THE ROLE OF SOCIAL RANK IN THE DEVELOPMENT, PHYSIOLOGY AND REPRODUCTIVE STRATEGIES IN SALMONIDS

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

…… JEFFERSON MURUA

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ABSTRACT

Salmonids naturally organise into social hierarchies both in the wild and aquaculture. This thesis investigates how social rank influences the physiology and development of salmonids with different life strategies using Atlantic salmon (*Salmo salar*) as a model. In broad terms two types of studies were conducted. Firstly osmoregulatory traits of freshwater parr prior to smolting, maturing or remaining immature where investigated using Na^+ gill uptake kinetics. Highly distinct patterns emerged, especially for Na^+ uptake affinity, between future alternative phenotypes, which could potentially be used as an identification tool in otherwise visually identical fish. Examination of Na^+ uptake kinetics from a social status perspective revealed that first and intermediate ranked fish, which received less aggression and had lower cortisol, were better prepared for sea water entry. In the second batch of studies brain serotonergic activity (5-HIAA/5-HT), a key regulator of agonistic behaviour in vertebrates, was examined in a range of social conditions. First, the stability of social ranks was tested by food manipulation. The most dominant fish were able to retain their high status even after being kept in nutrient poor conditions. High status was associated with a high standard metabolic rate (SMR) and low brain 5-HIAA/5-HT. Secondly, studies on hierarchies with marked bimodal size asymmetries showed that upper modal group fish (UMG) became dominant. Despite being subordinate lower modal group (LMG) individuals showed similar growth rates, serotonin turnover and cortisol to UMG fish, possibly due to high aggression and fin injury sustained by high rank fish fighting for dominance. Thirdly, the association between social dominance and developmental pathway was examined in size-matched groups of immature parr and precocious parr, with the latter obtaining higher social positions and showing higher aggression. Brain serotonin turnover revealed higher 5-HIAA/5-HT in immature parr, a phenotypic distinction that was also identified in immature salmonids in aquaculture. Plasma samples from alternative life histories (immature parr, precocious parr and smolts) were also used for a preliminary investigation of potential metabolite signatures utilising metabolomic techniques.

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ABBREVIATIONS

ACTH Adenocorticotrophic hormone

CNS Central nervous system

CRF Corticotrophin releasing factor

DA Dopamine

DOPAC 3,4-dihydroxyphenylacetic acid

E Epinephrine

5-HIAA 5-hydroxyindoleacetic acid

HPA Hypothalamus-pituitary-adrenal (axis)

HPI Hypothalamus-pituitary-interrenal (axis)

HR High responders

5-HT 5-hydroxytryptamine, serotonin

5-HTP 5-hydroxytrytophan

LMG Lower modal group

LR Low responders

L-DOPA 3,4-dihydroxyphenylalanin

MAO Monoamine oxidase

MRC Mitochondria rich cell

Na^+,K^+-ATPase Sodium, potassium ATPase

NE Norepinephrine

PNA Peanut agglutinin binding

SMR Standard metabolic rate

TRP Tryptophan

UMG Upper modal group