Differential susceptibility of blue catfish, *Ictalurus furcatus* (Valenciennes), channel catfish, *I. punctatus* (Rafinesque), and blue × channel catfish hybrids to channel catfish virus

P S Silverstein¹, B G Bosworth¹ and P S Gaunt²

¹ Catfish Genetics Research Unit, ARS/USDA, Stoneville, MS, USA
² College of Veterinary Medicine, Mississippi State University, Stoneville, MS, USA

Keywords: blue catfish, challenges, channel catfish, channel catfish virus, hybrids, susceptibility.

Channel catfish virus (CCV), also known as ictalurid herpesvirus-1 (IHV-1), primarily affects juvenile channel catfish, *Ictalurus punctatus* (Rafinesque), that are less than 6 months old and was first reported by Fijan (1968). CCV outbreaks can be sporadic, and are usually associated with fry and fingerlings when the water temperature is above 25 °C (Plumb 1978). The virus has been reported to be transmitted vertically (Wise, Harrell, Busch & Boyle 1988) and horizontally (reviewed in Plumb 1978). The external signs of CCV disease (CCVD) include exophthalmia, distended abdomen and haemorrhages at the bases of fins. The trunk kidney may exhibit oedema and necrosis, and this tissue is commonly used to confirm the presence of the virus using a tissue culture assay (reviewed in Wolf 1988). In addition, the virus appears to maintain a latent state in leucocytes (Bowser, Munson, Jarboe, Francis-Floyd & Waterstrat 1985), which raises the possibility that latent CCV infection may alter the immune response to other pathogens.

It has been over 30 years since it was determined that different strains of catfish exhibited differential resistance to CCV when the virus was mixed with their feed (Plumb, Green, Smitherman & Pardue 1975). A subsequent study by Plumb & Chappell (1978) examined the relative susceptibility of blue catfish, *I. furcatus* (Valenciennes), and reciprocal blue × channel hybrids to CCV.

Since Plumb’s (1978) study, there have been no reports on the relative susceptibility of blue catfish or hybrids to CCV. The present study was conducted to determine the relative susceptibility of four different groups of fish: blue catfish, a blue × channel hybrid, a group of channel catfish obtained from 10 farms in the Mississippi Delta, hereafter referred to as the ‘industry pool’ (IP), and a new strain of catfish produced by the Catfish Genetics Research Unit of USDA at Stoneville, MS (USDA 102 × 103).

For each strain of fish, nine replicate tanks were stocked with 40 fish per tank; eight tanks were used for virus challenge while the remaining tank was used as an uninfected control. Fish were placed in 38 L tanks that were filled to 11 L and had a flow-through rate of 1.8 L min⁻¹ and allowed to acclimatize for 8 days. Fish were fed to satiation twice per day beginning the day after stocking and feeding continued throughout the course of the study.

The blue catfish (avg. wt. 3.45 ± 0.18 g) used in this study were of the D and B strain. Fry from seven different spawns were pooled and raised communally in tanks until used in the challenge. The hybrid catfish (avg. wt. 4.10 ± 0.21 g) were produced by crossing female USDA 103 strain channel catfish and D and B strain blue catfish.

Twelve hybrid spawns were pooled and used in this
study. The IP fish (avg. wt. 6.30 ± 0.28 g) were collected from 10 commercial hatcheries in MS. Four spawns were collected per hatchery. One fish from each of the 40 families was stocked per aquarium. The USDA fish (avg. wt. 6.35 ± 0.18 g) resulted from crosses between the Red River strain (also known as the USDA 102) and the USDA 103 strain. Fish from 20 families were used; 10 families had the USDA 103 as the female parent and the 102 strain as the male parent, 10 other families were from the reciprocal cross. Two fish from each family were stocked per aquarium. All fish that were used in the study were between 90 and 105 days old.

The CCV strain used in the challenge was the Auburn-1 strain. The virus was grown using channel catfish ovary (CCO) cells utilizing the procedure previously described by Silverstein, van Santen, Nusbaum & Bird (1998). Virus titrations were performed using CCO cells; titres were calculated by the method of Reed & Muench (1938).

To initiate the challenge, water flow was stopped and virus was added to a final concentration of 10^{3.5} TCID_{50} mL^{-1}. A trial that was conducted immediately prior to this challenge indicated that this was an approximate LD_{50} for channel catfish juveniles. Water flow was fully restored in 2 h and feeding was restored the day after addition of the virus. Mortalities from each tank were removed prior to each feeding and stored at -80°C until they were assayed for the presence of virus. For viral assays, the trunk kidney was homogenized in PBS with mortar and pestle. The homogenate was centrifuged at 12,000 g for 5 min and filtered through a 0.2 μm syringe filter, after which 30 μL of the filtrate was added to each well of a 12-well plate containing freshly plated CCO cells. Virus was confirmed by the presence of the cytopathic effect, characteristic of channel catfish virus (Wolf 1988). Analysis was performed using a one-way ANOVA, followed by Duncan's multiple range test.

Initial mortalities in all groups occurred within 2 days. Most mortalities occurred before day 6, thereafter mortalities were sporadic. The blue catfish were the most resistant fish, experiencing approximately 11% mortality, followed by the IP fish (47% mortality), the blue-channel hybrids (63% mortality) and the USDA 102 × 103 cross (68% mortality) (Fig. 1). The hybrids and USDA fish both had the highest daily mortalities on day 3 post-challenge. In contrast, the IP fish experienced the highest daily mortality on day 4, while the day of highest mortality for the blue catfish was on day 5 (Fig. 2). The percentage of CCV-positive fish among the mortalities examined varied according to strain. In the more sensitive groups, such as the hybrids, over 70% of the examined mortalities were positive for CCV, while in the blue catfish only 44% of the mortalities tested positive for CCV. Only one death occurred in the uninfected controls. Although this fish was negative for CCV, assays for other pathogens were not performed.

Of the groups tested, the blue catfish were the most resistant to infection with CCV. This is consistent with the results of Plumb & Chappell (1978). In their work, infection of blue catfish could only be consistently accomplished by
injection. Dipping fish in water containing CCV, oral administration of the virus, or swabbing of the gills with virus did not produce consistent infection. The fish used in their immersion studies were smaller than those used in the present study (1.9 g vs. 3.5 g), and their studies were conducted at 27 °C, whereas the current study was performed at 30 °C. Our previous experiments with channel catfish have shown that the higher temperature results in more consistent mortality (P. Silverstein, personal communication).

Plumb & Chappell (1978) did not show any data on hybrid survival, but it is often cited that blue-channel hybrids are more resistant to CCV than pure strain channel catfish (Wolf 1988; Thune 1993). In the study of Plumb & Chappell (1978), the strain of channel catfish used to create the hybrid was not noted, but it was stated that in some of the experiments ‘a strain of channel catfish known to be resistant to CCV was used’. In the present study, some of the difference in mortality may be attributable to difference in size between the hybrids and the channel catfish (4.1 g for the hybrids and 6.3 g for the channel catfish). However, a number of factors including temperature, water quality, stocking density and genetic differences could account for the disparity between our observations and those reported by Plumb & Chappell (1978).

The differences in mortality seen among the different groups of fish are unlikely to be due to CCV carrier status. A recent study demonstrated that at early ages fish that carry vertically transmitted CCV were more resistant to challenge. However, 1 month after hatching the CCV-negative and CCV-positive fish had similar susceptibilities (Hanson, Rudis & Petrie-Hanson 2004).

Although all the fish were of the same approximate age at the time of challenge (90–105 days), their average sizes varied significantly. However, because the USDA 102 × 103 fish were of approximately the same size as the IP fish the difference in mortality was neither size- nor age-related.

The difference in ability to isolate CCV from all mortalities may be due to differences in viral loads in the different fish strains. It is noteworthy that the percentage of CCV-positive fish examined correlated with the susceptibility of the strain (i.e. a higher percentage of the more susceptible fish were CCV-positive). The inability to re-isolate CCV from some infected fish has been previously observed (Plumb et al. 1975). This could be due to lower viral loads in the more resistant fish. Such determinations await further research.

In conclusion, although blue catfish appear to be relatively resistant to CCV infection by immersion, all experimental tanks with blue catfish experienced some mortality. This raises the possibility that blue catfish may be carriers of the virus and serve as a reservoir of the disease. The study also showed that all hybrid catfish cannot be assumed to be resistant to CCV.

References


Accepted: 10 March 2007
Revision received: 13 March 2007
Received: 18 December 2006