CITY UNIVERSITY OF HONG KONG

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Survival Strategies of Common Carp, *Cyprinus carpio*, during Prolonged Starvation and Hypoxia

鯉魚於長期饑餓與缺氧情況下的生存策略

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Abstract:

There are many similarities in the responses of animals to hypoxia and starvation such as depressed metabolism, reduced locomotion and impaired reproductive ability. We hypothesize that there are similarities in the gene expression profile during starvation and hypoxia, in both cases directed towards energy conservation. Common carp, *Cyprinus carpio*, a hypoxia-tolerant fish, is able to survive prolonged periods of food deprivation. Carp were exposed to prolonged (six weeks) exposure to hypoxia or starvation. All fish survived these treatments. Liver and kidney gene expression profiles reflected the metabolic depression observed in both starved and hypoxic carp, however, the responses were somewhat different, with a different time frame between starvation and hypoxia and between tissues.

Carp kidney genes respond to starvation much faster than liver. In the kidney, many genes involved in ATP generating pathways (glycolysis, tricarboxylic (TCA) cycle, and oxidative phosphorylation); as well as ATP-consuming pathways (ubiquitin-proteasome degradation pathway, protein biosynthesis) were down-regulated. On the contrary, liver only showed altered gene expression after 16 days and up-regulation of glycolytic genes were observed after 42 days of starvation, which coincided with decreased in hepatic glycogen content. Interestingly, no change in hepatic lipid and protein was observed. Other genes involved in processes such as signaling, transcriptional regulation, stress responses were also identified to respond to starvation in carp. In addition, starvation-induced gene expression in common carp was found to be very different from that observed in mammals and the

general metabolic changes associated with starvation in mammals are not applicable to fish.

Unlike starvation, carp liver and kidney responded to hypoxia similarly and more acutely. Anaerobic respiration genes and some gluconeogenic genes were induced during hypoxia, whereas expressions of genes involved in other metabolic pathways were virtually all suppressed. The degree of induction or suppression of these genes declined or leveled off with prolonged hypoxia. Surprisingly, myoglobin, a known muscle-specific gene, was found to be induced strongly in both hypoxic carp liver and kidney. In this study, uncoupling protein 2 which limits free radicals production by mitochondria, was greatly enhanced during hypoxia in carp. The gradual reduction of hypoxia-induced gene expression as hypoxia was prolonged probably reflects the re-establishment of homeostasis in these hypoxic carp.

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