ZEBRAFISH AS A MODEL FOR INVESTIGATING THE PHYSIOLOGICAL BASIS OF DOMINANCE AND ITS DISRUPTION BY ENVIRONMENTAL CHEMICALS

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Introduction:

The zebrafish (*Danio rerio*) is an emerging model for studying social behaviour in fish, as well as an established model in ecotoxicology. In this species, dominance hierarchies are established in both sexes in small groups, and dominant individuals have a greater reproductive success. The physiological basis of dominance, and whether this may act as a target for chemicals discharged into the environment, has however yet to be characterized.

Methods:

We undertook a series of studies to determine the physiological underpinnings of dominance, including its neurological mechanisms. This knowledge was then used to unravel possible mechanisms of effect of the environmental oestrogen 17α-ethinyloestradiol (EE_2) on social hierarchies in this species.

Results:

Comparing the physiology of dominant versus subordinate zebrafish, we found wide-ranging differences, which varied temporally and between the sexes. Dominants were larger in size than subordinates and had both lower plasma cortisol and lower expression of a suite of hypothalamo-pituitary-interrenal (HPI) axis genes. Gene expression profiles in the spleen also suggested differences in immune status between ranks. In females, dominants had a larger gonad and showed different patterns of germ cell development, but this was not the case in males. Dominant males, however, had higher levels of plasma 11keto-testosterone (11-KT) than subordinates. Targeted analyses of 40 genes involved in aggression in the brain identified substantial differences between ranks associated with phenotypic differences in aggressiveness, which occurred mainly in the hypothalamus and telencephalon. These results implied regulatory control of aggression in dominant fish by the hypothalamo-neurohypophysial-system (HNS), serotonin, somatostatin, dopamine, HPI, hypothalamo-pituitary-gonadal (HPG), and histamine pathways. These proposed roles were supported by pharmacological manipulations of various nodes within the axes. Exposure to EE_2 (at 10 ng/L for 10 days) caused 50% of dominant males to loose their dominant rank and show reduced aggression, while the aggression of subordinate males increased, and the consequences of these changes in behaviour for reproductive success were assessed. Differences in sex steroid gene expression, plasma 11-KT, and brain gene expression present between ranks in control fish were no longer present, or were reversed, after exposure, suggesting possible mechanisms of effect of`EE_2 on fish behaviour.

Conclusion:

In summary, we characterised wide-ranging differences in physiology that develop in individual zebrafish upon social hierarchy formation. This information is important both for the development of this species as a behavioural model and for understanding behaviour in fish more widely. Oestrogens present in the environment can affect key neurological systems controlling aggression and physiological differences associated with dominance in fish, and this can alter social hierarchies and affect breeding outcomes with implications for fish populations.