2 May 2018

Dr Paula Reynolds
Consultant in Fish Medicine, Aquatic Pathobiologist, Director of Research
LFH Laboratories
The Little Paddock Millfield Lane West
Frampton, Lincolnshire, PE20 1BW
United Kingdom

Dear Dr Reynolds

An undated copy of your letter to an Australian Senator raising your concerns about the proposed release of Cyprinid herpesvirus three (CyHV-3, hereafter 'the carp virus') into the Australian environment has recently been forward to me.

Although the letter is not addressed to me, I would like to respond directly to your concerns on behalf of the National Carp Control Plan (NCCP).

First, please accept my apologies for any misunderstanding regarding our work in the biosecurity sphere to control the introduced pest species common carp (*Cyprinus carpio*) in Australian waterways. Such misunderstanding was certainly not my intention.

As you are probably aware, the current stage of the NCCP is a planning process led by the Fisheries Research and Development Corporation (FRDC) on behalf of the Australian Government. The process is thoroughly investigating the most appropriate options for an integrated program of carp control, with a focus on the potential release of the carp virus, along with a complementary suite of measures.

Through this 18-month period of extensive scientific research and community and stakeholder consultation, the NCCP will ensure that the benefits and risks of a biocontrol strategy for carp are fully explored, understood and communicated. After considering all the evidence, the NCCP will make recommendations to the Australian government about the best integrated approach for controlling

carp, and whether the carp virus should be used. Governments will then reach a decision regarding virus release.

We welcome all feedback and contributions to the NCCP – including your contribution – and I want to emphasise that the NCCP is a process, not a foregone conclusion. We do not take this responsibility lightly.

Australian decisions on carp biocontrol must reflect our unique environments and the wildlife and people who rely on them. We are extremely mindful of the potential risks of biocontrol programs in Australia and the final recommendations and decisions will draw on the best available research, from within Australia and around the world.

The NCCP is bringing together world-class social scientists, economists, biologists, water-quality experts, veterinarians and risk assessment specialists to investigate the challenges, risks, costs, opportunities and potential benefits of carp biocontrol.

Our extensive research program into the potential release of the carp virus includes:

- Research using market and non-market valuation techniques to understand costs and benefits of carp biocontrol;
- A multi-method biomass study that will provide the most accurate picture obtained to date of carp abundance and distribution in Australian waterways.
- Epidemiological modelling exploring patterns of viral transmission and efficacy under varying scenarios and environmental conditions.
- Completion of trials testing susceptibility of non-target species to the carp virus.
- A quantitative assessment of the social, economic, and ecological risks posed by carp biocontrol.
- Field experiments and modelling investigating risk of water quality impacts including anoxia and blue-green algal blooms following major carp mortalities.
- Development of strategies for cleaning up dead carp.
- Exploring feasibility of secondary carp control approaches.
- Assessing productive uses for harvested dead carp.

- Social science investigating community attitudes to carp biocontrol.

For more detail on these projects please visit http://www.carp.gov.au/What-we-are-doing/Research/NCCP-research-projects.

I speak on behalf of all those working on the NCCP when I say that we are committed to investigating and understanding international experiences with the carp virus, and using these to inform our research. This is a similar approach to that taken by Australian scientists when assessing the risks and benefits of releasing two control agents for rabbits – myxoma virus and rabbit calicivirus. In the United Kingdom (and much of Europe), both the myxoma virus and rabbit calicivirus were unwanted intruders rather than carefully-deployed biocontrol agents, and Australian plans to use calici for rabbit biocontrol drew concern and criticism from international scientists. For example, Dr Brian Cooke, the CSIRO epidemiologist involved in the initial rabbit calicivirus release, described his European colleagues' scepticism as follows:

> *Our visits aroused a lot of controversy and interest and I particularly remember a talk I gave in Tübingen, Germany, at the Federal Research Centre for Virus Diseases in Animals. The seminar room was packed while I faced a grilling by veterinarians and researchers who were concerned about such use of a lethal virus. Despite some difficulties in explaining how the risks of introducing a virus could be balanced against expected economic and conservation gains from its release, this two-way exchange of information was highly beneficial. I was better able to explain and weigh up risks and benefits, while scientists in Europe had better back-ground information to help them think about the issues in context.* (Cooke, 2014, p. 68).

As Dr Cooke describes, these discussions provided a basis for mutually-beneficial dialogue between Australian and international scientists, ultimately contributing to a highly-successful biocontrol program. Indeed, rabbit biocontrol using both myxoma virus and calicivirus provided a benefit of approximately A$70 billion to Australian agriculture in the 60 years to 2011 (Cooke et al., 2013). Neither virus has infected Australian native animals, nor have they negatively affected human health. The environmental benefits of reduced rabbit populations have been substantial (Cooke et al., 2013). While rabbit and carp biocontrol are not always directly comparable, Australia's experience of the former indicates that viral biocontrol of vertebrate pests deserves thorough investigation.

I note that page two of your letter raises some particular concerns including species specificity, the impact of dead carp and secondary infections. I propose that we re-open dialogue so that we can better understand your references to literature and work undertaken in the United Kingdom. However, as a first step, please find below a summary of work currently being undertaken by the NCCP in relation to these matters:

CyHV-3 species specificity

Twenty-two non-target species have now been tested for susceptibility to the carp virus in Australia, adding to a significant global body of work demonstrating the virus's specificity to carp. Taxa tested for susceptibility by CSIRO scientists comprise thirteen species of native Australian teleosts, native short-headed lampreys, the introduced rainbow trout (*Oncorhynchus mykiss*), two amphibian (frog) species, two reptiles (a lizard and a freshwater turtle), a freshwater crustacean, chickens (a representative bird), and mice (a representative mammal). Species selected for testing represent a broad (though not complete) range of the taxonomic groups likely to encounter CyHV-3 if it is released in Australia. The selection of species for non-target susceptibility trials was reviewed and approved by the relevant regulatory body, the Australian Pesticides and Veterinary Medicines Authority, and test results have been published in the international, peer-reviewed *Journal of Fish Disease* (McColl et al., 2016). An independent review of the non-target species testing, conducted by an experienced veterinary pathologist, is also underway, reflecting the central importance of thoroughly investigating the virus's species specificity. This review will also determine whether testing of additional species is advisable.

I also note that you cite Grimmett et al. (2006), who reported CyHV-3 replication in cultured cell lines of fathead minnow (*Pimephales promelas*), as evidence that CyHV-3 may infect species other than common carp. Grimmett et al. (2006) were seeking to identify the virus responsible for a mass carp mortality in the Chadakoin River, New York. Their study was not designed to test *P. promelas* susceptibility to CyHV-3, nor do they claim to have done so. Rather, they used cultured cell lines from *P. promelas* as a tool for identifying the virus. Crucially, culturing a virus using cell lines is a different procedure to testing a species' susceptibility to a virus, and viral replication in cultured cells does not imply susceptibility in the species from which the cultured cells were drawn. Viral replication in cultured cells does not reflect a species' real-world susceptibility because cultured cells exist in isolation from the immune system. In a living fish, susceptibility or resistance to virus infection is not solely determined at the cell level, but rather involves complex host-virus interactions including virus-

specific receptor and host immune responses (Davidovich et al., 2007). Thus, there are examples wherein CyHV-3 has been observed to replicate in cell cultures of species definitively identified as non-susceptible. For example, CyHV-3 can replicate in Au cell lines derived from goldfish (*Carassius auratus*) (Davidovich et al., 2007), yet living goldfish are not susceptible to CyHV-3 (Yuasa et al., 2013).

Assumption of a simple 'single-outbreak' epidemiology

Your letter states that "*Mr Barwick and the NCCP may be expecting a simple mass carp mortality…*". I would like to respectfully refute this claim that the NCCP assumes a simplistic outcome from virus release. On the contrary, the NCCP's entire research and planning process is based on recognition of the complexity of CyHV-3's epidemiology, and challenges associated with continental biocontrol. Research to better understand the delicate inter-relationships between water temperature, carp behaviour, viral transmission, and the inevitable increase in host resistance is essential to informing the NCCP's recommendations to the Australian Government. Previous experience with biological control of vertebrate pests both in Australia and internationally has clearly shown that success is contingent upon detailed knowledge of viral epidemiology in the specific context of the planned release location, and the NCCP has thorough research underway to ensure the program capitalises on this insight.

The NCCP's carp biomass estimation project was briefly mentioned earlier in this letter, but warrants further discussion, as it will provide data essential for understanding the carp virus's epidemiology in Australian environments. International experience in natural ecosystems and Australian laboratory experiments confirm that the carp virus is transmitted between carp most effectively when fish are in close proximity or direct physical contact. Therefore, understanding carp population density in the various habitats throughout the species' Australian distribution is a fundamental input to epidemiological modelling.

Carp biomass has been estimated in several Australian locations to date, but only for geographically-restricted areas, and without a standardised methodology enabling direct comparison between areas. The NCCP's carp biomass estimation project will provide estimates with the geographic coverage and standardised sampling methodologies necessary to enable delivery of epidemiological modelling results that accurately and usefully inform decision-making. The carp biomass estimation project involves collaboration between the fisheries agencies of four Australian states and the Australian

Capital Territory, and uses a multi-method approach, enabling cross-validation of estimates derived from different sampling approaches. The project will also use carp biomass data collected during various other aquatic sampling programs, and will calibrate and standardise these valuable pre-existing data sources to strengthen biomass estimates and increase efficiency. In summary, estimating carp biomass across the species' Australian distribution is a challenging but essential component of the NCCP research program. The project draws on appropriate expertise and is based on scientifically rigorous sampling approaches.

While habitat-specific carp biomass estimates are essential for predicting patterns of viral transmission, the complex epidemiology of CyHV-3 demands consideration of other factors including carp behaviour and physiology (especially aggregation and movement patterns), water temperature and hydrological (river flow) regimes, possible evolution of resistance as carp and the virus move towards equilibrium, viral salinity tolerance, and the possible existence in Australia of benign cross-reactive viruses that could confer resistance to the virus. These factors are being investigated by CSIRO and RMIT University researchers. Like the biomass estimation project, results from this research will directly inform the NCCP's epidemiological modelling work, ensuring that predictions of virus behaviour in Australian ecosystems are based on accurate, context-specific biological knowledge, and can therefore be confidently used to inform decision-making and planning.

The NCCP's epidemiological modelling project will use data collected from Australian ecosystems and carp populations to develop a detailed understanding of virus spread, efficacy, and the consequent timing and geographic distribution of carp mortality events if virus release proceeds. Epidemiological modelling is being coordinated by an experienced CSIRO veterinary epidemiologist, and involves collaboration with experts in carp biology and Australian river hydrology. Epidemiological modelling also draws on international experience and the insights of commercial fishers and other river users, ensuring that the NCCP benefits from existing knowledge. Ultimately, the epidemiological modelling work will provide insights into viral behaviour and host-virus interactions essential for deciding whether CyHV-3 release should proceed. If carp biocontrol does proceed in Australia, knowledge derived from epidemiological modelling will inform development of virus release and clean-up strategies.

The impact of dead carp on other fish species and wildlife

Understanding and mitigating risks to water quality (and hence to other species and ecosystems) posed by possible major carp mortalities is central to the NCCP research program. University of Adelaide and University of Western Australia researchers are currently investigating the effects of decaying carp on water quality parameters, and the potential for short-term release of nutrients resulting from carp kill events to trigger cyanobacterial (blue-green algae) blooms. Crucially, the cyanbacterial component will also identify options for using river flow to divert nutrients down environmentally-benign pathways, potentially enabling some of the nutrients currently locked away in millions of invasive carp to benefit native ecosystems. Both the anoxia and cyanobacterial projects are basing their estimates on very high carp densities, providing an accurate understanding of 'worst-case' scenarios crucial to decision-making.

The anoxia and cyanobacterial projects are complemented by work underway at the University of Technology Sydney to investigate the effects of varying dead carp densities on a broad range of water quality parameters, including bacterial loads and the presence of decomposition byproducts. We are also co-investing in research to investigate appropriate water treatment responses to carp mortalities. More broadly, the NCCP risk assessment project is focussed on identifying risks to Matters of National Environmental Significance (MNES) as part of the NCCP's stringent approval process under the *Environmental Protection and Biodiversity Conservation Act 1999.* This suite of projects aims to quantify the potential impacts of major carp kills on water quality and specific ecosystem components.

A second set of projects addresses the logistical and practical elements of clean-up. These projects include a global scan and review of fish-kill clean-up approaches, including discussions with international agency staff, contractors and organisations with direct and extensive fish-kill clean-up experience, and work to explore engineering solutions that could enhance clean-up efficiency. Clean-up planning is being undertaken by a dedicated Operations Working Group (OWG) within the NCCP. The OWG includes suitably qualified and experienced representatives from all the Australian jurisdictions where carp occur, and will also consult widely with people and organisations with direct practical experience of fish kill clean-up, large-scale logistical response, and complex operational planning. The OWG will use information from research and consultation to develop effective, achievable, and flexible clean-up plans.

Risk of secondary infections:

Your letter also raises the prospect of secondary infections by pathogenic bacteria living on decaying carp bodies. Bacterial loads following carp mortality events are partly a function of water quality. Oxygen and nutrient levels are especially important determinants of bacterial proliferation. For example, your letter specifically mentions *Clostridium botulinum*, an anaerobic bacterium requiring anoxic (no oxygen) or hypoxic (low oxygen) conditions, and *Aeromonas*, some species of which multiply in decaying fish. The NCCP's work in developing strategies to safeguard water quality has been described elsewhere in this letter, but is also relevant here, as protecting water quality will provide an inherent safeguard against the proliferation of harmful bacteria.

Risks associated with harmful bacteria are also being directly assessed through research underway at the University of Technology Sydney (and already mentioned briefly). This research includes quantification of bacterial loads under varying densities of decaying carp, while the NCCP risk assessment will ensure that this risk is considered as part of legislative approval processes. The risk assessment project also provides a trigger for further investigation of bacterial risks, should these emerge as a key concern.

This letter has covered considerable detail, but a key point I would like to make is that no decision has been made at this time on deployment of a biocontrol agent for the control of carp in Australia. Rather, the National Carp Control Plan is coordinating the careful research, planning, and community consultation necessary to determine whether virus release is viable. Virus release cannot proceed unless stringent legislative approval processes, requiring transparent and thorough risk assessment, are satisfied.

As research and risk assessment under the NCCP proceeds, I welcome an open dialogue between your organisation and the Fisheries Research and Development Corporation to further discuss these and any other issues you wish to raise. There are a range of ways we can continue to work together to explore how your insights and research may benefit work underway by the NCCP. I suggest a useful next step would be a call to discuss. My number is +61 249163957. Please feel free to call any time convenient to you.

I thank you for your interest and concern.

Yours sincerely

Matt Barwick
National Coordinator, NCCP.

Further Reading

Cooke, B.D. (2014). *Australia's War Against Rabbits: The Story of Rabbit Haemorrhagic Disease.* CSIRO Publishing, Collingwood, Victoria.

Cooke, B., Chudleigh, P., Simpson, S. & Saunders, G. (2013). The economic benefits of the biological control of rabbits in Australia, 1950 – 2011. *Australian Economic History Review*, 53, 91 – 107, doi: 10.1111/aehr.12000.

Davidovich, M., Dishon, A., Ilouze, M. & Kotler, M. (2007). Susceptibility of cyprinid cultured cells to Cyprinid herpesvirus 3. *Archives of Virology*, 152, 1541 – 1546. 10.1007/s00705-007-0975-4

Grimmett, S.G., Warg, J.V., Getchell, R.G., Johnson, D.J. & Bowser, P.R. (2006). An unusal koi herpesvirus associated with a mortality event of common carp *Cyprinus carpio* in New York State, USA. *Journal of Wildlife Diseases*, 42, 658 – 662.

McColl, K.A., Sunarto, A., Slater, J., Bell, K., Asmus, M., Fulton, W., Hall, K., Brown, P., Gilligan, D., Hoad, J., Williams, L.M. & Crane, M St J. (2016). Cyprinid herpesvirus 3 as a potential biological control agent for carp (*Cyprinus carpio*) in Australia: susceptibility of non-target species. *Journal of Fish Diseases*, 10.1111/jfd.12591.

Yuasa, K., Sano, M. & Oseko, N. (2013). Goldfish is not a susceptible host of Koi Herpesvirus (KHV) disease. *Fish Pathology*, 48, 52 – 55. http://dx.doi.org/10.3147/jsfp.48.52