Detection and Quantification of Flavobacterium psychrophilum-Specific Bacteriophages In Vivo in Rainbow Trout upon Oral Administration: Implications for Disease Control in Aquaculture.

The use of bacteriophages in the treatment and prevention of infections by the fish pathogen Flavobacterium psychrophilum has attracted increased attention in recent years. It has been shown recently that phage delivery via the parenteral route resulted in immediate distribution of phages to the circulatory system and the different organs. However, little is known about phage dispersal and survival in vivo in rainbow trout after delivery via the oral route. Here we examined the dispersal and survival of F. psychrophilum phage FpV-9 in vivo in juvenile rainbow trout after administration by three different methods: bath, oral intubation into the stomach, and phage-coated feed with special emphasis on the oral route of delivery. Phages could be detected in all the organs investigated (intestine, spleen, brain, and kidney) 0.5 h postadministration, reaching concentrations as high as $\sim 10^5$ PFU mg intestine$^{-1}$ and $\sim 10^3$ PFU mg spleen$^{-1}$ within the first 24 h following the bath and $\sim 10^7$ PFU mg intestine$^{-1}$ and $\sim 10^4$ PFU mg spleen$^{-1}$ within the first 24 h following oral intubation. The phages were most persistent in the organs for the first 24 h and then decreased exponentially; no phages were detected after 83 h in the organs investigated. Phage administration via feed resulted in the detection of phages in the intestine, spleen, and kidney 1 h after feeding. Average concentrations of $\sim 10^4$ PFU mg intestine$^{-1}$ and $\sim 10^1$ PFU mg spleen$^{-1}$ were found throughout the experimental period (200 h) following continuous delivery of phages with feed. These experiments clearly demonstrate the ability of the phages to survive passage through the fish stomach and to penetrate the intestinal barrier and enter the circulatory system after oral delivery, although the quantity of phages found in the spleen was 100- to 1,000-fold lower than that in the intestine. It was also shown that phages could tolerate long periods of desiccation on the feed pellets, with 60% survival after storage at -80°C, and 10% survival after storage at 5°C, for ~8 months. Continuous delivery of phages via coated feed pellets constitutes a promising method of treatment and especially prevention of rainbow trout fry syndrome.