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The effect of disrupting seasonality to dynamics of epidemics: the case of KHV

Koi herpesvirus (KHV), a highly virulent disease affecting carp (fish in freshwater) that emerged in the late 1990s, is a serious threat to aquaculture industry. After a fish is infected with KHV, there is a temperature dependent delay before it becomes infectious, and a further delay before mortality. Consequently KHV epidemiology is driven by seasonal changes in water temperature. It has also been proposed that outbreaks could be controlled by responsive management of water temperature in aquaculture setups. We use a mathematical model to analyse the effect of seasonal temperature cycles on KHV epidemiology, and the impact of attempting to control outbreaks by disrupting this cycle. We show that, although disease progression is fast in summer and slow in winter, total mortality over a two year period is similar for outbreaks that start in either season. However, for outbreaks that start in late autumn, mortality may be low and immunity high. A single bout of water temperature management can be an effective outbreak control strategy if it is started as soon as dead fish are detected and maintained for a long time. It can also be effective if the frequency of infectious fish is used as an indicator for the beginning of treatment. In this case, however, there is a risk that starting the treatment too soon will increase mortality relative to the case when no treatment is used. This counterproductive effect can be avoided if multiple bouts of temperature management are used. We conclude that disrupting normal seasonal patterns in water temperature can be an effective strategy for controlling koi herpesvirus. Exploiting the seasonal patterns, possibly in combination with temperature management, can also induce widespread immunity to KHV in a cohort of fish. However, employing these methods successfully requires careful assessment to ensure that the treatment is started, and finished, at the correct time.