct horizontal transmission was an important route of transmission (Qiu *et al.*, 2017; Chen *et al.*, 2019). There is no evidence of vertical transmission; however, samples from hatcheries have been found to be DIV1 positive (Qiu *et al.*, 2018c; Qiu *et al.*, 2019b). The biophysical characteristics of the virus are not well studied so it is difficult to determine the significance of indirect transmission by fomites.

2.2. Reservoir

Infected populations of crustaceans, both farmed and wild, are the only established reservoirs of infection. The original source of DIV1 is not known.

2.3 Risk factors (temperature, salinity, etc.)

Targeted surveillance in China (People's Rep. of) in 2017-2018 detected DIV1 in shrimp and crayfish at temperatures from 16°C to 32°C. The virus has not been found in samples taken at temperatures above 32°C (Qiu *et al.*, 2018c; Qiu *et al.*, 2019b).

3. HOST RANGE**3.1. Susceptible species**

Currently known susceptible species of infection with DIV1 include: *Penaeus vannamei*, *M. rosenbergii*, *Exopalaemon carinicauda*, *M. nipponense*, *Procambarus clarkii*, and *C. quadricarinatus* (Xu *et al.*, 2016; Qiu *et al.*, 2017; Qiu *et al.*, 2019a; Chen *et al.*, 2019). Two crab species, *Eriocheir sinensis* and *Pachygrapsus crassipes*, have only been shown to be infected with DIV1 in experimental challenge through unnatural pathways (Pan *et al.*, 2017), and cannot be identified as susceptible species.

3.2. Affected life stage

Disease signs and mortality were observed in infected *P. vannamei* from post larvae to sub-adult shrimp in experimental challenges (Qiu *et al.*, 2017). Targeted surveillance in China (People's Rep. of) from 2017-2018 detected the virus in shrimp and crayfish with body lengths in animals of all sizes. The highest detection rate was in animals of body length from 4 cm to 7 cm (Qiu *et al.*, 2018c; Qiu *et al.*, 2019b). Other reports have not addressed different levels of mortality by life stage.

3.3. Additional comments

None.

4. GEOGRAPHICAL DISTRIBUTION

Infection with DIV1 has been reported in some coastal provinces of China (People's Rep. of) since 2014 (Qiu *et al.*, 2017). Targeted surveillance in China (People's Rep. of) in 2017 and 2018 detected the virus in 11 of 16 provinces (Qiu *et al.*, 2018c; Qiu *et al.*, 2019b). There have been reports of DIV1 from Thailand at a very low prevalence, but this is yet to be officially confirmed (Ramsden & Smith, 2018). Wild caught *P. monodon* samples from the Indian Ocean have tested positive for DIV1 (Srisala *et al.*, 2020).

5. CLINICAL SIGNS AND CASE DESCRIPTION

5.1. Host tissues and infected organs

DIV1 infects haematopoietic tissues, haemocytes and lymphoid organs (Qiu *et al.*, 2017). Low level infection may also exist in *E. carinicauda* (Chen *et al.*, 2019; Qiu *et al.*, 2019a).

5.2. Gross observations and macroscopic lesions

Body slightly reddish, hepatopancreatic atrophy with colour fading, empty stomach and guts. In *M. rosenbergii* a white triangular area under the carapace at the base of rostrum can be observed (Qiu *et al.*, 2017; Chen *et al.*, 2019; Qiu *et al.*, 2019a).

5.3. Microscopic lesions and tissue abnormality

Histopathological examination showed the existence of dark eosinophilic inclusions mixed or surrounded by basophilic staining, and karyopyknosis in the haematopoietic tissues, epithelium, lymphoid organs, haemocytes of gills, pereopods, and hepatopancreatic sinus (Qiu *et al.*, 2017; Qiu *et al.*, 2019a; Chen *et al.*, 2019).

5.4. OIE disease listing status

Infection with DIV1 has been proposed for listing in the OIE Aquatic Animal Health Code (OIE, 2016). The disease meets the OIE definition of an 'emerging disease' and, as such, Members must report it in accordance with Article 1.1.4 of the *Aquatic Code*. Infection with DIV1 is listed in the OIE/NACA quarterly aquatic animal disease reporting programme (<https://enaca.org>)

6. SOCIAL AND ECONOMIC SIGNIFICANCE

Crustacean aquaculture is economically important worldwide, particularly for some developing countries. The global aquaculture production of crustaceans is estimated at 7.9 million tonnes with a current value of U.S.\$57.1 billion (FAO, 2018). DIV1 has been shown to cause significant mortalities (up to 100%) and has resulted in serious economic losses to aquaculture (Qiu *et al.*, 2018c; Qiu *et al.*, 2019b).

7. ZOO NOTIC IMPORTANCE

None

8. DIAGNOSTIC METHODS

In situ hybridization (ISH) (Qiu *et al.*, 2017), PCR (Xu *et al.*, 2016), nested-PCR (Qiu *et al.*, 2017), two TaqMan probe based real-time PCR tests (Qiu *et al.*, 2018a; Qiu *et al.*, 2020), and *in situ* DIG-labelling-loop-mediated DNA Amplification (ISDL) (Chen *et al.*, 2019) have been established. The nested PCR and real-time PCR methods are more sensitive and have been validated (Qiu *et al.*, 2017; Qiu *et al.*, 2018a).

8.1. Definition of suspect cases

Presence of mortalities associated with gross signs and histopathology of infection with DIV1.

8.2. Presumptive test methods

Samples are tested as positive results with one of the following test: in situ hybridization, PCR and sequencing, nested-PCR (followed by sequencing), TaqMan probe based real-time PCR or ISDL.

8.3. Confirmatory test methods

Infection with DIV1 is considered to be confirmed if two or more of the following criteria are met: gross clinical signs and histopathology consistent with infection with DIV1, ISH positive result in target tissues, PCR (followed by sequencing), nested-PCR (followed by sequencing), and TaqMan probe based real-time PCR with positive results for DIV1.

9. CONTROL METHODS

Enhanced biosecurity is the key strategy for control of infection with DIV1, including surveillance plans for farms, quarantine, and testing for DIV1 in broodstock and postlarvae. Generic biosecurity measures to minimise fomite spread via equipment, vehicles or staff (i.e. cleaning and disinfection) should also be implemented. (Qiu *et al.*, 2018c). Restrictions on the movement of live crustaceans and removal of moribund or dead individuals from affected farms will limit the spread of the disease. Crustacean polycultures should be avoided. Live or frozen raw decapods or polychaetes should not be used as feed to broodstock (Qiu *et al.*, 2018c; Qiu *et al.*, 2019b).

10. TRANSMISSION RISK

As DIV1 has been shown to be horizontally transmitted through ingestion of infected tissue, disease transmission is likely through live crustaceans and frozen product. There is limited information about biophysical properties of the virus. However, it may be assumed that it will share properties of other large particle DNA viruses in crustaceans,

such as white spot syndrome virus. Evidence suggests that different tissues, including haemolymph, antennal flagellum, rostrum, gills, hepatopancreas, pleopods, muscle and uropods, may contain high concentrations of DIV1. Consequently, solid, and liquid waste is likely to be contaminated (Qiu *et al.*, 2018a; Qiu *et al.*, 2019a).

11. ADDITIONAL USEFUL INFORMATION

- The 15th Meeting of the Asia Regional Advisory Group on Aquatic Animal Health of Network of Aquaculture Centres in Asia-Pacific (NACA) has raised awareness on *Cherax quadricarinatus* iridovirus and added iridovirus in crayfish under non-OIE listed diseases in its Quarterly Aquatic Animal Disease Report (QAAD) since July 2016. <https://enaca.org/?id=8>
- Network of Aquaculture Centres in Asia-Pacific (NACA). Infection with decapod iridescent virus 1 (DIV1): Disease card. <https://enaca.org/?id=1104&title=infection-with-decapod-iridescent-virus-1-%28div1%29-disease-card>
- China (People's Rep. of) has undertaken annual targeted surveillance for infection with DIV1 since 2017. A brief report of the annual surveillance was reported in *the annual Report for Aquatic Animal Health in China* (Edited by the Fisheries and Fishery Administration Bureau under Ministry of Agriculture and Rural Affairs and the National Fisheries Technology Extension Center, published by China Agriculture Press, Beijing, 2018 and 2019). Details of the annual targeted surveillance data analysis were published in the annual books *Analysis of Important Diseases of Aquatic Animals in China in 2017 and 2018* (Qiu *et al.*, 2018c, 2019b). Some aquatic animal emerging diseases, including infection with DIV1 have been under control with the highest biosecurity measures in China (People's Rep. of) since September 2018.

REFERENCES

- CHEN, X., QIU, L., WANG, H.L., ZOU, P.Z., DONG X., LI, F.H. & HUANG J. (2019). Susceptibility of *Exopalaemon carinicauda* to the infection with Shrimp hemocyte iridescent virus (SHIV 20141215), a strain of Decapod iridescent virus 1 (DIV1). *Viruses*, **11(4)**, 387. doi: 10.3390/v11040387.
- FAO. (2018). FAO yearbook: Fishery and aquaculture statistics.
- One New Genus with One New Species in the Subfamily Betairidovirinae. Available online: https://talk.ictvonline.org/files/ictv_official_taxonomy_updates_since_the_8th_report/m/animal-dna-viruses-and-retroviruses/8051
- LI, F., XU, L. & YANG, F. (2017). Genomic characterization of a novel iridovirus from redclaw crayfish *Cherax quadricarinatus*: evidence for a new genus within the family *Iridoviridae*. *Journal of General Virology*, **98(10)**, 2589-2595. doi: 10.1099/jgv.0.000904.
- PAN, C. K., YUAN, H. F., WANG, T. T., YANG, F. & CHEN, J. M. (2017). Study of *Cherax quadricarinatus* iridovirus in two crab. *Journal of Applied Oceanography*, **36(1)**, 82-86 (in Chinese).
- RAMSDEN, N. & SMITH, J. (2018). Clarification: Shrimp disease SHIV detected in China, Thailand, but not Vietnam. *Undercurrentnews*, **Oct. 1 2018**. <https://www.undercurrentnews.com/2018/10/01/clarification-shrimp-disease-shiv-detected-in-china-thailand-but-not-vietnam/>
- SANGUANRUT, P., THAIUE, D., THAWONSUWAN, J., FLEGEL, T.W. & SRITUNYALUCKSANA, K. (2020). Urgent announcement on usefulness of the lymphoid organ (LO) as an additional prime target for diagnosis of decapod iridescent virus 1 (DIV1) in diseased *P. vannamei*. <https://enaca.org/?id=1092&title=urgent-announcement-on-usefulness-of-lymphoid-organ-for-diagnosis-of-decapod-iridescent-virus-1>
- SRISALA, J., SANGUANRUT, THAIUE, P. D., LAIPHROM, S., SIRIWATTANO, J., KHUDET, J., POWTONGSOOK, S., FLEGEL, T. W. & SRITUNYALUCKSANA, K. (2020). Urgent warning: Positive PCR detection results for infectious myonecrosis virus (IMNV) and decapod iridescent virus 1 (DIV1) in captured *Penaeus monodon* from the Indian Ocean. NACA Newsletter, ISSN 0115-8503, 2020, XXXV: 2. <https://enaca.org/?id=1093>.
- QIU, L., CHEN, M. M., WAN, X.Y., LI, C., ZHANG, Q.L., WANG, R.Y., CHENG, D.Y., DONG, X., YANG, B., WANG, X.H., XIANG, J.H. & HUANG, J. (2017). Characterization of a new member of *Iridoviridae*, Shrimp hemocyte iridescent virus (SHIV), found in white leg shrimp (*Litopenaeus vannamei*). *Scientific Reports*, **7(1)**, 11834. doi: 10.1038/s41598-017-10738-8.
- QIU, L., CHEN, M.M., WAN, X.Y., ZHANG, Q.L., LI, C., DONG, X., YANG, B. & HUANG, J. (2018a). Detection and quantification of Shrimp hemocyte iridescent virus by TaqMan probe based real-time PCR. *Journal of Invertebrate Pathology*, **154**, 95-101. doi: 10.1016/j.jip.2018.04.005.
- QIU, L., CHEN, M.M., WANG, R.Y., WAN, X.Y., LI, C., ZHANG, Q.L., DONG, X., YANG, B., XIANG, J.H. & HUANG, J. (2018b). Complete genome sequence of shrimp hemocyte iridescent virus (SHIV) isolated from white leg shrimp, *Litopenaeus vannamei*. *Archives of Virology*, **163(3)**, 781-785. doi: 10.1007/s00705-017-3642-4.
- QIU, L., DONG, X., WAN, X.Y. & HUANG, J. (2018c). Analysis of iridescent viral disease of shrimp (SHID). In Analysis of Important Diseases of Aquatic Animals in China in 2017 (in Chinese). Fishery and Fishery Administration Bureau under the Ministry of Agriculture and Rural Affairs, National Fishery Technical Extension Center, Eds., *China Agriculture Press, Beijing*, 187-204, ISBN 978-7-109-24522-8.
- QIU, L., CHEN, X., ZHAO, R.H., LI, C., GAO, W., ZHANG Q.L. & HUANG J. (2019a). Description of a Natural Infection with Decapod Iridescent Virus 1 in Farmed Giant Freshwater Prawn, *Macrobrachium rosenbergii*. *Viruses*, **11(4)**, 354. doi: 10.3390/v11040354.
- QIU, L., DONG, X., WAN, X.Y. & HUANG, J. (2019b). Analysis of iridescent viral disease of shrimp (SHID) in 2018. In Analysis of Important Diseases of Aquatic Animals in China in 2018.. Fishery and Fishery Administration Bureau under the Ministry of Agriculture and Rural Affairs, National Fishery Technical Extension Center, Eds., (in press) (in Chinese).
- QIU, L., CHEN, X., GUO, X.M., GAO, W., ZHAO, R.H., ZHANG, Q.L., YANG, B. & HUANG, J. (2020). A TaqMan probe based real-time PCR for the detection of Decapod iridescent virus 1. *Journal of Invertebrate Pathology*, **173**, 107367. doi: 10.1016/j.jip.2020.107367.
- XU, L., WANG, T., LI, F. & YANG, F. (2016). Isolation and preliminary characterization of a new pathogenic iridovirus from redclaw crayfish *Cherax quadricarinatus*. *Diseases of Aquatic Organisms*, **120(1)**, 17-26. doi: 10.3354/dao03007.