Candidate Species for Florida Aquaculture: *Discus Symphysodon* spp., a Profitable but Challenging Species for Florida Aquaculture[1]

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General Description

Discus fish of both wild and domestic origin are in great demand by freshwater aquarium enthusiasts and command high prices worldwide. The peaceful behavior, body shape, posture, and stance of the fish, along with its appealing colors and pattern markings (often associated with royalty) have earned it the reputation of "King of Aquarium Fishes."

Discus fish are very laterally compressed and have disc-shaped bodies. They can grow 15–20 cm in total body length and height (approximately 6 to 8 inches; a size similar to the 18–22 cm of an Olympic throwing discus); adults weigh some 150–250 grams (approximately one third to half of a pound). There are no morphological or sex-specific color differences, but males may grow larger than females. Although discus fish are highly variable in color and pattern markings, their body base colors usually range from dark brownish to blue and green hues. They are spotted and striated with blotches of black, yellow and red pigmentation.

Habitat and Feeding

Discus fish have been collected for the aquarium trade from the wild in water tributaries belonging to the Amazon River of Brazil, Colombia, and Peru. They are found primarily in still or slow-moving bodies of water, over sandy or sediment-free bottoms topped with decomposing leaf litter and wood debris. They prefer water temperatures ranging from 26°C to 31°C (79°F–88°F); although temperatures in still, shallow pools may rise to 35°C (95°F) and above. Although often collected in the black waters of the Rio Negro in Brazil, discus fish are also found in clear and white water tributaries of the western, central, and eastern Amazon River. Black waters are often nutrient-poor and contain high levels of dissolved humic and tannic acids, products of the decay of organic matter. These acids impart the dark brown color to the water and make itacidic (pH usually below 5.0). White waters are characterized by high turbidity and nutrient levels, with pH close to neutrality (pH 7.0); clear waters are typically transparent with pH 4.5 to 7.8. Field studies have found that discus fish often congregate or school under "galhadas" or submerged tree crowns and shore scrub. They have also been known to school in large "families" of up to 400 individuals. The congregation of discus in "galhadas" or other submerged substrate has been suggested as a mechanism of reproductive isolation leading to the color variations observed within populations in the same Amazonian drainage system. In the wild, discus fish consume principally periphyton (the nutritive slime that builds up on underwater surfaces and substrates), plant

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matter, and edible material originating from outside the water such as falling detritus or insects.

Conservation Issues

Although it is not well documented, the absence of discus fish from some of their traditional fishing areas has led fishermen to report possible declines in discus wild populations. Especially in the last ten years, such reports have been increasing, leading researchers to speculate that over-fishing and destructive fishing methods may have diminished populations of the brown discus. These observations further emphasize the need to aquaculture the discus, potentially relieving the pressure on the wild population from collection for the aquarium trade.

Taxonomy or Classification

"Discus" is a generic term for a distinct group of ornamental fish belonging to the family Cichlidae. The cichlid family also contains other important groups of colorful aquarium fishes like the cichlids of Lake Malawi and Lake Tanganyika in Africa. Angelfish of the genus *Pterophyllum*, and tilapias (popular food fishes), also belong to the cichlid family. Discus are classified in the genus *Symphysodon* (referring to the reduced dentition the fish has at the jaw symphysis, the area at the front of the mouth where the jaw bones meet), but there is considerable dispute on their classification at the species level. Most widely accepted schemes recognize two species of discus and some five clades, or related groups, sometimes referred to as subspecies: the species *Symphysodon discus*, that is comprised of the 'Heckel' and 'Abacaxis' varieties, and the species *Symphysodon aequifaciatus*, consisting of the 'Brown', 'Blue', and 'Green', varieties; a relatively new, sixth variety of 'Xingu' discus was reported from the Xingu River drainage in Brazil. The five, six, or more varieties of discus are typically identified by their body color and marking patterns, and which portion of the Amazon River basin they originated. The water flow, dissolved oxygen, pH, dissolved nutrients, and turbidity of the body of water seem to greatly influence the evolution of color types associated with the different varieties of discus.

The 'Heckel' variety of discus was first described from the Rio Negro River basin by Dr. Johann Heckel in 1840, hence it's name. The 'Heckel' discus inhabits primarily the black water streams and pools in the Rio Negro river basin and Guyana Shield region (northern sector of the Amazon River basin). Instead, its sister variety, the Abacaxis or 'Pineapple' discus, was described from the Rio Abacaxis, a tributary of the Rio Madeira, Brazil (southern sector of the Amazon River basin). The 'Brown' discus are recognized primarily from the central and eastern Amazon River drainage, and typically found in slow-moving white and clear bodies of water. The 'Blue' and 'Green' discus varieties are known primarily from the central and western Amazon River basin, typically from the more clear water river areas. Although the Xingu River is in the eastern section of the Amazon River basin, it is considered to have clear water. Refer to Table 1 for a summary of proposed classifications and scientific names for discus.

Although there have been numerous classification schemes describing discus species and subspecies, one important fact remains: all the species, subspecies, and varieties of discus are crossbred and produce fully fertile offspring. Therefore, given the different classification schemes proposed for discus, the phylogenetic evidence provided by conventional and modern molecular tools, and the practical considerations for selecting, culturing, and domesticating an aquatic species, the authors of this publication have adopted to classify *Symphysodon* as an unispecific genus (a genus with just one evolutionary unit or generic species, in this case, *Symphysodon* spp). However, we agree with Farias and Hrbek (2008), who propose that no specific species of discus exists and that the genus *Symphysodon* is in the process of speciation. As a result, no ancestral or descendent species can yet be identified. Since all discus groups can hybridize, a multitude of varieties and strains have been developed, are recognized by hobbyists, and are available worldwide through the aquarium fish trade (Figure 1). The trade has expanded from the traditional brown, blue, and green varieties and now markets turquoise, blue diamond, solid red, pigeon blood, golden, snakeskin, leopard and leopard snakeskin, ghost, snow white, and albino strains.

Figure 1. The phenotypic varieties in the discus species can be seen here with color variations from dark red to turquoise.
Credits: Acuario Calypso

Genetics and Domestication

The understanding and application of fundamental genetic principles are essential for the mass production and commercialization of discus fish. Desired heritable traits or characteristics that can be transmitted from parent to offspring must be identified and selected and a selective breeding program put in place to produce a population with the desired color markings and looks (phenotype). Since discus fish have such a wide range of colors expressed from breeding hybridization, it is important to maintain control of the genetic strains. Conveniently, genetic variants or strains in discus fish generally inherit changes in body base color and pattern markings, and hobbyists worldwide are continuously creating new varieties of discus and introducing them to the market place. Such varieties are a result of selecting a fish with a mutation that exhibits a particular desirable marking and carrying out selective hybridizations with such mutant or other discus strains that exhibit the desirable traits. Viable mutations occur infrequently but are almost always quickly detected because of the close network communications among discus fanciers all over the world.

The market for discus fish now depends upon the constant development of new strains (presently there are close to 100 distinct strains). One viable strategy to intensify commercialization of discus is to select or create a strain that is popular and mass-produce and market them. The difficulty of mass rearing discus young represents a major constraint upon the mass commercialization of discus fish. Fortunately, much information exists in the hobby literature on the particular breeding schemes and viability of crosses that may be incorporated to possibly standardize discus production.

The guidelines developed for breeding and selection programs serving land-based agricultural industries (e.g., dairy or poultry), and now also implemented in the food fish aquaculture industry will work for discus fish as well. With a well-founded pedigree (perhaps with some performance and progeny testing), and an effective number of brood stock (e.g., some 20–30 pairs for each generation), one can develop a simple mating scheme for a genetic individual or family selection program. Tave (1995) provides an excellent introduction to selective breeding programs for fish that can easily be implemented on a discus farm.

Culture Methods

Breeding

The first step to establishing domestication and subsequent cultivation is through a good program on brood stock development. Discus breed like many other cichlids, in that they naturally pair one male with one female in "breeding pairs." Selection of these breeding pairs can be difficult; most breeders keep a group of 6–8 supposed males and females together until pre-spawning behavior is observed. Pre-spawning behavior includes territorial behavior and a courtship dance of swimming toward each other and splaying and retracting the tail fin.

A study of ovarian development in female wild discus fish revealed they have oocytes in various stages of development and are fractional spawners, with multiple spawning events in a season. Discus eggs are adhesive and stick to any surface (plants or woody debris in the wild). The outer surface of the eggs is composed of fine fibers called fibrils that form a jelly-like coat. Discus eggs have a single micropyle (the pore through which the spermatozoa enters the egg) that is smooth and funnel shaped with irregular sides when viewed under an electron microscope. Measurements of fecundity in discus have shown production of 300–400 eggs per spawn, each 1 mm in size.

Discus attach their eggs to a substrate like the freshwater angelfish *Pterophyllum scalare*, and the same method used to induce spawning in that species is effective for discus fish. In many cases a clay slate, breeding cone, or overturned flowerpot serves as a spawning stimulus and provides a suitable substrate for the female to lay her eggs on. Raising the temperature and slightly lowering the pH of the water have been known to serve as environmental triggers to spawning. Some aquaculture facilities also use injectable hormones. When the female finishes depositing eggs and the male has fertilized them, male and female begin their first stages of parental care by guarding, fanning, and moving oxygenated water over the eggs, which incubate for 3–4 days. Brood stock spawning and newly hatched larvae require low pH (5–6.5), and low alkalinity (60–90 mg/L). Most breeders achieve the correct pH and alkalinity with the aid of a reverse osmosis system, but it is also possible to grow discus to maturity in neutral and buffered waters. Natural spawning and growing of fish occur under normal light regimes (i.e., light between 6 am and 6 pm).

Nutrition and Feeding of Brood Stock

Feeding a complete and nutritionally diverse diet to fish can influence their growth and allow them to reach sexual maturity at an earlier age, two factors that are extremely important when culturing fish. In the past, discus have had a reputation in the trade of being choosey or finicky eaters, and this prompted aquarists to try to feed them a variety of diets. Some of the main foods for discus are tubifex worms

(*Tubifex tubifex*), bloodworms (*Chironomus*), and mosquito larvae. Minced beef heart has also been used as a diet for adult discus with some success. Additionally some research has been conducted on the supplementation of the discus brood stock diet with soybean meal in various percentages; however, results showed reduced growth in discus fed a diet of 30% soybean meal or higher. Formulated dry, frozen, and gel diets for discus are commercially available but are marketed for the hobbyist and are therefore economically unfeasible for use on discus farms. Discus are also carnivorous and require a great percentage of protein in their diets with some studies suggesting as much as 44–50% of protein in their diet. Development of a high protein nutrient-dense diet is necessary for successful commercial discus culture.

Larval Nutrition

One of the biggest bottlenecks to commercial aquaculture of discus fish is the difficulty and mystery associated with appropriate feeding of larvae. Discus fish exhibit a very unique parental care pattern and relationship with young; when fry are approximately 4 days old and free-swimming they begin to feed on the mucus on the sides of both parents (Figure 2). There remains some mystery about the exact physiological benefit discus larvae receive from the parental mucus, but there is no question that this is an important first feed. The mucus may contain essential nutrients or it may aid digestive function to allow for larval growth and development. With advanced biotechnology methods, the scientific research on why discus larvae require this mucus as their first feed is currently underway. Several studies have been conducted to determine the nutritional composition of parental mucus secretions. The protein vitellogenin was tested for but not noted to be present; vitellogenin is the precursor of yolk in the egg. Mucus on discus parents was found to contain high levels of essential amino acids such as lysine, isoleucine, and phenylalanine. Larvae had a consistent biting pattern on parental mucus with a gradual increase until approximately day 12–15.

The feeding on the mucus was correlated with the onset of protease activity in the stomachs of the developing larvae. Protease activity has been found to be high at around 20 days post-hatch; it coincides with development of the gut in the fry and suggests that 20 days after hatching could be an appropriate time to implement a microdiet. When discus larvae have reached the appropriate size and it is no longer necessary for them to feed on parental mucus, they can be switched over to a diet consisting of *Artemia nauplii*, Spirulina powder, and rotifers. When examining the discus species for aquaculture, the problems associated with larval nutrition and development of a first feed need to be further explored in order to achieve a more controlled intensive culture.

Figure 2. Discus young feed at first on the mucus secreted by their parents. (The ceramic object behind the fish in the foreground is a type of breeding cone.)
Credits: Acuario Calypso

Growout Systems

In contrast to most systems of aquaculture production where fish are raised intensively in ponds or tanks, most discus aquaculture systems raise fish in large aquaria from 20–40 gallons that are equipped with simple systems for aeration and filtration, and gentle water movement; tanks usually contain no other substrate and are bare. Maintaining excellent water quality is an important consideration of the species. Discus fish usually require higher temperatures for their maintenance (28–30°C) than many other tropical fish. Contrary to popular belief, discus fish can be grown and mature in neutral and buffered waters.

Considerable experience and labor are required to raise and grade discus throughout the period of breeding and growout; because their unique body shape is particularly fragile, discus fish require very careful handling on the farm and during transport. Discus are also susceptible to many of the common diseases that afflict other tropical aquarium fishes such as parasites, bacteria, fungi, and viruses. Many discus are still wild-caught, especially brood stock. All wild-caught fish will need to be quarantined before they are introduced to the aquaculture system because they are often infested with parasites. Monogenes and protozoa commonly infest the skin and gills. Nematodes and flagellates, especially *Spironucleus vortens* and *Cryptobia iubilans*, are commonly found in the gastrointestinal tract. Head and lateral line erosion syndrome (HLLES, aka “hole-in-the-head”) is also seen in discus and other cichlids, and may have both infectious and non-infectious causes.

Markets

The discus species is a popular and valuable fish appealing to freshwater aquarists because of its bright colorations, variety, and unusual method for rearing young. By value, discus are considered one of the top 10 species of the ornamental fish trade. *Symphysodon* spp. individuals can retail for $60–$80 USD and have a very loyal hobbyist following with national and international organizations showcasing the various varieties or hybridizations. There is no specific market size for discus fish, which may be sold in a variety of sizes and color strains. Certain strains are currently being intensively cultured in East Asia including Malaysia, Thailand, Singapore, and Indonesia. Some breeding and exportation is also being conducted in Colombia, and there is some small-scale local production in Florida. However, wild collection still exists and the market potential for this species has not reached its maximum.

Conclusion

Symphysodon spp. remain a good candidate species for aquaculture. Feeding the larvae and juveniles remains the main challenge to the intensification and aquaculture of the species, and research to address nutrition issues with both adult and larval discus is underway. Discus production can be standardized and intensified by adopting a genetic selection breeding program. The prices on market remain high and intensive cultivation appears as if it would be profitable, making this species a successful part of Florida's aquaculture industry. Discus fish are non-native to Florida and there are specific regulations for non-native species concerning their possession, sale, and transportation. In Florida, any commercial aquaculture operation must be certified by the Florida Department of Agriculture and Consumer Services. All commercial aquaculture operations are recommended to follow best management practices for the protection of wildlife, water and land resources; and for the prevention of the escape of non-native species (see DACS, Florida Aquaculture Best Management Practices).

Supporting References

Most of the information on the biology and culture of discus fish is found in the aquarium hobby literature, and only a few scientific articles have been critically reviewed and published on their classification and natural history. Listed below are selected and authoritative references on keeping discus fish. The citations include both technical and popular publications, including references to all scientific articles used for preparation of this document.

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Table 1. The common names for discus fish and their proposed taxonomic classifications.

Common name	Scientific name	Geographic area	Author(s)
Discus, common	*Symphysodon* spp.	Amazon River basin	Farias and Hrbek (2008)
Heckel	*Symphysodon discus* or *S. d. discus*	Rio Negro basin; central and north of Amazon River basin	Shultz (1960); Burgess (1981); Kullander (1996); Bleher et al. (2007)
Abacaxis	*S. d. willischwartzi*	Central, and south of Amazon River basin	Shultz (1960); Burgess (1981)
Blue and Brown	*Symphysodon aequifasciatus*	Central and eastern Amazon River basin	Pellegrin (1904); Shultz (1960); Burgess (1981); Kullander (1996, 2003); Bleher et al. (2007)
Blue	*S. a. aequifasciatus* (Green in popular literature)	Central Amazon River basin	Shultz (1960); Burgess (1981)
Brown	*S. a. axelrodi*	Eastern Amazon River basin	Shultz (1960); Burgess (1981)
Blue and Brown	*Symphysodon haraldi*	Central and eastern Amazon basin	Bleher et al. (2007)
Green	*S. a. haraldi* (Blue in popular literature)	Western Amazon River basin	Shultz (1960); Burgess (1981); Bleher et al. (2007)
Tarzoo a.k.a. Green	*Symphysodon tarzoo*	Western Amazon River basin	Ready et al. (2006); Bleher et al. (2007)
Xingu	A divergent lineage group	Eastern Amazon	Farias and Hrbek (2008)

[1] We recognize only the genus *Symphysodon* (no species). For purposes of brood stock development we recommend selection based on the following groupings as demarcated in Farias and Hrbek (2008): the Heckel + Abacaxis + Brown varieties as one group, a Blue group, a Green group, and the divergent group variety from the Xingu River.