

## 7.6 Freshwater fish seed resources in Colombia<sup>1</sup>

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### ABSTRACT

Aquaculture in Colombia started in the early 1950s, with the introduction of rainbow trout *Onchorhynchus mykiss*, followed by common carp and tilapia from Brazil, for which a number of government-operated, pilot-scale fish farming stations were constructed. During the late 1970s and early 1980s, research on native species began, yielding important results which, together with the culture of exotic species helped develop today's Colombian aquaculture.

Freshwater aquaculture production in Colombia has had marked fluctuations, reaching a maximum in 1999, with 43 000 tonnes and an almost 50 percent drop the following two years due to social unrest in producing regions. Tilapia contributes 80 percent of the total national freshwater aquaculture production, the balance being comprised of native species such as *Piaractus mesopotamicus*, *Colossoma macropomum* and rainbow trout.

Freshwater fish seed production in Colombia is carried out in 65 government-operated and private hatcheries. The annual estimated production of tilapia fingerlings is almost 112 million, followed by rainbow trout (27 million) and native species (7.5 million). Such hatchery outputs meet the national demand, which is lower than the reported national installed capacity.

Breeding and hatchery technologies vary according to the species. For tilapia, semi-natural breeding techniques are employed. Breeders are stocked at 0.3/m<sup>2</sup> with a sex ratio of 1 male:3 females, either directly in 0.08-0.12 ha open earthen ponds, or in 10 x 25 m pens placed within the ponds. Fry are collected and transferred to sex-reversal small ponds, hapas or cages, where they are stocked at 200-500/m<sup>2</sup> and sex-reversed using standard hormones. Fry are raised to 5 g in nursery ponds under high protein pelleted feeds.

Trout fingerlings are produced through dry artificial insemination and incubation in flow-through incubation troughs, while native species are artificially induced to spawn employing homoplastic or heteroplastic hormones, including human chorionic gonadotropin hormone and carp pituitary extracts. Depending on species, fry are stocked in earthen ponds and fed artificial diets.

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Genetic selection is limited to phenotypic approaches, in most species. However, introduction of genetically improved strains of tilapia into the country by private companies is common, although often not officially recorded.

As far as seed quality is concerned, there are no official standards in the country. Supply and demand are the driving forces for producers to improve fingerling performance in terms of survival, growth rate and size homogeneity. Seed buyers, if unsatisfied with the product, will change supplier. Seed certification only focuses on disease prevention and is carried out through random sanitary inspection by fisheries authorities.

Some challenges the industry has to face include seed pricing determined by external factors (i.e. inflation), rather than by factors such as direct input costs, shortage of skilled labour and low economic capacity of producers to incorporate technological innovations, increased oil pollution in seed production zones, genetic deterioration of existing broodstock due to the lack of genetic improvement programmes and seasonal production of native species, which limits production.

## INTRODUCTION

The objective of the present study is to describe the present state of the production of freshwater fish seed in Colombia, its strengths, weaknesses, to determine future perspective and to make recommendations for its development.

Information were obtained through: (i) field visits to Meta in the region of Llanos Orientales; (ii) telephone interviews with seed and fish producers in Huila, the Valley of Cauca, Santander and Antioch; (iii) compiled updated information from the Ministry of Agriculture and Rural Development; and (iv) author's personal notes and knowledge.

## EVOLUTION OF AQUACULTURE IN COLOMBIA

Aquaculture in Colombia is divided into four periods based on the level of development, modernization and events during the period. The first period was from 1938 to 1975, the second period from 1975 to 1990, third period from 1990 to 2003 and the fourth period from 2003 to present.

### First period (1938–1975)

This period is characterized by the introduction of rainbow trout (*Oncorhynchus mykiss*) for sport fishing. In the 1950s, mirror carp (*Cyprinus carpio* var. *specularis*) was introduced from Brazil and in the 1960s, Mozambique tilapia (*Sarotherodon mosambicus*) and Tilapia rendali (*Tilapia rendalli*) were introduced to develop rural aquaculture in Cauca Valley, the coffee zone of the country. In addition, during this period, induced breeding of bocachico (*Prochylodus magdalenae*) was adopted. Bocachico is a native species in the basin of Magdalena River, widely preferred by consumers and thus, has great commercial importance in Colombia.

In this period, aquaculture stations were constructed in San Cristobal (Bolívar) and Buga (Cauca Valley) to develop culture technologies for warmwater species. Similarly, stations were established in Santander, Tota (Boyacá) and Huasipongo in Cocha lagoon (Nariño).

In 1974, Act 2811, National Code for Renewable Natural Resources and Environmental Protection, was promulgated. This is the first environmental law of the country and includes exploitation of fishery resources and aquaculture.

### Second period (1975–1990)

This phase continued with the strengthening of state infrastructure directed towards research and promotion of the culture of both native and exotic species by means of constant extension services and technical assistance. Two of the most important

aquaculture stations were built during this period: Repelon (Atlantico) and Alto Magdalena (Gigante and Huila), both of which are still functioning.

Likewise, three other stations were constructed in this period, namely: (1) La Terraza aquaculture station (Villavicencio, Goal), (2) Oiba station (Santander) and (3) Timbio station (Cauca Valley) – for the purpose of strengthening small- and medium-scale aquaculture using the seed produced from Gigante and Repelon.

Additionally, in La Terraza station, research began on the domestication and reproduction of both the white and the black cachamas (*Piaractus brachypomus* and *Colossoma macropomum*).

In the 1980s, Nile tilapia (*Oreochromis niloticus*) and the red hybrid tilapia were introduced with the purpose of developing medium- and large-scale aquaculture. At this time research on the cultivation of the sabaleta (*Brycon henni*) commenced.

### Third period (1990–2003)

This period was marked by the promulgation of Act 13 (dated 1990), General Statute of Fishing, which created the National Institute of Fisheries and Aquaculture (INPA). Until 2003, it was in charge of research and regulation of fisheries and aquaculture at the national level. At the beginning of the 1990s, there was an increase in aquaculture production, i.e. 60 percent more than that produced during the previous decade. Factors such as a technical improvement in the culture of red tilapia, increased number of native species cultured, and the construction of large-scale fish farms in many regions of the country (particularly in Huila, Goal, the Valley of the Cauca and Antioch).

Another outstanding aspect during this period, was the opening of technical, professional and advanced courses in aquaculture by some regional universities and in the capital city of Bogota. This has provided a great supply of technicians and professionals required at different production levels. In particular, the Universidad de los Llanos Orientales (Villavicencio, Meta), the Universidad de Córdoba (Lorica, Córdoba) and the Politécnico Colombiano Jaime Isaza Cadavid (San Jerónimo, Antioquia) established aquaculture stations to: (a) carry out research and to promote the culture of native species in each region, (b) develop some activities for exchange of information and technical assistance for mutual cooperation in the development of technologies, and (c) to further the knowledge on the biology and aquaculture performance of several target species.

In the 1990s, reproduction in captivity and culture methods were developed for the following native fresh water species: yamú (*Brycon siebenthalae* and *B. hylarii*), capaz (*Pimelodus grosskopfii*), bagre rayado (*Pseudoplatistoma fasciatum* and *P. tigrinum*), yaque (*Leiarius marmoratus*) and nicuro (*Pimelodus blochii*).

Likewise, in Repelón and Gigante stations, projects on genetic improvement of existing lines of red tilapia used for aquaculture were undertaken, the purpose of which was to maintain and optimize the production of seed and consequently to improve the quality of fish in terms of individual colour and weight at harvest as well as the overall pond yields.

As of 1999, fresh water aquaculture was included in the policy of competitiveness of the farming sector led by the Ministry of Agriculture and Rural Development through the Fish Farming Productive Chain or “Chain”, where other public institutions participate (e.g. Ministry of Environment, Housing and Territorial Development; Ministry of Natural Treasury; Ministry of Commerce, Industry and Tourism; National Learning Service, SENA and INCODER), as well as representatives of the private sector (e.g. independent fish farmers and fish farming associations, aquaculture products dealers, feed manufacturers, financial and transport services and others).

Recent studies realized by the “Chain” in the zones with major aquaculture potential (i.e. Huila, Tolima, Santander, North of Santander, Goal, Casanare, Antioch, the Valley of the Cauca and the Cauca) reported that in 1999 Colombia obtained its maximum

aquaculture production of 42 969 tonnes, representing an annual average growth of 26.6 percent since 1989.

Unfortunately in 2000, aquaculture production decreased by 50 percent (21 641 tonnes) as a result of the general economic crisis experienced by the country, which led to more than 20 percent unemployment, and unstable public conditions that resulted in the closure of some aquaculture farms. In addition, prices of imported tilapia from Ecuador are lower than that of tilapia produced in Colombia, thus making the local industry less competitive.

#### **Fourth period (2003 to present)**

This period was marked with the closure of the INPA as well as of three other organizations within the farming sector that were responsible for rural development and agrarian reform. These functions have now been taken over by the new National Institute for Rural Development or INCODER. Unfortunately, it seems that the fisheries and aquaculture institution does not represent the needs of the various aquaculture stakeholders and it does not have the capacity to respond appropriately to the requirements of the sector at the national level.

Of the five aquaculture stations operated by the INPA, only two continue to function under INCODER, these are Repelón and Gigante. These stations continue to work on projects related to rearing of eggs, larvae and fingerlings, fattening of native species; genetic improvement of red tilapia; production of seed for rural producers and other actions for the promotion of aquaculture and restocking of public water bodies. The rest of the stations have been transferred to regional and private academic organizations.

Currently, the species that are consistently being used for aquaculture in the country are tilapia (red and silver), cachama, trout and yamú, which are sold in local, regional and national markets. Culture of native species is still at the experimental stage and seed are produced for restocking of natural water bodies, while small-scale culture ponds are for home consumption, whose excess production is locally marketed.

According to the last reports of the “Chain” for 2004, tilapia production has recovered, which means that tilapia seed production has increased. In spite of this, some aquaculturists have complained that seed quality is poor, as reflected in high morbidity/mortality rates and high size heterogeneity. This has promoted the Ministry of Agriculture and Rural Development to cofinance projects that foster strategic alliances between the public and private sectors in areas such as genetic improvement, fish pathology and other breeding technologies (e.g. sex reversion).

Seed production is carried out in both private and state hatcheries or fishfarms which possess an established broodstock. The most important species are: red and silverplated tilapia, carp, white and black cachama, yamu and catfish, or else, through imported eggs of rainbow trout. Nevertheless, it should be emphasized that none of the seed produced are certified according to purity or quality by any national organization, either private or public.

Since the 1990s, aquaculture products contributed greatly to the diet of Colombians, although there is no official data available to confirm this observation. During the year 2002, INPA and INCODER had great difficulties in collecting and analyzing statistical data. Nevertheless, it was observed that in supermarkets and fish markets there was an increase in the supply of red and silverplated tilapia (whole and fillet), trout (cut sections and fillet) and gutted cachama.

Similarly, in many restaurants, red tilapia is commonly included in their menu. The period where there are great sales of tilapia includes Fridays (throughout the year) and during Lenten and Easter Season in the months of March and April.

## SEED RESOURCES SUPPLY

All seed of different native and exotic species are produced from government aquaculture stations and many private fish farms of medium- and large-scale, that have hatchery facilities. This means that there is no seed used in aquaculture ponds, that comes from natural sources.

In general terms, red and silverplated tilapia, the “Chitralada” strain, as well as cachama, trout, mirror and red carps are produced throughout the year in ponds or hatcheries. The yamu reproduces three times a year, while other native species such as dorada, sabaleta, catfish and capaz, reproduce during the rainy season (May, June, July, October and November) which coincides with their natural breeding season.

The present state of production and marketing of seed of major aquaculture species in Colombia are:

**Tilapia:** The main cultured species is tilapia (or red and silverplated) with an average monthly production of 500 000 fry. The average farm-gate price is about US\$35.24/thousand fry and US\$55.07/thousand fry from middlemen. Because of great acceptance from middle- and high-class consumers, fish meat commands a price US\$ 2-6/lb. From 2003, the Chitralada variety of Nile tilapia was introduced, and because of its high performance/unit area, it became possible to produce fillet for the international market which has a market value of, on average, US\$3.5/lb. The main producers of tilapia are Huila, Tolima, Put, Santander, Cauca Valley and Antioquía.

**Cachama:** The second species of commercial importance is native to Orinoquía where it has been cultured traditionally. In Santander in the northeastern part of the country, there is a high consumer preference for cachama. Average monthly production is about 30 000 fry which are sold at a farm-gate price of US\$35.24/thousand fry and US\$55.07/thousand fry from middlemen. The price has remained stable during the last 5 years. It should be emphasized that the price of market size fish in supermarkets and fish markets reaches US\$2-5/lb.

**Trout:** Trout is cultivated in the cold climate areas of Antioquía, Santander, Cauca Valley, Quindío, Huila, in the high plateau regions (cundi-boyacense) and the coffee plantation regions. Seed are produced from imported *Kanloop* eggs, 100 percent triploid females, sold at US\$36.79/thousand eggs for purchases between 1 to 5 000 eggs and US\$35.77/thousand eggs for purchases of more than 5 000 eggs. Depending on the size, fry are sold between US\$57.27 and US\$171.81/thousand. The market niche for trout is constituted by the population of middle to high class. Prices can range from US\$2.50 to US\$4/lb. Although attempts have been made to export to the United States of America, the results have not been positive because producers cannot fulfill all of the requirements in terms of quantity and quality certification demanded by the international market.

## SEED PRODUCTION FACILITIES AND TECHNOLOGY

### Public and private facilities of seed production

INCODER, like other agencies who execute aquaculture programmes, has a total of 22 aquaculture stations located in diverse regions of the country. There were originally five stations under the authority of the INPA, of which only two of the largest remain (Repelón and Gigante) now under INCODER. The other three stations were transferred as follows: (i) La Terraza (Villavicencio) to the National University of Colombia and (ii) San Cristóbal (the Bolívars) and Oiba (Santander) to aquaculture associations of their respective locations.

There are, in addition, eleven other stations managed by autonomous regional corporations (regional environmental institutions) as follows: (i) three stations are inactive due to lack of funds, (ii) three stations under state universities, (iii) one station

under a public-private sector partnership and (iv) the rest of the stations are under the Department of Farming and Mining Development of Huila.

Many private producers have their own breeders to supply seed for their fish ponds: tilapia (15), cachama (5), yamú (4), catfish (3) dorada (2), common and red carp (5) and ornamental fish (1).

There are also 24 and two hatcheries for the production of trout and tilapia fry, respectively. Since production and incubation of eggs of native species are made in a hatchery, it is possible to infer that there are as many hatcheries of native species as farms producing such species.

Table 7.6.1 provides a summary of the number of stations and farms producing fish seed of different species in Colombia.

In two private farms in Meta, breeding is done in chambers with a dimension of 10 x 20 x 1 m in earthen ponds of 1 200 to 2 500 m<sup>2</sup> with breeders with a density, for example per 1.5 square meters of water visibility, using a ratio of 1 male for every 3 females. Eight days after seeding, all seed are collected from the mouth of females and brought to the laboratory where seed are incubated using a density of 500 eggs/ml in incubating cones with 3 liters of water with constant water flow in order to obtain an average monthly production of 800 000 fry.

Similar techniques used by government stations are utilized by other producers where average production of 200 000 and 400 000 are achieved by small- and medium-scale producers, respectively.

In 1996, INPA initiated research on genetic improvement of tilapia which was continued by INCODER, using the lines provided by Repelon and Gigante stations as well as other private producers of Huila. On the other hand, other aquaculturists opted to import breeders with the objective of maintaining the purity of genetic lines of the farm.

**Trout:** Fry production is done in hatchery using incubation trays with constant water flow laboratory starting with eggs imported by Troutlodge Inc., 100 percent female triploid of variety Kanloop, 100 percent triploid females variety *Kanloop*, which has a monthly production of 2 million fry.

There are two government stations that produce trout fry, namely: (1) Neusa Lake (Cundinamarca) station and (ii) Cocha (Nariño). Seed are obtained from breeders maintained in ponds consisting of 20 broodfish/m<sup>2</sup> and ratio of 1 male:3 females. Matured breeders are brought to the hatchery for stripping to collect ova and sperm. Dry fertilization is used. These stations produce 150 000 fry every month.

**Native species:** Breeders in earthen ponds has a density depending on the weight of the fish, in general terms it is about 1 kg weight/m<sup>2</sup>. Matured breeders are determined by swelling of the belly or abdomen of the males, sperm are expelled by putting slight pressure in the abdomen, afterwhich they are brought to the hatchery to induce breeding using hormone. Most commonly used hormones are *Extract of Pituitaria de Carpa* (EPC), or human hormones like the Prymogonil, LH-RH or the combination of EPC or one of these two.

For yaque and nicuro, males are operated to remove the mature testicles, macerated to obtain sperms that will fertilize the ova. Other aquaculturists cryopreserve the sperm to avoid sacrificing other breeders.

With respect to catfishes and cachama, since 1998 trials were made to cryopreserve semen of wild broodfish and broodfish from captivity. Results of these trials revealed sperm viability of 50 percent of cryopreserved sperm and can last for 3 years. In spite of these positive results, it has not been possible to advance the research due to budgetary constraints and also because of institutional transition which occurred between INPA and INCODER in 2003 and 2004. The private sector had expected for the outcomes of the research so that they will have the opportunity to enhance their production.



### Broodstock management

**Tilapia:** In private farms, tilapia broods are not strictly selected according to rigorous genetic definition but based on simple phenotypic observations such as color (e.g. color separation: red, orange, pink or white), presence or absence of black spots and also according to the body length. From 1996 to date, in both Repelón and Gigante, genetic management starts from red tilapia lines coming from diverse zones of the country. This practice results to genetic improvement of broodfish as demonstrated by growth rate and absence of black spots in the body.

Almost all private farms and state farms maintain two groups of selected breeders, especially females. Each group is bred alternately. This sequence stays for 2-3 years after which the whole lot is replaced by new ones. Feeding regime consist of 30 percent protein using pelleted feed for every 2 percent body weight divided in 3-4 rations a day.

**Trout:** Government stations in Neusa and Cocha maintain their broodfish in ponds and are renewed every 5 years; feeding consist of 45 percent protein using peleted feed for every 3 percent body weight, 4 rations/day.

Due to technical limitations in obtaining successful reproduction, 90 percent of private producers without breeders prefer to import eggs. As a result, from 2004, major producers in Antioch and the Cauca presented to the Ministry of Agriculture and Rural Development a project to produce triploid fry (only females), which started in 2005 and will be completed in 2008.

**Native species.** Due to insufficient number of appropriate tanks to hold the fish, earthen pond are utilized using polyculture system. They are fed with feeds with 28 percent of protein, in a proportion equivalent to 2 percent of its body weight, distributed in three daily rations. Breeders are replaced between 5-10 years after use, by selection from the same batch or by natural means.

### Fry management

**Tilapia:** The fry are harvested from breeding tanks between 12 to 30 days after seeding. At this time, fry weigh between 0.2 to 0.5 g and they are now placed in pens, cages or small earthen jars of 5 m<sup>2</sup> (depending on the system and economic capacity of the producer) using a density between 30 and 500 fry/m<sup>2</sup> (ponds) or equal density per cubic meter (in pens and cages) for sex reversal and conversion of male through the hormone *17 alfa metil testosterone* mixed with powdered feeds with 35 percent protein. This mixture is provided at 12 percent biomass divided 10 times/day for 28 days in order to gain a weight of 1-2 g. Fry are then transferred to earthen ponds or concrete tanks with a density of 50-100 samples/m<sup>2</sup> for 20 days when they reach 5 g. During this period, they are fed with feed extracts with 35 percent protein at eight percent of biomass using six daily rations.

There are also two private hatcheries which incubate eggs for 10 days in conical incubators with 3 l of constant flowing water until exclusion of the larvae, after which they are placed in bowls or trays until absorption of the vitelline sac. This is followed by sexual reversion in hapas (2 x 3 x 1 m) installed in ponds enriched with primary productivity where the fry feed with powdered feed extracts containing 40 percent protein (first hatchery); the second hatchery use commercial feeds with 35 percent protein, plus hormone *17 alfa metil testosterone* at 12 percent biomass using 14 daily rations for 28 days. Feeds are changed to 35 percent protein until they reach a size of 5 g.

**Trout.** After hatching, they are placed in nurseries at a density of 200 fry/m<sup>3</sup> where feeding starts. After absorption of the vitelline sac, powdered feed with 50 percent protein are given at 12 percent biomass until they reach 1 g of weight. Then they are transferred to concrete tanks using a density of 150 fry/m<sup>2</sup> feeding with 0.5 inch

concentrated pellet with 50 percent protein divided into eight daily portions until reaching 8 g. They are then transferred to rectangular concrete tanks using a density of 100 fry/m<sup>3</sup> with feeding regimen of ¾ inch pellet with 45 percent protein at 8 g biomass divided in eight daily rations until reaching 5 g required for market.

**Native species.** After hatching, larvae are harvested and placed in aquaria with a density of 500 samples/m<sup>3</sup> until absorption of vitelline sac. After which they are placed in ponds of 200 m<sup>2</sup> which are just full and rich with primary productivity through chemical fertilization. The fry are ready for market when they reach an average size of 3 g.

### SEED QUALITY

About 30 percent of producers provide information on fry production volume and value. After determining the weight, they are classified according to sizes in order to market homogenous size. Also producers monitor which breeders produce fast growing fry, uniform in size and color (in the case of tilapia, color is the ultimate parameter). Despite this, 90 percent of producers complain about the quality and heterogenous size of fry they buy as well as low supply, e.g. package of 100 percent males in red tilapia and Nile tilapia.

Survival rate from hatching to market are: tilapia (75-80 percent), trout (90 percent) and native species (45-55 percent).

### Disease and sanitary control

Despite the efforts and advocacy which universities and state entities undertake through development and research programmes in aquaculture and pathology, many producers think that cultured fish do not get sick and only considers this possibility when there is high mortality. This means that it was not possible to develop awareness on the importance of disease diagnosis supported by laboratory findings both in water and fish.

With the support of the Ministry of Agriculture and Rural Development, state universities (Colombia, Llanos Orientales and Cordoba) have identified pathological agents in native and exotic species, in seed production as well as in grow-out due to deficiencies in water management and feed storage and monitoring of feed quality parameters. Instead of going to the laboratory, the common practice is that farmers use chemicals and antibiotics (human or animal) to deal with disease problems, e.g. malachite green in different doses, formaldehyde at 4 or 10 percent, 10 percent methylene blue, furazone or its components; these are applied based on experiences by other farmers dealing with similar disease problems. It is estimated that only 10 percent of medium- and large-scale producers send samples to universities or to the Colombian Institute of Agriculture and Livestock (ICA) for laboratory analysis in order to receive appropriate treatment.

Concerning sanitary and hygiene practices (for equipment, materials used in seed production and grow-out), the common practice is weekly cleaning and disinfection with chlorine, formol, etc.

Concerning feeds, only 10 percent of private producers and state stations have improved feed management practices using the recommendations by feed producers. In the same manner, they have improved water management by controlling water exchange to avoid contamination. On the other hand, 90 percent of producers do not have any water management practice.

### SEED MARKETING

The main seed producing areas are Meta, Huila, Santander and Valle del Cauca that cover 80 percent of the national, regional and local demand. Seed producers are not organised which presents a difficulty when they need to communicate with the state, clients and other business relations, as they act independently from each other.

In the 1980s, most of the fingerling supply was originated from government facilities. By the end of the decade, aquaculture had developed significantly in certain areas increasing the seed demand for tilapia and cachama which triggered the seed production by the private sector who sold their excess to government facilities that could not satisfy their needs.

In the 1990s, the Municipal Units of Farming Technical Support *Unidades Municipales de Asistencia Técnica Agropecuaria (UMATA)* supported aquaculture projects triggering the seed production as a second effect. Departments related to the coffee plantations promoted culture diversification in the coffee plantations including aquaculture as an interesting option. Other institutions, such as SENA promoted aquaculture for food security in rural areas and the National Prison Institute (INPEC) implemented aquaculture projects in some of the prisons where there was enough infrastructure for the prisoners to work.

At the moment seed distribution flow follows some of these routes:

- Producer ▶ Medium to small farmer
- Producer ▶ UMATA ▶ Small farmer
- Producer ▶ Promoting Entity ▶ Farmer
- Producer ▶ Intermediate ▶ Small or medium farmer
- Producer ▶ Primary intermediate ▶ Secondary intermediate ▶ Farmer

From the point of view of the financing, Colombia has lines of credit for aquaculture from the Financing Funds of Sector Agropecuario (FINAGRO), a bank that offers resources to small-, medium- and big-scale rural producers. It has been estimated that nearly 10 percent of the seed producers resorted to this system to cover the setting up of all the project, to construct or to improve the physical infrastructure (ponds and laboratory) or to acquire working capital for equipment, furniture, materials and consumables.

The allocation of FINAGRO finance of up to 80 percent of the cost of the project, offers an incentive to rural capitalization equivalent to 40 percent of the total amount of the debt if the production goals are fulfilled; payments are provided to the bank immediately after the first year of credit and in addition, the borrowers have access to the Farming Guaranty Funds (FAG), in case of some problems with the credit.

With respect to the trade system, seed producers usually do not execute strategies of sales promotion to increase the demand, but it is limited to satisfy the demand of the intermediaries and farmers who make direct connection with them. This might be the reason for the stability of the price of cachama fingerlings during the last 5 years.

## SEED INDUSTRY

### Scale of production

The production of seed of native and exotic species are made at different levels depending on the scale and automation of its infrastructure, systems and volumes of production and places of sale. Similarly, intermediaries can be classified using the same criteria. In the opinion of the author, small producers have minimum infrastructure necessary to produce monthly up to 200 000 fingerlings of red tilapia, or 20 000 fingerlings of native species, including cachama. Grow-out farmers at medium- or big-scale operations obtain their own seed and sells the excess independently of the technological level of culture operations.

There are seven medium-scale producers that sell seed at local, regional and national levels with monthly production between 200 000 and 500 000 fingerlings of tilapia; and annual production between 20 000 to 150 000 fingerlings of cachama and 50 000 fingerlings of carp, yamú, bocachico, catfish, golden, sabaleta or capaz. The minimum infrastructure consists of external and internal laboratories, circular tanks for handling of broodstocks and production of fingerlings.

The bigger producer differs from the medium-scale producers by the volume of production. Big producers obtain more than 500 000 monthly fingerlings of tilapia (exceptionally, a producer can offer monthly nearly a million fingerlings); more than 250 000 fingerlings of cachama monthly or more than 30 000 fingerlings annually of two or more native species. With respect to carp, still its demand is low and therefore a big producer may offer more than 10 000 fingerlings of this species on a monthly basis.

With respect to the producers of trout fingerlings, at national level, there are eight small-, ten medium- and six big-producers. Their business depends on the biweekly provision of imported ovas; those working at large-scale obtain more than two million of fingerlings monthly.

Similarly, intermediaries also classify themselves through the volume of sales, regardless of the species. This means that those who commercialize up to 20 000 fingerlings monthly are small scale, up to 100 000 fingerlings monthly are medium scale and from this number onwards are considered as wholesalers. The wholesale intermediary counts together with national representatives imported trout ovas from North America and distributes fingerlings of several species at national level, with figures over 100 000 fingerlings per month.

## RISKS

Seed production entails technological, socio-economic, environmental and sanitary risks that can be mitigated with the incorporation of safety measures in critically important points and the observation of the standard quality.

It is possible that small producers undergo greater risks in optimizing production as they face more difficulties of access to appropriate technologies and economic resources, a situation not faced by those with more resources. Nevertheless, in all cases, the pursuit of traditional practice and over-confidence in their experience can be highly dangerous. The most outstanding risks faced by the freshwater aquaculture sector are:

- in spite of the high demand of seed of diverse species, the prices increase annually based on inflation index and therefore, in smaller proportion than the production costs, particularly of feed costs, thus the margins of the producers are continuously reduced;
- lack of knowledge and incorporation of good practices by the farmers in spite of qualified personnel dispatched by government organizations and universities involved in the subject as well as the lack of economic resources to adapt their facilities according to the technological advances or developments;
- seed and fish producers from different regions in the country are affected by alterations in public order and the occasional petroleum spills caused by irregular groups that contaminate the water bodies;
- genetic degeneration of some lines with which investigations or actions of improvement have not gone ahead, in the case of the tilapia;
- unregistered imports and introduction of tilapia from Ecuador at non-competitive prices with respect to the Colombian tilapia discourages national production and therefore the demand for seed;
- relatively high mortality: in tilapia it ranges from 0.5 percent to 10 percent broodstock and 20 percent in fingerlings from post-larvae to market size; in native species it reaches 1 percent in broodstock and between 40 percent and 60 percent in fingerlings; in trout 3 percent in broodstock and 5 percent in fingerlings;
- seasonal production of fingerlings: native species such as yamú which reproduces three times a year (cachama is an exception as it generates seed all year round) and since it has a stable demand, seasonal production cannot satisfy the market requirements;

- environmental changes and rainfall events which throw muds in the water, and thus require the use of special equipment to avoid mortalities of fingerlings and fish and not all producers possess such equipment;
- problems in the hydrographic river basins that affect aquaculture directly;
- weakness in the institutional management to solve deforestation problems, sedimentation and contamination.

### THE ROLE OF WOMEN IN FRESHWATER FISH SEED PRODUCTION

Participation of women is more active in grow-out stages especially in rural areas involved seed production, except in aquaculture stations and private sector farms where the placement of professional women and students of biological sciences is well-known where they assume fundamental functions in research and production. Although there are no official numbers to sustain this hypothesis, it is estimated that 30 percent of those who participate in obtaining seed are women.

Often, producers have received training and technical support for the establishment and operation of aquaculture farms from state and private advisors, specialized in various phases of production. Big- and medium-scale producers provide technical support to small producers to ensure that seed produced are of good quality.

### SUPPORT SERVICES

From the creation of the stations of Repelón and Gigante in 1979, training by government and private sector was initiated, as well as the elaboration of extension leaflet whose distribution was initially free.

The state provides continuous service since the 1980s in the production of seed to cover the demand of rural producers. Price of seed from the state excludes Tax Valor Agregado (IVA). Stocking with native species of public water bodies is the state's responsibility.

In the 1990s and the beginning of the present decade, the creation of the INPA and the support of the Ministry of Agriculture and Rural Development led to the development of programmes of technology transfer through productive projects that has maximum duration of three years directed to communities of farmers and small scale fishermen who also were useful in validating production packages (e.g. culture of tilapia, cachama and trout) technically, economically and socially before commercialization. Along the same line, INPA elaborated two editions of the book "Foundations of the continental aquaculture" and published additional two books such as "Foundations in nutrition" and "Foundations of marine aquaculture".

Some seed producers (big-scale and wholesale intermediaries), feed producers and independent professionals offer their services and technical support for active and potential farmers in the handling of fingerlings and fish in farms as well as during transport to avoid significant mortality rates.

### SEED CERTIFICATION

In Colombia, seed quality certificates have not been made compulsory and therefore no organization has legally assumed this function, except for health issues where ICA is in charge of certifying that the seed for export is free of diseases. ICA is also responsible of verifying the health of the fishing resources (ornamental seed and fish) for import and export. On the other hand, the Ministry of Commerce, Industry and Tourism issues the certificate of origin of the seed that is exported, requirement that is demanded by the buying countries.

In order to obtain a certificate, the exporter asks for a visit to his farm where the ICA representative takes samples from fish and water for laboratory analyses which is the basis for approving the health certificate.

## LEGAL AND POLITICAL FRAMEWORKS

The legislation that directly and indirectly relates to seed production are described below:

- In 1974, the first norm about aquaculture was released (Decree Law 2811 - National Code of Renewable the Natural Resources and Protection to the Environment). It was the basis to formulate the Law 13 of 1990 - Statute General of Fishing and the prescribed Decree 2256 of 1991, which continued being the legal instrument for the sector. Since 1998, there has been attempts to update the law since it is outdated and also with respect to the reform of the Political Constitution of Colombia of 1991, to the reformed environmental norm from 1993, and the Code of Conduct for Responsible Fisheries (CCRF) as well as other international directives in the matter of production and standards for the quality of seed in aquaculture.
- Credit is governed by Law 16 of 1990 which created FINAGRO and defines the general framework for financing of the farming sector. During the last fifteen years, the National System of Farming Credit has regulated adjustments to the lines of credit and benefits for all level of producers.
- The Political Constitution of Colombia of 1991 contains provisions for handling of natural resources to ensure its sustainable development. It refers to the promotion of the fishing development, investigation, technology transfer and credit schemes.
- Law 99 of 1993 created the National Environmental System and the Ministry of the Environment, responsible for formulating national environmental and renewable natural resources policies.
- Decree 1753 of 1994 of the Ministry of Environment regulates the introduction of “parentales” to reduce to the presence of foreign species of fauna and flora, gives environmental licenses to commercial aquaculture producers. At the moment, farmers are not required any environmental licenses other than permissions to import new exotic species and to transfer species between river basins.
- Law 811 of 2003 stipulates the consolidation of production chain organizations and the definition of sectoral agreements of competitiveness to develop subsectors, with the active participation of its representatives from both public and private sectors.
- Decree 1300 of 2003 created INCODER as a decentralized institute assigned to the Ministry of Agriculture and Rural Development. It has four technical submanagement divisions in charge of (i) agrarian reform, (ii) earth adjustment, (iii) rural development, (iv) fish and aquaculture - functions that until that moment were assumed by INCORA, INAT, DRI and INPA, institutions that were terminated. INCODER has 982 positions representing that representing 56 percent less than the four eliminated organizations combined and a smaller physical coverage as compared to the previous institutions which were located in strategic sites of the country based on the specific mandates.
- Agreement 009 of 2003 of INCODER sets the requirements to obtain permission for fishing and aquaculture activities and the procedures for these transactions.

Is important to emphasize that at the moment a law on water is being debated before the Congress and when approved, this law will have a fundamental impact in the development of aquaculture and consequently seed production.

Although Colombia has apparently not advanced significantly in the application of FAO CCRF, this could be an important instrument of support to standards or guidelines for aquaculture. Article IX establishes that states must promote the responsible development for aquaculture production, use of genetic resources, culture in transboundary aquatic systems and zones subject to national jurisdiction.

There is no updated fishing and aquaculture policy of government nor of the states. The last document dates back from 1997 although it was not fulfilled because

of the weakening of INPA, the lack of coordination with other organisms and the little budget for projects. At present, INCODER is formulating a policy document on aquaculture to support institutional policy that focuses on resources and projects in specific areas of rural development. On the other hand, in 2003 a policy document was prepared which transferred the functions of INCODER to regional authorities that already have programmed aquaculture projects, but not fisheries because they recognize their lack of knowledge in the subject and prefer that INCODER continues in charge of such functions.

### ECONOMIC CONSIDERATIONS

Based on the information compiled by the author from private producers, the Aquaculture Production Chain and some recent documents, the factors that determine the prices of seed are described below:

- Labour represents 7 percent of the production costs. Since small producers are family-based, manual labour is usually not quantified; in medium-scale operations, there are three people, while in big-scale operations, there are between 5 to 12 labourers.
- Consumables and services for the production are accounted as follows: feed (45 to the 55 percent), transport (12 to the 15 percent), packing (3 percent), medicines (1 percent), energy (1 percent) and administration (18 percent). In general terms, one can calculate that production costs increase US\$25/thousand seed produced.
- Price of seed of tilapia, cachama, trout and carp is about US\$37.44/thousand, including 16 percent of VAT, tax fee which has become a burden since December of 1998. On the other hand, intermediaries sell seed to grow-out farmers at US\$52.86 to US\$60.10/thousand, which means that the margin of profit of the intermediaries comes near to 47 percent per hundred seed.
- From the perspective of the supply, the biggest constant suppliers of tilapia seed originate from Huila and Meta; cachama comes from Meta and Cordova, while the red or mirror carp comes from the Valley of the Cauca, Meta and Santander. Trout fingerlings are regularly supplied from Cundinamarca, Boyacá, Santander and Antioquia.
- Integrated farms (for fingerling production and grow-out) have an income between 40 to 70 percent of the total economic income generated by their aquaculture project.

### PRODUCTION LIMITATIONS

There is little inter-institutional coordination to exchange technical information and to improve investments in human, technical and financial resources for research, promotion and administration of aquaculture between seed and fish meat producers.

A similar situation exists in the private sector side as there is no strong union that represent all aquaculture producers at the national level. However, there is the Colombian Federation of Aquafarmers (FEDEACUA) that congregates only one proportion of these players. Although FEDEACUA has five regional associations, not all producers are associated; however, during the last years FEDEACUA has increased the awareness on its importance.

Despite existing credit lines for small-, medium- and big-scale producers of seed and fish through FINAGRO, weaknesses remain in accessibility to farmers, especially small-scale farmers so that they will be aware of conditions and benefits. It has been estimated that throughout the 15 years of existence of FINAGRO, only 5 percent of the small-scale, 10 percent of the medium-scale and 40 percent of the big-scale producers have benefitted from the system.

While feed producing companies have made efforts to satisfy the nutritional requirements for species such as tilapia and cachama, they but have not reached the

targeted levels because the same feeds for both species are used, which generates problems in the conversion index and growth of the fish. Some attempts to solve such nutritional weaknesses have been done through research projects by the academic sector, whose efforts at the present time concentrate on the requirements of feeding of native species like cachama and the yamú. Trout does not have such a problem because nutritional formulation has already been established in the United States of America.

From the economic perspective, production limitations are centered on: (i) high cost of the feed that represent 60 percent of the production costs, (ii) reduced profit margin, (iii) insufficient supply to generate sufficient quantity exportable and (iv) necessity to develop and to apply technologies that make the culture more efficient and allow to generate profits on a large scale.

### STAKEHOLDERS

**Tilapia:** There are 70 companies concentrated in Huila, Goal, Valley of the Cauca, Antioch, Santander, Casanare, Risaralda, Quindio and Calda.

**Cachama:** There are 22 companies located in Meta, Casanare, Santander, North Santander, Cordoba, Caqueta and Amazon.

**Trout:** There are 35 companies located in Cundinamarca, Antioch, Santander, the Cauca, North Santander, Boyaca and Tolima.

Other producers, clients and institutions related to seed production are described below:

**Farmers:** It is estimated that there 125 000 rural farmers that receive free technical assistance from the state and occasionally free fingerlings.

**Local institutions.** Departmental and municipal secretariats of agriculture, the National Federation of Coffee, professional departments, committees of farming and biological sciences that function like extensionist workers and some NGOs which lend technical support to the small- and medium-scale farmers.

**Universities, feed producing companies, commercial farmers and suppliers of inputs for aquaculture production:** They participate in promoting the use of improved seed and in the implementation of appropriate technologies.

**Medium- and big-scale producers:** Farmers at these levels of operation sell excess seed and are in charge to supplying local and regional markets.

**Aquaculture stations of Repelón, Giant, the Terrace, the Neusa and the Lagoon of the Cocha:** They participate in the development of new lines of seed and projects for genetic improvement. In addition, there are two big private producers of tilapia and 25 producers of native species in the department of Meta who participate in these activities.

**FEDEACUA:** This association has the mission of organizing associations of fishfarmers such as the Asoacuicola in Antioquia, Acuioriente in Meta and Casanare, Association of Trout Producers of Santander, Andean Association of Trout Producers in Cundinamarca, Asoacuica in Caquetá and Society of Aquaculturists in Valley of the Cauca. Acuanal organizes shrimp farmers, however some of their members have taken interest in the polyculture of shrimp and tilapia, because of the low prices of the shrimp and the potential of export for tilapia fillet. For this reason, the National Center

of Investigations in Acuicultura (CENIACUA) sponsored by Acuanal, is advancing their research on shrimp-tilapia polyculture.

**Government institutions.** The main actors are the Ministry of Agriculture and Rural Development that formulates the sectoral policy and being implemented by INCODER, although the ministry also participates in other actions. Other related entities according to its competente include the following: (i) ICA that evaluates and certifies the health of the exportable fishery resources; (ii) the Ministry of Environment, Housing and Nacional Development; (iii) the Ministry of Commerce, Industry and Tourism; (iv) National Planning Department; (v) Regional Autonomous Corporation; (vi) INVIMA which regulates the health and standards of quality of processing plants and final products; (vii) COLGIENCIAS which supports research projects; (viii) PROEXPORT which promotes exports; (ix) FINAGRO and BANCOLDEX which finance aquaculture; BANCOLDEX is the center for exports; (x) municipal and departmental secretariats of agriculture that promotes aquaculture; (xi) SENA concerned with capacity building and technical assistance and (xii) Network of Social Solidarity which supports projects in communities INE in qualification and technical attendance and Network of Social Solidarity that supports projects in vulnerable communities in the conflict zones.

**Researchers.** The principal centres for training of technicians and professionals in aquaculture which conduct basic and applied research are the following universities: National University of Colombia (Cordova in Montería and Lorica), UNILLANOS (Villavicencio, Goal), Polytechnical University of Jaime Izasa Cadavid (Medellín and San Jerónimo, Antioch) and Surcolombiana University (Neiva, Huila).

At the level of international cooperation, at the moment there are no current projects but a mode of assistance is the exchange of experts on specific themes in fisheries and aquaculture. From 1997, technicians of Brazil, Cuba, Mexico, Peru and Norway have supported Colombia in the areas of genetics, pathology, reproduction, nutrition and feeding, adaptation and adjustment of culture technologies and fishing.

## RECOMMENDATIONS AND FUTURE PERSPECTIVES

Based on the outcomes of this survey and the author's experience in freshwater aquaculture, the following recommendations and perspectives for the future development of the sector are elaborated below:

- The initial difficulty in this decade provided evidence on the necessity for private and public sectors to unite or join forces to overcome those limitations. The big tilapia producers in Huila, Tolima and Meta are optimistic in exploring export possibilities to the USA. However, a number of things need to be in place, e.g. improvement and modernization of infrastructure, processing and application of better management practices and HACCP. This will create a chain of benefits also to small- and medium-scale producers of seed and fish in the sense that it will be necessary to generate sufficient volume of production to meet the internal and external demands for fish.
- The results of research in breeding, feeding/nutrition, sanitary control and genetic improvement of tilapia and native species that the academic sector implemented in cooperation with the public and private sectors, will enable improvement of existing culture technologies, culture of new species and optimize the nutritional composition of feed.
- Tilapia producers recognize the importance of supporting the research on genetic improvement started by the academic and public sectors, in order to find solutions to the problem of seed quality by providing seed samples, offering space for practical application of research, or providing financial support to projects.

- Producers of Meta and Huila are concerned with improving production techniques in order to reduce mortality below 10 percent, to increase production and profitability.
- It is recommended that producers prepare strategies for the promotion and publicity to increase their access to potential clients. In addition, scientific and technological advancements will result to improving seed quality that will enable access to international market, e.g. Honduras which has great deficiency in the supply of tilapia fry.
- Producers have expressed their desire to increase production volume that will strengthen their position in the local market and to access international market. In order to achieve this, it is necessary that the state government and private sector producers assist in enhancing capacity and providing technical assistance to small- and medium-scale producers to enable them to produce fish of high quality at commercial scale for the export market. In this way, there is possibility for small- and medium-scale producers to produce their own fry.
- It is recommended that those involved in the chain of aquaculture operation, for example, producers and air and land transporters strengthen their cooperation to obtain the freight cost that will be most advantageous to both parties and to make the business more competitive therefore reducing production cost.
- In order to improve efficiency, it is necessary to strengthen the capacity of aquaculturists to implement production technologies that will result to high quality seed as the final product as well as direct measures to optimize the use of physical infrastructure, and other inputs and economic resources.
- Policy and legislation in aquaculture and environment should be harmonized; the requirements about environmental impacts and permits/licences requested by the Ministry of Environment, Housing and National Development like the Regional Independent Corporations need to be validated. These steps will facilitate streamlining of procedures and will enable a better understanding about the requirements of aquaculture versus environment. Capacity building in the areas of environmental management, control of parental lines, defining the procedures for the introduction or transfer of native and exotic species is recommended.

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