Integrated Pest Management Approach to Ectoparasite Management in Freshwater Aquaculture.

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Title page image: Sodium percarbonate treatment in an Australian freshwater aquaculture farm. Image J. M. Forwood.

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Summary

World aquaculture is dominated by the production of freshwater finfish. In comparison, Australia's dominant aquaculture production is marine, but there are abundant freshwater sites with high quality water available for the development of fish farms. Two fresh water finfish species have potential for aquaculture expansion in Australia: rainbow trout (*Oncorhynchus mykiss*) and silver perch (*Bidyanus bidyanus*). A factor limiting growth of the industry is the management of ectoparasitic diseases. Two problematic parasites in Australian freshwater aquaculture are the ciliate, *Ichthyophthirius multifiliis* and the monogenean *Lepidotrema bidyana*. To facilitate better on-farm management for these parasites information based on the lifecycles of these parasites, interactions between the parasites and hosts, epidemiology, minimum effective concentrations (MEC) for chemotherapeutants, histological changes in hosts exposed to chemotherapeutants and evaluated treatment application methods is required.

The effects of temperature and salinity on lifecycle duration of a temperate Australian isolate of *I. multifiliis* and the preferred settlement sites on rainbow trout are described. The Australian isolates reproduction was proportional to temperature and reproduced faster and had a greater sensitivity to salinity than other temperate isolates. Temperature-lifecycle information and identification of an optimal body region for skin scrapes for surveillance will aid in development of specific management plans for the Australian isolate of *I. multifiliis*, and facilitate strategic timing of treatments.

To improve treatment efficacy the MECs for formalin (FOR) and sodium percarbonate (SPC) were determined for *I. multifiliis*, this information is required on farms to set effective target doses. The MEC for SPC exceeded the current dose recommendations; therefore the structural damage to the gill in rainbow trout exposed to repeated higher doses of SPC was assessed based on the temperature-lifecycle information of *I. multifiliis*. There was minimal structural change in rainbow trout gills exposed to doses of SPC up to 150 mg/L

for 1 h indicating that SPC it is safe at this dose. A requirement of an efficacious treatment is delivering the target dose into the system for the desired time. To determine if current applications met this requirement, four SPC and two FOR application methods on four Australian trout farms with different flow and water quality characteristics were assessed. All methods resulted in under-dosing at various times and positions within the systems during the treatments, which can result in ineffective treatments. Applying the treatments as static baths or reducing flow limits system variables that can influence dose, and monitoring the dose throughout the treatment and adding additional product as required.

Attachment by *L. bidyana* to the gills of silver perch and resulting pathology was described using scanning electron microscopy (SEM) and histology. *Lepidotrema bidyana* attachment causes minor structural damage to the gills and presence is often associated with epitheliocystis. Treating juvenile fish in a short-term bath during grading is a way to economically reduce *L. bidyana* abundance, decreasing the need for repeated treatments in ponds. Efficacy of current treatments for *L. bidyana*: FOR, trichlorfon (DEP) and sodium chloride (NaCl) were assessed. Sodium chloride and FOR were effective *in vitro* but were ineffective at the current recommended doses *in vivo,* and DEP was ineffective *in vitro*. The current treatment's lack of efficacy highlighted the need for alternative treatments that can be administered in short-term baths. Five alternative treatments for *L. bidyana* were investigated. The only effective treatment was praziquantel (PZQ) but this was ineffective against juvenile parasites at the base of the secondary lamellae, suggesting a repeat bath or extended exposure is required to eliminate all parasites. To determine post treatment abundance a sub-sampling method used to count *L. bidyana* was validated.

Results from this research will aid in the development of integrated pest management (IPM) frameworks, enhance surveillance, inform when intervention is required, and improve efficacy when treatment is delivered through strategic timing of treatments, optimising dose and applying treatment using appropriate methods. This will improve management of these parasites on Australian freshwater aquaculture farms.

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Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text

James Michael Forwood
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Chapter 3:
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Manuscript writing: J.F., M.D., J.H., M.L.

Forwood, J., Harris, J.O. Landos M. and Deveney, M. (2014) Lifecycle and settlement of an Australian isolate of *Ichthyophthirius multifiliis* from rainbow trout. Folia Parasitologica.

Chapter 4:
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Forwood, J., Harris, J.O. Landos M. and Deveney, M. (under review). Histological evaluation of sodium percarbonate exposure on the gills of rainbow trout. *Disease of Aquatic Organisms*.

Chapter 6:
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Forwood, J., Harris, J.O. and Deveney, M. (2013). Validation of a rapid counting method for assessing treatment efficacy against *Lepidotrema bidyana* infecting silver perch *Bidyanus bidyanus*. *Diseases of Aquatic Organisms,* 105(3) pp. 253-257.

Chapter 9:
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Forwood, J., Harris, J.O. and Deveney, M. (2013). Efficacy of current and alternative bath treatments for *Lepidotrema bidyana* infecting silver perch, *Bidyanus bidyanus*. *Aquaculture,* 416-417: 65-71.

Previous publications related to the PhD

Forwood, J., Harris, J.O. and Deveney, M. (2012). Host impact of monogenean *Lepidotrema bidyana* infection and intensity estimates for onsite monitoring. *Diseases of Aquatic Organisms,* 100(1): 51-57.

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