Diversity of sex determination in fish: Lesson learned for sex manipulation in aquaculture

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ABSTRACT:
Controlling the sex ratio is an important and essential aspect of fish aquaculture. A balanced sex ratio is useful for broodstock management and enables the development of appropriate breeding schemes. In some species, production of monosex populations is desirable because sexual dimorphism in growth, color and shape renders one sex more valuable than the other. Knowledge of the genetic architecture of sex determination (SD) is pivotal for sex manipulation in breeding programs. Mammals and birds have highly conserved master genes that control a genetic network responsible for gonad differentiation but large diversity of SD mechanisms has been reported in fish. Dynamic complexity and rapid sex chromosome turnover make fish an interesting study model to answer questions about the genetic diversity and evolutionary origin of sex determination mechanisms. These phenomena were studied in catfish and fighting fish as important aquaculture species where SD systems remain poorly understood. Comparative genomics with genome-wide SNP and linkage homology analyses were applied across different species and populations, coupled with chromosomic approaches to investigate and characterize SD systems. Whole genome sequencing was also performed using multiple platforms including Illumina, Pacbio, Oxford Nanopore and Hi-C sequencing to generate reference level assemblies and isolate entire sex chromosome sequences from their genomes. Results from SNP data in both fish lineages revealed several sex-linked loci, supporting the hypothesis of complex multiple XX/XY and ZZ/ZW or polygenic sex determination systems in the lineages. In Siamese fighting fish, the sex determining region was identified from SNP data at chromosome 9. These findings provide a solid baseline to reveal the diversity of sex determination mechanisms and identify potential sex determination markers in a variety of fish species, thereby facilitating further investigations of genetic improvements in breeding programs.

KEYWORDS:
catfish; fighting fish; sex chromosome; genomics; SNP