The Potentials of Inter-specific Hybrids in Fin Fish Aquaculture

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Abstract—Inter-specific hybrids have been produced to increase growth rate, improve productivity through heterosis, transfer desirable traits, reduce unwanted reproduction through production of sterile fish, combine other valuable traits such as good flesh quality, disease resistance and increase environmental tolerances, better food conversion and utilization, and increase harvestability in aquaculture systems. Hybrids play a significant role for increase in aquaculture production of several species of marine and freshwater fishes; for example, hybrid catfish in Thailand, hybrid striped bass in the USA, hybrid tilapia in Israel and hybrid characids in Venezuela. With the expansion of aquaculture sector and the increased number of species being bred and farmed, there are hybrids that now account for a substantial proportion of national aquaculture production. As the domestication of fish species increases, the possibilities to increase production through appropriate hybridization techniques is ongoing with a view to produce new hybrid fishes, especially in culture systems where sterile fish may be preferred because of the concern that fish may escape into the open freshwater, marine and coastal environment. Chromosome-set manipulation has been combined with hybridization to increase the viability and to improve developmental stability of hybrid fishes. Intentional or accidental hybridization can lead to unexpected and undesirable results in hybrid progeny, such as reduced viability and growth performances, loss of color pattern and flesh quality and also raises risks to maintenance of genetic integrity of species if the hybrids escape to the natural habitat and undergo backcrosses with the parental species. The success of inter-specific hybridization can be variable and depend on the genetic structure, crossing patterns, gamete compatibility and gene flow patterns of the parental species. Proper acquaintance on the genetic structure of the broodstock, appropriate broodstock management and checking of the viability and fertility of the progeny of brood fishes is thus very essential before starting the hybridization trials. In addition, some non-generic factors such as weather conditions, culture systems, seasons and stresses associated with selecting, collecting, handling, breeding and rearing of broodstock and progeny may greatly influence hybridization success in a wide variety of freshwater and marine fin fishes.

Keywords—Inter-specific hybridization, Desirable traits, Hybrid vigor, Stock improvement, Aquaculture production.

I. INTRODUCTION

THE mating or crossing of two different species is a process called hybridization with the offspring known as hybrids. Hybrids can have some characteristics of both parental species. When a hybrid has characteristics superior to both parents, it is believed to certify hybrid vigor or positive heterosis, which obviously, the final breeding goal. Inter-specific hybrids thus, have attracted attention because they can improve productivity through hybrid vigor, transfer desirable traits such as better growth and flesh quality, disease resistance and increase environmental tolerances or produce sterile animals [1–8]. This paper focuses on the crossing among different genetically distinct species and rearing of hybrids to understand the potentiality of hybrids in the world’s aquaculture production.

II. USE OF INTER-SPECIFIC HYBRIDS IN AQUACULTURE PRODUCTION

Inter-specific hybridization has long been practiced in various species of fishes to increase growth rate, improve flesh quality, produce sterile animals, increase disease resistance and environmental tolerance, and to improve other quality traits to make fish more profitable. The increased use of artificial propagation and in-vitro fertilization techniques and increased knowledge of breeding biology inspire the aquaculturists to produce hybrids in a view to improve the quality traits over their pure parental siblings. Evaluation of some of the important traits and performances that have been improved through hybridization among different species of fishes are described below:

A. Improved growth performances

Enhanced growth rate is the most desirable trait for stock improvement in aquaculture. Increased heterozygosity has been implicated in improved growth and other desirable characters in a variety of species such as developmental compatibility [9] food conversion efficiency, and oxygen metabolism [10]. A hybrid between white bass (Morone chrysops) and the striped bass (M. saxatilis) is called sunshine bass, exhibits faster growth and has many good culture characteristics than either parents under captive culture system [11]. Crosses of the black crappie x white crappie (Pomoxis nigromaculatus x P. annularis) stocked in small ponds and impoundments [12] were reported to grow faster.
The tiger trout, a hybrid between brown trout (Salmo trutta) and brook trout (Salvelinus fontinalis) is sterile with good growth rate and good overall performance in cage culture [15]. The hybrid between striped bass (Morone saxatilis) and yellow sunfish (Lepomis cyanellus) with blugill (L. macrochirus) [14], and crosses of the gilthead seabream (Sparus auratus) with red seabream (Pagrus major) also had positive heterosis in growth rate and other culture characteristics [15].

B. Production of sterile animals

Production of sterile animals may be advantageous to diminish unwanted reproduction or to improve growth rate and avoiding energy loss due to prolific breeding. The cross between the black crappie (Pomoxis nigromaculatus) and white crappie (P. annularis) exhibits positive heterosis and is often recommended for stocking in small impoundments because of reduced fertility of the F2 generation that would prevent overpopulation [12].

The red seabream x gilthead seabream cross also produced sterile hybrids and this may be an important quality in marine aquaculture due to improved growth rate and good overall performance in cage culture [15]. The tiger trout, a hybrid between brown trout (Salmo trutta) and brook trout (Salvelinus fontinalis) is sterile with good growth rate and therefore is useful for stocking areas where reproduction is to be very limited.

C. Manipulation of sex-ratio

Production of mono-sex populations is often desirable for aquaculture development. This preference should be due to growth differences between sexes, e.g., male tilapia grows faster than females, whereas female salmonids and sparids grow better than males. A particular sex chromosome may produce a valuable product and monosex populations help reduce unwanted reproduction as well as improve growth performances. Hybridization between some species of tilapias such as Nile tilapia (Oreochromis niloticus) and the blue tilapia (O. aureus) results in the production of male offspring and reduces unwanted reproduction in grow-out culture [16]. The hybrid between striped bass (Morone saxatilis) and yellow bass (M. mississippiensis) produced 100% females with excellent survival and growth [17].

D. Overall improvement

The principal aim of hybridization is to combine desirable traits from different species to increase the overall production or marketability of a cultured species. The major hybrid catfish cultured in Thailand is a cross between African (Clarias gariepinus) and Thai (C. macrocephalus) catfish, which combines fast growth rate of the African catfish with the desirable flesh characters of the Thai catfish [18]. The hybrid between rohu (Labeo rohita) and catla (Catla catla) grows exactly as fast as pure catla, but has the small head characteristics of the rohu and is therefore valuable in Indian aquaculture farms [19]. The sunshine bass hybrid (white bass x striped bass) has a suite of traits including high thermal tolerance, resistance to stress and disease, high survival in water-bodies, and ability to utilize soy beans as a protein source [20]. Among the interspecific hybrids of North American catfish, crosses between channel catfish (Ictalurus punctatus) and blue catfish (I. furcatus) exhibits good culture characters of the channel catfish with the ease of harvesting characters of the blue catfish such as better angling and increased seinability [21]. Once breeding problems are worked out, these hybrids may be useful in culture as they show heterosis for growth rate and are superior to channel catfish in low oxygen tolerance, disease resistance uniformity in body shape, angling vulnerability, seinability, and dress-out percentage [21].

E. Disease resistance and environmental tolerances

Hybridization may be used to improve disease resistance by breeding a higher resistant species with a less resistant one. It has been reported that the rainbow trout (O. mykiss) x char (Salvelinus spp.) triploid hybrids had increased resistance to several pathogenic salmonid viruses, and early sea water tolerance [22]. Hybridization between Mossambique and Nile tilapias yields a red tilapia with higher salinity tolerance [23]. Crosses between Nile tilapia and blue tilapia also resulted in progeny with good salinity tolerances [24]. Hybrids also may be used to exploit degraded aquatic environments. Lakes affected by acid rain may not be suitable for native salmonids, but splake, a hybrid between lake trout (Salvelinus namaycush) and brook trout (S. fontinalis) can tolerate reduced pH levels of 4.9-5.4 of acid lakes of Ontario. The splake also was shown to have higher survival and growth than both brook and lake trout in lakes with pH in the range of 5.5-7.2 [25].

F. Hybrid polyploidization

Hybridization combined with chromosome manipulation may increase the viability and developmental stability of hybrid fishes during early life history stages [26]. Triploidization of Atlantic salmon (Salmo salar) x brown trout (S. trutta) hybrids increased survival and growth rate to a level comparable to Atlantic salmon [27]. General disease resistance was improved by triploidizing the cross between rainbow trout and char; rainbow trout and coho salmon triploid hybrids had increased resistance to infectious disease [22]. Triploid Pacific salmon hybrids between chum salmon (Oncorhynchus keta) and chinook salmon (O. tshawytscha) have earlier seawater acclimatization times and higher salinity tolerance [28].

G. Experimental hybridization

Hybrids produced from appropriate cross-fertilization techniques among commercially important fish species have been tested for their growth performance, viability and fertility. Hybrid produced experimentally between Sheim (Acanthopagus latus) and sobiaty (Sparidentex hasta) in Kuwait appears to have good growth, flesh quality and is fertile [4, 7]. Experimental hybrids (marbled grouper x camouflage grouper) exhibited faster growth performances and increased conversion efficiency [29]. Hybrid between the Beluga (Huso huso) and Russian sturgeons (Acipenser...
Hybridization with wild fish is especially prevalent in tilapia ponds connected to natural water bodies that contain indigenous or wild tilapia populations. Such uncontrolled hybridization could undermine the performance of cultured stocks and make future use of the contaminated stocks as broodstock questionable. For example, wild three-spotted tilapia (Oreochromis asotus) invaded Nile tilapia ponds in Mozambique and produced hybrid tilapia that were less marketable than pure Nile tilapia. Inadvertent hybridization at a chinook salmon hatchery was suggested as the probable explanation for the appearance of chinook x coho salmon hybrids in a California stream [36]. The level of unintentional or accidental hybridization has important considerations of aquatic biodiversity and will influence risk assessment on the use of hybrid fishes in aquaculture.

H. Unplanned/accidental hybridization

Unplanned and accidental hybridization in hatchery stocks may cause a genetic deterioration into the aquaculture production and open water fisheries. During the production of Indian major carp seeds, different species often are induced to spawn in a common spawning tank thus providing the opportunity for unintentional hybridization [33]. Silver carp (Hypophthalmichthys molitrix) and bighead carp (Aristichthys nobilis) sometimes are hybridized inadvertently because of their similar appearance and because of the shortage of “the correct” species at spawning time due to differences in maturation times between male and female. This hybridization often results in a fish that does not feed efficiently as its gill rakers are intermediate in shape between those of the silver carp that eats phytoplankton and those of the bighead carp that consumes zooplankton. Interspecific hybridization in some carp species has recently been reported in Bangladesh [34]. Either out of scientific interest or shortage of adequate hatchery populations (i.e., brood stock), introgressed hybrids are being produced intentionally or unintentionally by private hatchery operators and sold to hatchery and nursery owners. These hybrids are being ultimately stocked knowingly or unknowingly, either in grow-out ponds or in open water bodies like floodplains. Hybrid introgression in major carp species is very likely to have negative consequences as a result of loss of distinct feeding strategies of the pure species [35]. If the introgressed hybrids reproduce in natural water bodies or are used as broodstock in hatcheries, they will not be true breeders; therefore, collection of carp seed from the pure species/strains will be difficult.

It should be concluded that hybridization is not only a preferred method of genetic improvement but also a potential tool for stock improvement through transmitting desirable traits in inferior parents. Appropriate evaluation of hybridization depends solely on the genetic structure, crossing patterns, gamete compatibility and gene flow patterns of the
parental species. Practical knowledge on the genetic constitution of brood fishes is thus very crucial before initiating hybridization experiments. It can not be ignored that some non-generic factors such as weather conditions, culture systems, seasons and stresses associated with selecting, collecting, handling, breeding and rearing of broodstock and progeny may influence hybridization success to a greater extent.

REFERENCES


