Indigenous Species Promise Increased Yields

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Aquaculture production in Latin America is very low. In 1985, it accounted for only 0.8% of the world's yield of 9.5 million t. Produced on *Penaeus* farms, mainly in Ecuador and Central America, aquaculture in Latin America is insignificant compared to its marine fisheries, which produce about 9 million t annually, accounting for 12.5% of the world catch.

In recent years however, attention has focused to aquaculture due to limitations of the natural fish resources, plus increasing costs of fishing and the change in maritime laws.

Taxonomy and Biology

The genus *Colossoma*, formerly with three species, has recently been revised into the genera *Colossoma* and *Piaractus*. Two of the three species, *C. macropomum* and *P. brachypomus* (synonym *C. brachyponum*) occur in the Orinoco and Amazon River Systems; while *P. mesopotamicus* (synonym *C. mitrei*) inhabits the Parana-Uruguay River (Fig. 1).

The common names of *C. macropomum* and *P. brachypomus* are *tambaqui* and *pirapitinga* in Brazil, *cachama* and *morocoto* in Venezuela, *gamitama* and *paco* in Peru, and *cachama negra* and *cachama blanco* in Colombia, respectively. *P. mesopotamicus* is known as *pacu* or *pacu-caranha* in Brazil.

C. macropomum, the largest species, can weigh up to 30 kg. Adults are considered exclusively fruit-eaters, while juveniles are omnivorous, feeding additionally on zooplankton. Studies on *P. brachypomus* (20 kg maximum weight) indicate that adults are not exclusively fruit-eaters. *P. mesopotamicus* (7 kg maximum weight) shows a similar diet.

In the Central Amazon Region the characoid *Brycon cephalus*, called *matrincha*, is promising for aquaculture purposes. For the Peruvian Amazon Region, it is *B. erythropterus*, locally

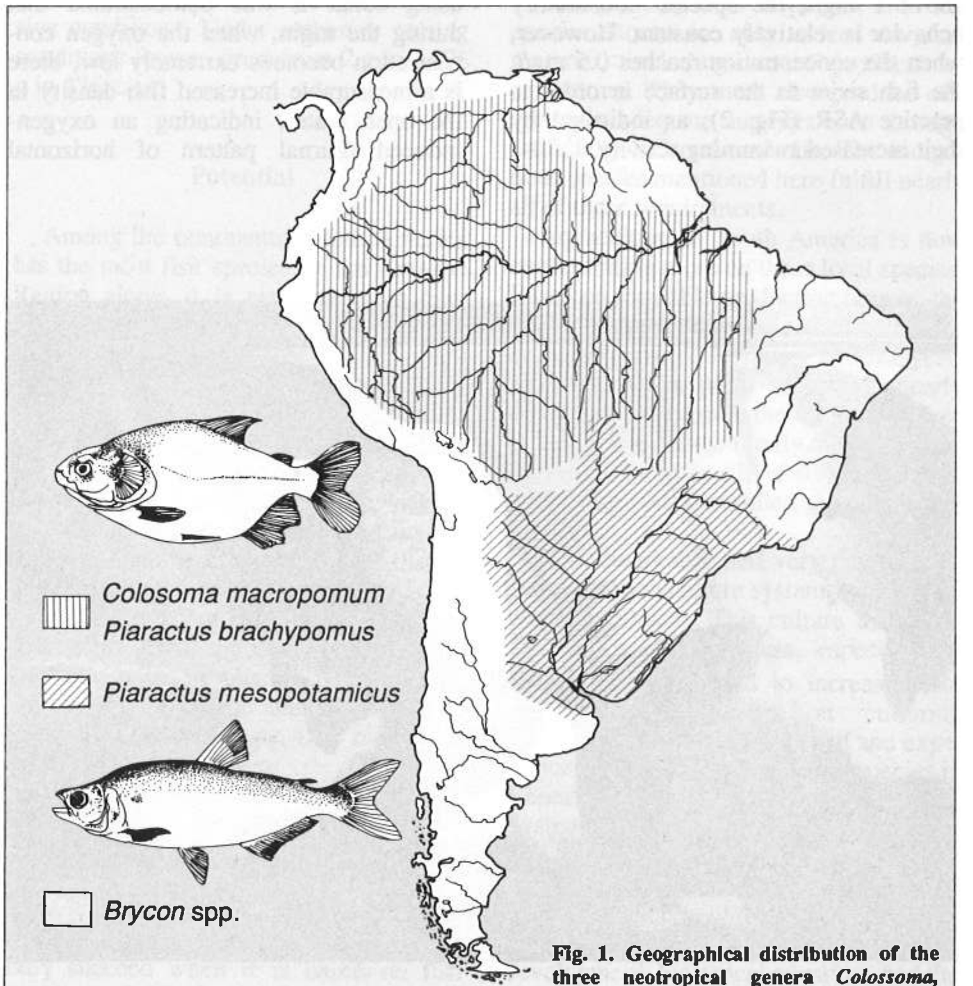

Fig. 1. Geographical distribution of the three neotropical genera *Colossoma*, *Piaractus* and *Brycon*.

called *sabalo roja*. This species can weigh up to 5 kg and is considered omnivorous, however its diet includes a large amount of plants.

Adaptations to Oxygen Depletion

Diurnal oxygen variations with periods of severe hypoxia frequently occur during the night in tropical fish ponds. During periods of low oxygen, several small tropical fish, such as cyprinodonts and poeciliids, use the millimeter-thick surface layer for gill respiration. This surface layer is relatively rich in oxygen due to diffusion from the atmosphere. Investigations have shown that this emergency respiration ability, which Kramer calls "aquatic surface respiration" (ASR), is widespread among small tropical fish species.

Extended ecological experiments by scientists from the University of Hamburg proved that some large neotropical characoids have the same ability to display ASR. At oxygen concentrations above 1 mg/l, the species' locomotory behavior is relatively constant. However, when the concentration reaches 0.5 mg/l, the fish swim to the surface in order to practice ASR (Fig. 2), as indicated by their increased swimming activity.

After a long exposure to low oxygen concentrations, an unusual dermal swelling at the lower jaw (Fig. 3) has been observed in characoids of the genera *Colossoma, Piaractus, Brycon, Mylossoma* and *Triportheus*.

During ASR, the fish protrudes the top of its head out of the water, rhythmically moving its lower jaw with the dermal extension; while the body axis, depending on the species, keeps a specific angle of 30-45° to the surface.

After the water is aerated, the lip slowly retrogresses to its original size and the fish returns to its normal swimming position. As the histological sections show no unusual aggregations of blood vessels, the dermal extension is obviously only a hydrodynamic function for utilizing the oxygen-rich surface layer of the water for respiration.

Floodplains and tropical fish ponds are often partly covered by floating macrophytes e.g., *Eichhornia* or *Pistia*. *Brycon* and *Colossoma* usually aggregate between and under these macrophytes and show significantly less swimming activity than when in the open water. By using sonar it was demonstrated that during the night, when the oxygen concentration becomes extremely low, there is a measurable increased fish density in the open water, indicating an oxygen-induced diurnal pattern of horizontal migrations between the zone of macrophyte cover and the open water.

Fig. 3. Disc-shaped lip of *Piaractus mesopotamicus* in its final form after five hours of aquatic surface respiration.

During longer periods of oxygen depletion, *C. macropomum* returns to the region of macrophytes and survives there, apparently without the usual kind of ASR. Mortality studies performed in net cages exposed in a natural lake environment, confirm its ability to survive severe hypoxia beneath the macrophyte cover.

This makes it very likely that *C. macropomum* can utilize oxygen released from the macrophyte's rhizoid system, which was positively proven for several waterplants. All other fish species investigated did not survive oxygen depletion beneath the macrophyte cover.

ig. 2. When oxygen is low, *Colossoma macropomum* swims to the surface, rhythmically moving its wer jaw with enlarged lips and keeping its body at a specific angle of 30-45° to the surface.

Artificial Reproduction

None of the characoids have been induced to breed naturally in captivity. However, hypophysation experiments on *Colossoma* and *Piaractus* done in Brazil, Venezuela, Peru and Panama were reportedly successful. Positive results are reported as well with combined dosages of hypophysis extract and a synthetic HGH hormone, or with applications of the gonadotrophic hormones SGG 100 and LH-RH.

The hypophysal material is injected intermuscularly in two doses. Females weighing at least 7 kg receive 5 mg of hypophysal dry weight per kg, after being prepared by a first injection with about 10% of this dosage. Males are initially given 0.5 mg/kg and then a subsequent dosage of 1.0 mg/kg.

Females weighing 10 to 15 kg lay one to two million eggs which are fertilized dry. The incubation period at 26-29°C is 17-23 hours. The semi-pelagic eggs can develop successfully in a Zoug jar. The yolk-sac stage lasts 4 days, and the first feeding occurs 5 days after hatching. The procedure of artificial reproduction of *P. brachypomus* and *P. mesopotamicus* is similar.

Brycon spp. are also artificially reproduced by hypophysation.

Conditions for ongrowing and growth results of some South American characoids.

	C. macropomum	P. brachypomus	P. mesopotamicus	Brycon spp.
Temperature [°C]				
upper lethal	>40	>40	>35	>40
lower lethal	<15	<15	<15	<15
optimum	27-32	27-32	20-28	25-30
Feeding				
natural diets	+	+	+	++
chicken diets [16 % RP]	++	++	++	+
fish diets [30 % RP]	+	+	++	++
agricultural byproducts	++	+	-	-
Ongrowing facilities				
pond culture	++	++	++	++
polyculture	+	+	+	+
tank culture	+	+	+	-
cage culture	+	-	+	-
Market size [g]	1,000-1,500	1,000-1,500	1,000	>500
Production time [months]	12-18	12-18	24	12
Growth rate [%/day]	0.4-1.6	0.7-1.2	1.2	1.4
Production [t/ha/year]	1.2-9.2	2.5-8.0	5.9	2.0

- no information; + less common; ++ most common

Nutrition and Growth

Information on the nuritional requirements of *C. macropomum* is limited. This species can live on both natural and artificial food. Artificial feed should contain about 30% raw protein, the main protein source may come exclusively from plants.

In Brazil, Venezuela, Colombia and Peru, pond monoculture of *C. macropomum* has been successfully practiced (see Table) with a stocking density from 1,180 to 10,000 fish/ha. The maximum annual production attained 9.2 t/ha. In Venezuela the first commercial fish farm with an annual production capacity of 300 to 400 t was established. Fry take about 14 months to grow to a marketable size of 2-3 kg.

In Brazil, polyculture of this species with tilapia or carp achieved a production of 8.9 t/ha through a combined stocking density of 10,000 fish/ha.

The growth rate of *P. brachypomus* seems to be less promising (see Table). The greatest production, 8.3 t/ha per year, was achieved at a stocking density of 10,000 fish/ha.

Under extensive and semi-intensive culture, *P. mesopotamicus* grew to a weight of 577 g after a year, corresponding to an annual production of 5.9 t/ha. *P. mesopotamicus* shows satisfactory growth rates even at temperatures between 15 and 20°C. Hybrids of *C. macropomum* and *P. mesopotamicus* are supposed to combine excellent growth rates with low temperature tolerance.

For *Brycon* artificial diets should contain about 35% protein. Up to 20% of the feed may be substituted using dried water hyacinth without any reduction in fish growth. In pond experiments, best growth rates of more than 500 g per year, corresponding to an annual production of about 2 t/ha, were achieved under semi-extensive conditions. Under extensive rearing conditions *Brycon* grew from 2 g to 1,096 g in 476 days.

Potential

Among the continents, South America has the most fish species. In the Amazon Region alone, it is estimated that over 2,000 species occur. In spite of this, it was initially believed that the establishment of pond culture facilities would succeed most rapidly if the widely-raised species of warmwater aquaculture, such as tilapia and carp, were introduced. The obvious reason for this was the lack of knowledge in the cultivation of native species. Thus exotic species, like tilapia, were introduced without controls.

While the use of such species provides short-term advantages, it creates long-term ecological problems. The introduced species could escape and subsequently adapt to natural habitats, thus modifying indigenous communities.

A major goal in aquaculture development, especially in the tropical zone, is to meet local people's basic needs. Considering the low living standards of the local population and the special socio-geographical situation, fish culture can only succeed when it is based on fish species suitable for the extreme limnological conditions of tropical ponds.

Furthermore, it is important that the species chosen are able to feed on plant material, including waste products of agriculture. They must also produce offspring in adequate numbers even through artificially-induced methods. The indigenous species mentioned here fulfill nearly all of these requirements.

Aquaculture in South America is now concentrating more on these local species. Based on available production figures, the average yield from a semi-extensive monoculture of *Colossoma* is 3t/ha/year. Thus, a 0.2-ha pond would be nearly sufficient to supply the daily requirements of an average family of 10 persons. However, there is still a serious lack of knowledge on controlled breeding and nutrition.

It is remarkable that very few investigations of polyculture systems have so far been undertaken. This culture technique has shown great success, especially in Asia, and is expected to increase yield considerably. Attempts at culturing *Colossoma* and tilapia in Brazil and experiences with numerous endemic species in Venezuela seem to confirm this potential. Systematic studies on different polyculture systems however, are still necessary.

The further development of fish culture in South America will depend first on its feasibility. During the early stages of development, biological questions had the priority, but in the future, the economics of production will be more important. ●