Cannibalism in Barramundi *Lates calcarifer*: Understanding Functional Mechanisms and Implication to Aquaculture

Flavio Furtado Ribeiro, BSc. MSc.

A thesis submitted for the degree of Doctor of Philosophy,

School of Biological Sciences,

Faculty of Science & Engineering,

Flinders University

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Summary

Cannibalism is a major issue in the culture of piscivorous fish and severe cannibalism can cause great production loss especially during the larval and juvenile period. This thesis uses barramundi *Lates calcarifer* as a representative of typical carnivores to understand the mechanisms behind fish cannibalism and to develop protocols for fish cannibalism control in aquaculture. Four studies were performed to investigate (1) the morphological limitation of cannibalism, (2) the prey size selection and cannibalistic behaviour, (3) the bioenergetics and growth advantage of cannibalism, and (4) the effects of environmental and biotic factors on barramundi cannibalism. In study 1, it was found that barramundi would become cannibals when conspecifics were smaller than 50% of the cannibal size. Once an individual became cannibal, it would progressively develop its predatory capacity to ingest a conspecific prey up to 78-72% of its total length (25-131 mm total length, respectively). The maximum ingestible prey size relative to the cannibals decreased as cannibals grew, as a result of allometric growth of body parts. In study 2, cannibalistic barramundi (40–130 mm total length) showed a consistent preference for smaller prey when the prey size was in the range of 30-65% cannibal size. A behaviour-energetic analysis showed that smaller prey would result in more energetic gain in cannibals. Cannibalistic profitability was inversely correlated to cannibal size as illustrated by the reduction of prey vulnerability as fish grew. In study 3, cannibalistic barramundi (77 mm total length) showed a better growth performance by preying on conspecifics than siblings fed on formulated diets. The better growth performance by preying conspecifics was achieved by higher feed conversion efficiency and more energy allocation to growth than in those fish fed solely on formulated diet. Therefore, the fast-growing cannibals would continuously find slow-

growing and smaller victims to prey on, leading to a long-lasting cannibalism. In study 4, the effects of stocking density (1, 5 and 10 fish L^{-1}) and feeding frequency (once and three times per day) on barramundi cannibalism were tested in a 40-day trial starting with homogeneous fish size of 20 mm total length in average. Low feeding frequency and high stocking density were more likely to provoke cannibalism. The increase in fish size heterogeneity under the regime of low feeding frequency led to the emergence of cannibals, resulting in long-lasting cannibalism. In contrast, feeding frequency at three times per day suppressed cannibalism though could not exclude mortalities owing to wounds and suffocation. In summary, aggressive or predatory behaviour is inherent to barramundi, but cannibalistic impact on fish survival in aquaculture can be reduced by keeping a fish size difference under 50% through size grading, high feeding frequency and low stocking density. When the size of smaller fish is <50% of larger ones, cannibalism will prevail in the barramundi population during the nursery period of fish culture.

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.

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Flavio F. Ribeiro

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