Tilapia markets in the Americas, 2001 and beyond

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ABSTRACT

The total market for tilapia in the Americas was almost 300,000 metric tons of live weight fish in 2000. Production in the Americas was approximately 257,000 mt and the US imported fillets and frozen tilapia representing more than 30,000 mt of harvested fish from Eastern Hemisphere producers. Expanding demand sufficiently to absorb the rapidly expanding supply has become a critical task to support the current prices for tilapia products.

During the 1980's and 90's several different seafood publications declared tilapia to be the "new fish of the year". Since then tilapia has become one of the more popular seafood entrees in the Americas. As high quality tilapia products began to appear, its recognition as a quality seafood product has increased from Canada to Chile. Tilapia are not truly a new product in the Americas. Mossambique Tilapia, *Oreochromis mossambicus* were first introduced to the Caribbean by C.F. Hickling in 1947. They were quickly introduced throughout Central and South America. *O. aureus, O. niloticus* and several hybrid red strains were introduced in the 1960's and 1970's.

Mexico currently produces and consumes (≈100,000 mt) more tilapia than any other country in the Americas. The US is the next biggest consumer (>90,000 mt) but just a minor producer (<9,000 mt). Brazil and Cuba are the next largest producers/consumers. Costa Rica, Honduras, Ecuador, and Jamaica are the major exporting countries. Each has a well-developed infrastructure of production, processing and export, with Honduras being the most recent. Each of these exporting countries has some domestic consumption, but the relatively small population base and high level of investment required for large-scale production has driven them to look toward US and European markets.

As supply continues to expand, consumer demand must also increase. "Push" and "pull" strategies are used by marketers to increase demand. Examples of these techniques are described as well as advertising and sales tools. One example of the efforts made by some producers to increase demand was the

creation of a marketing entity. Several of the largest tilapia producers and importers/exporters to the U.S. have jointly funded the Tilapia Marketing Institute (TMI). The TMI has begun a broad ranging program to increase U.S. demand for tilapia products. The Institute is pursuing a generic campaign to increase demand for all product forms of tilapia.

Introduction

Tilapia was called the "Fish of the 90's" by seafood writers in several countries in the Americas. This has been reflected by the rapid increase in consumption, especially in the United States. No records of U.S. consumption were determined before 1992, when imports of tilapia were first reported as a separate commodity. Since that time consumption has grown to over 90,000 metric tons of live weight equivalent fish in 2000. (Live weight equivalent is calculated as 1.1 times the weight of frozen fish and 3 times the weight of a fillet). Per capita consumption has increased from 0.08 kg in 1993 to 0.19 kg in 1998 (Engle 1997, Posadas, 2000). Tilapia sales have exceeded those of trout in the U.S. every year since 1995. In the 1980's most of the demand was for live fish, which were grown in the U.S. In the late 1980's, whole frozen fish imported from Taiwan began to appear in U.S. markets. During the 1990's imports of fresh and frozen fillets of tilapia to the U.S. rapidly increased in volume. Much of this product came from countries in Central and South America. Production and consumption in other countries in the Americas have shown similar patterns. The share of overall tilapia production in the Americas is demonstrated in Figure 1.

Early marketing and production

From the late 1940's until the 1980's, most tilapia grown throughout the Americas were consumed in the community in which they were grown. Governments and international aid agencies promoted the production of tilapia as a low cost source of high quality protein. Most tilapia were grown in low input, pond-based farming systems. Marketing efforts were of the most basic form, word of mouth and roadside stands. Even the U.S. farms depended on word of mouth, local press, or free samples to build markets. Fish Breeders of Idaho and Pacific Aquafarms of California are two of the best examples of these pioneers.

Before 1986 virtually all U.S. demand for tilapia products was met by domestic production. Most of this demand was for live fish from Oriental restaurants and grocery stores. Small farms in the western and southern U.S. supplied Oriental communities on the West Coast and in urban centers of the South, respectively. Fish were transported live to markets either by the producers or by independent live haulers. Around 1986, imports of frozen whole tilapia from Taiwan began to appear on the U.S. West Coast. These products were distributed primarily through Oriental markets.

Demand for tilapia in the US has grown as Oriental and other ethnic consumer groups have increased in number and in level of disposable income. Other groups of early consumers were international aid workers and biologists who were acquainted with tilapia during international work. The general public's knowledge of tilapia slowly increased as small farms were started around the U.S. and international travelers tried tilapia dishes in other countries. Tilapia distribution has now widened to include seafood restaurants and seafood counters in many grocery stores. In the late 1980's, tilapia producers in Idaho, California and Arizona devoted considerable resources to developing markets on the U.S. West Coast. In the 1990's, Rain Forest Tilapia and Regal Springs Tilapia developed markets on the U.S. East Coast. Rain Forest imports most of its product from Costa Rica while Regal Springs imports tilapia from Indonesia and more recently from Honduras. Tilapia farms in Colombia and Jamaica were also early entrants to the US market. Colombia eventually built such strong domestic demand the farms there suspended exports in favor of local markets. Jamaica continues to export some product to the US, but European and local Jamaican markets have grown and absorbed much of the production.

Demand for tilapia in Mexico has grown as the fish were introduced into every state. The fish have been stocked into reservoirs across the country to supplement the catch of indigenous species. Hatcheries continue to stock some of these reservoirs, years after self sustaining populations of fish were established. The catch from these lakes goes into the "aquaculture" statistics and contributes to the high level of aquaculture production reported by the government. Regardless whether this catch belongs in the aquaculture category, there is no question that Mexicans eat a lot of tilapia. The major cities all support a large demand for tilapia with supplies coming in from across the country. Consumption of tilapia in Mexico exceeds 100,000 mt per year all supplied by domestic production.

Brazil is another country with a large supply and demand for tilapia (≈45,000 mt). Tilapia were introduced in the 1950's and the original markets were for local consumption as in most other countries. However, unique to Brazil was the development of a fee fishing industry based on tilapia, especially in the heavily urbanized southeast. Red skinned strains became popular at pay lakes both for sport and as an edible catch. Brazil may have the most diversified tilapia industry of any country. Farmers utilize everything from extensive ponds to the most intensive recirculating systems. Brazil will likely grow to be the largest tilapia producer in the Americas. It has the greatest warm, freshwater resources on the planet, strong domestic markets, a strong technological base and many of the grain products used in modern diets.

Cuba has become the third biggest producer and fourth biggest consumer of tilapia in the Americas (39,000 mt). Pond culture, cage culture and stocking of reservoirs are common techniques. Scientists in Cuba have also pioneered some of the most advanced genetic technologies applied to tilapia

US demand has grown from essentially zero in 1980 to 90,000 metric tons of live weight fish in 2000 and based on imports and production in mid-2001, total consumption in 2001 should be very close to 100,000 mt (Figure 2).

Shift in product forms

1993 was the first full year in which tilapia imports to the U.S. were recorded as a separate fish commodity from various countries. Imports of whole frozen tilapia were 10,046 mt in 1993. Since 1993, imports of whole tilapia have increased steadily at 2,000 to 3,000 mt per year, reaching 12,469 mt in the first 4 months of 2001. Recognizing the demand for fillet products in the U.S., growers in several countries began processing tilapia before exporting to the U.S. Import levels of *frozen fillets* rose quickly from 612 mt in 1993 to 2,347 mt in 1994. Frozen fillets remained near this level into 1999. In 2000 and 2001 large volumes, of frozen fillets from China and Indonesia came on the market to compete with fillets from Ecuador and other producers from the Americas. Fresh fillets have demonstrated a steady climb from 586 mt imported in 1993 to 3,590 mt in 1998 (Figure 3). Fresh fillets bring a slightly higher price in the U.S. Boneless, mild flavored fish fillets are preferred by American consumers and restaurant chefs. Tilapia fillets have been substituted for several more traditional fish products and this market niche will show the most rapid growth (Fitzsimmons and Posadas 1997).

In most of the producing countries, low labor costs encourage value adding through processing. Rapid advances in quality and dependability of land and air transportation have further increased the availability and quality of fresh tilapia fillets exported to the U.S. Several countries have also adopted Hazard Analysis at Critical Control Points (HACCP) procedures for their seafood processing regulations. This has encouraged processors to meet high standards and facilitated imports to the U.S.

Taiwan has been the major supplier to the U.S. but in recent years there has been a marked increase in production in Central and South America. The exports from some countries have decreased in recent years as their domestic markets have increased. Colombia and Mexico have ceased exports, while Costa Rica, Ecuador and Indonesia have increased (Fitzsimmons, 2000). Figure 4 shows the distribution of tilapia supply (by Live Weight Equivalent) for the U.S. in 2000.

Marketing Strategies

Marketing experts frequently describe efforts in terms of pushing product through the supply chain and pulling it through. Pushing product means that the producer tries to get the intermediate handlers to take more product. This can be accomplished by convincing the buyer that you have a superior product, better packaging, or even that you will take a lower price. Pull strategies are those that get consumers to "ask" for more product. Below are several examples of each strategy.

Improved packaging (Figure 5) and new product forms (Figures 6 and 7) are examples of push strategies. Advertising in a seafood business magazine is another push strategy. Each of these strategies is designed to get the wholesaler, broker or other handler to take more tilapia and in turn push it through the supply channel onto a final customer.

Pull marketing is a grass roots effort designed to get the final consumer to demand more of a product. In store advertising and recipe cards at the point of sale are typical examples of pull marketing. Advertising on television, on the radio or in the newspaper are other examples. One of the most effective pull strategies is placement advertising. This is when a product, tilapia in this case, appears as a food item in a favorable setting, as part of some other endeavor or entertainment. One recent example is a murder mystery book, which included a sumptuous dinner of tilapia. It really has nothing to do with the story, but leaves the consumer with a positive impression of the product. This can be a low cost or even free form of advertising. Web sales are another form of pull advertising. Potential customers find a Website and may even be able to order on line, although most still phone in orders (Figure 8). The Website maintained by the American Tilapia Association, (www.tilapia.org) is another example of pull marketing. By providing general information about tilapia aquaculture, with photos, reports, recipes, and biological information, the consumer will have more information which should lead to increased demand. Some strategies are hybrids that may improve demand from the broker and the consumer. Advertising the product through the delivery chain is a potent form of push and pull marketing. Advertising on vehicles (Figure 9) and packaging, and even on live tanks in a grocery store, encourages consumers to buy more product, but also makes the broker realize that the producer has a superior product. Generic advertising is mostly a pull strategy.

The biggest example of generic advertising is the Tilapia Marketing Institute (TMI). TMI was founded in 1998 and funded ($250,000) by several large producers and marketers with the goal of increasing awareness and demand for tilapia products (TMI 1999). TMI has nine producer members and one member from the packaging industry. The TMI strategy is to position tilapia by identifying its most favorable attributes and matching these to the needs of a target market. It is accomplishing this by working closely with food journalists to prepare informative stories reporting on tilapia and its place in the seafood market. A series of strategic messages have been developed which are highlighted to create a strong image of tilapia with consumers. Several themes were then presented to the food press to reinforce and diversify the basic message about tilapia. Key positioning statements, phraseology and themes have been proposed and are under consideration by the TMI members.

TMI's generic campaign is designed to benefit all tilapia producers and product forms. No differentiation has bee made between U.S. and foreign products. However, all producers are under pressure to insure that only the highest quality products are offered to the market. With a generic campaign, all producers suffer if any one should distribute poor quality fish. Additional members are being recruited in order to generate additional funding to support marketing efforts directly, to increase the potential of getting government funds to support marketing, and to bring producers together to insure that only high quality products reach the market.

Pricing

Prices for tilapia products vary considerably. Live fish sold by the producer will range from less that $1.00 per kg at the farm in some less developed regions to $2.20 to $6.60 per kg in the U.S. and Canada. Prices for processed forms also vary considerably (Table 1.)

Table 1. Typical prices for Tilapia products sold in the U.S. (August 2001.)

	Pondside / Processor $/kg	Wholesale $/kg	Retail $/kg
Whole live fish	2.20 – 6.60	2.80 – 7.10	3.90 – 9.90
Whole fresh fish on ice	2.25 – 3.60	3.20 –4.20	4.00 – 8.20
Whole frozen fish	1.20 – 2.20	2.00 – 2.50	2.25 – 4.75
Fillets, fresh	4.80 – 6.50	6.00 – 8.20	8.00 – 12.00
Fillets, frozen	4.80 – 6.80	5.50 – 7.80	7.00 – 11.00

Some of the price range in product forms is due to size differences of the products. In most countries, larger fish and larger fillets will bring a higher price per kilogram. In most North American and Brazilian markets, consumers prefer live fish greater than 450 g. Fish of 700 - 800 g bring the highest prices. Fillets are typically graded into 4-6 ounce and 5-7 ounce packages, with the larger grade bringing $0.20 to 0.50 more per kilogram.

It should be noted that virtually all forms are sold for the same prices, or even lower, than they were five years ago. Supply has at times exceeded demand, and prices have not increased. This pattern has been observed in other widely aquacultured products including trout, salmon, catfish, striped bass, clams, shrimp, and mussels. Newly domesticated stocks and rapidly advancing technology have managed to keep the costs of production down as supply rapidly increases from new and existing farms. The low prices further encourage demand, which has been met with new supply.

Conclusions

Tilapia markets in the U.S. are segmented between live fish, whole frozen fish, frozen fillets and fresh fillets. Growth in the live market has slowed in recent years. The traditional ethnic market demand (Los Angeles, San Diego, San Francisco, Vancouver, Houston, New Orleans, New York and most importantly Toronto) seems to be met and additional markets must be developed. Grocery stores and restaurants with live tanks, and local "farmer markets" are the mostly likely sectors to expand. Supplies of live fish from U.S. producers will continue to supply most, if not all, of the demand.

Markets for whole frozen tilapia are still large and demonstrate some continuing growth. This market, mostly supplied by product from Taiwan and increasingly the mainland of China, has a much lower growth rate than fresh fish fillets. Whole frozen fish still accounts for 50% of all tilapia imports. This product has the most uneven record for quality and the market price continues to sink. Improved quality of the fish should be a priority if market is to expand.

Frozen tilapia fillets have demonstrated almost no growth in imports since 1994. The primary source has been Indonesia and Thailand, but increasing amounts are imported from Taiwan. Additional marketing may be required to further expand this market. This should be a huge market, as this product form is used in restaurants and sold in grocery stores. Demand for frozen fillets will be a prime focus of the TMI.

Fresh tilapia fillets have demonstrated the most rapid growth of any tilapia product form. Some U.S. producers are now distributing fillets and imports have gone from 586 mt in 1993 to 3,590 mt in 1998, to 3,627 mt in just the first four months of 2001. The primary sources of fresh fillets have been Costa Rica, Jamaica and Ecuador. But in 2000 Honduran exports surpassed Jamaican tilapia in volume and China exported an equal amount.

U.S. consumption of tilapia is likely to continue expanding at a rate of 10% per year compared to virtually no increase in overall seafood consumption. Greater consumer awareness of tilapia as a product and increased marketing activity generated by the TMI and others (American Tilapia Association 2001) should further increase demand.

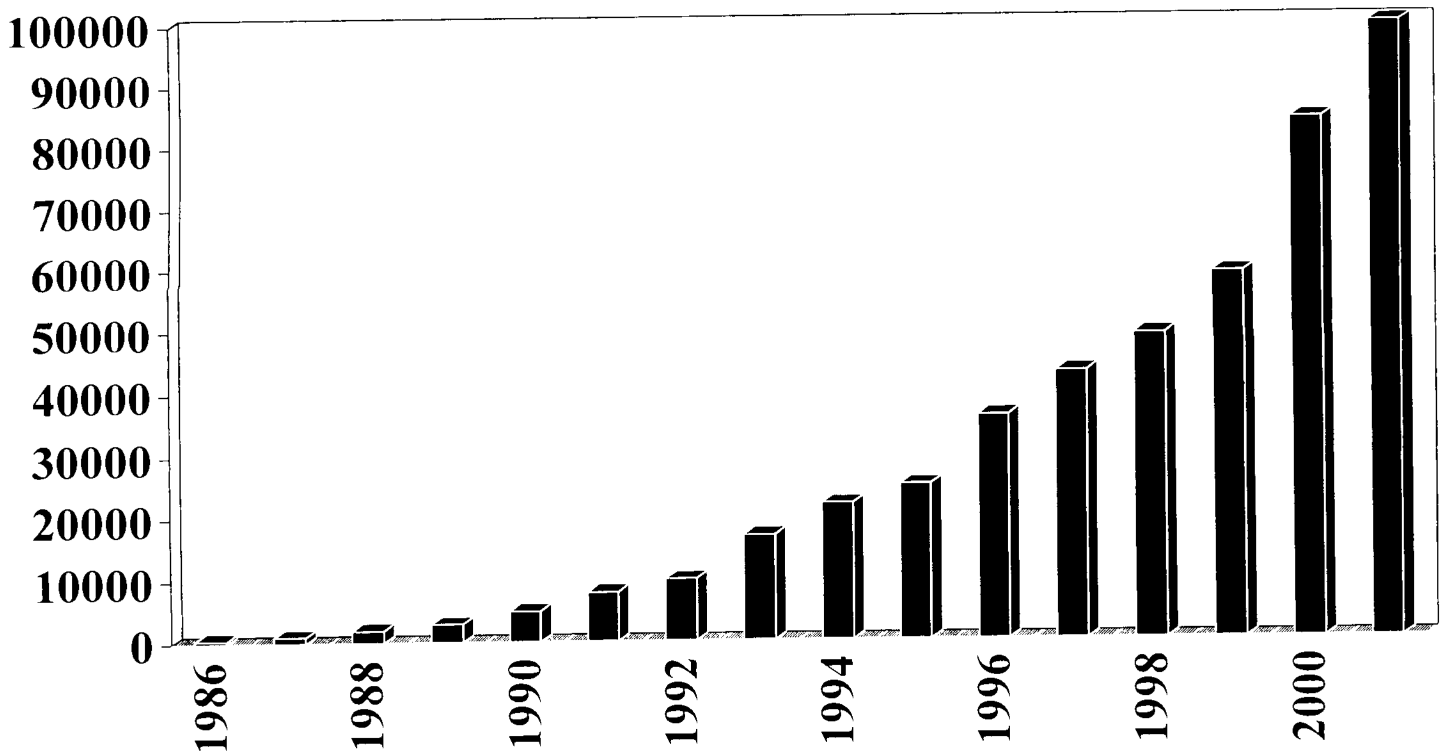

Figure 2. US Tilapia consumption (live weight in metric tons)

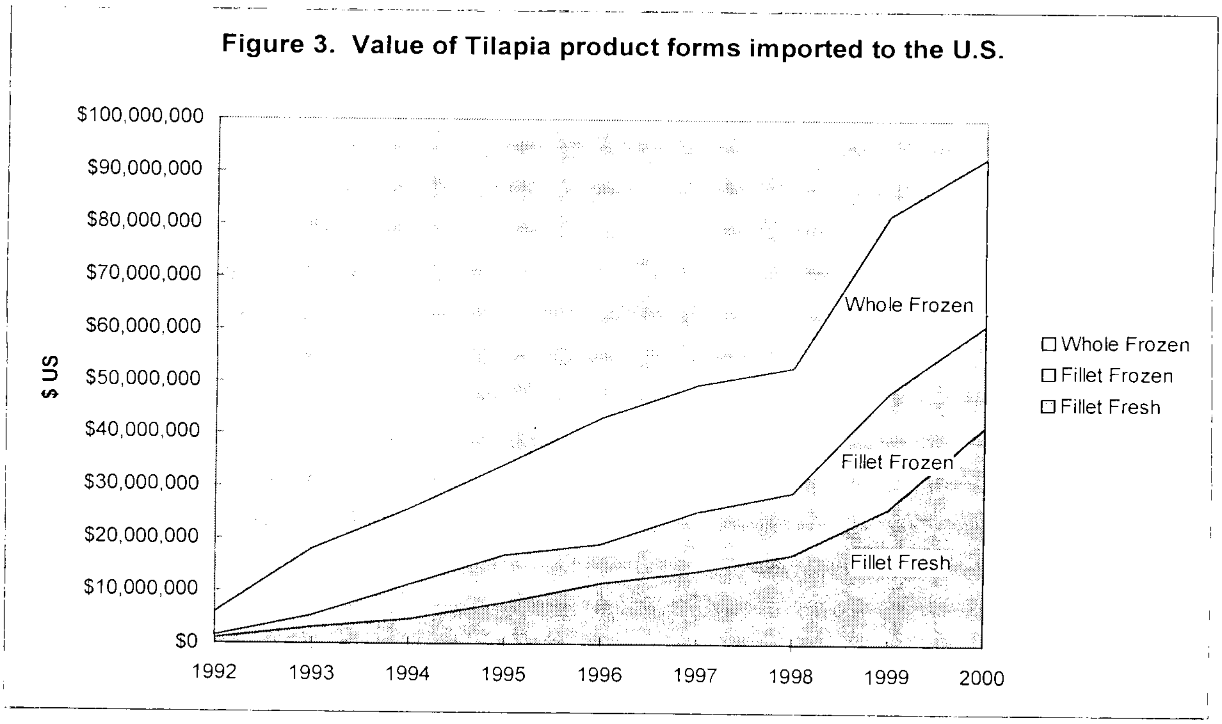

Figure 3. Value of imported tilapia products.

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Supermarket outlests for tilapia in Honduras: an overview of survey results

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Introduction

Tilapia culture was initiated in Honduras in the late 1970's (Teichert-Coddington and Green 1997). In the early years, tilapia production was primarily characterized by small-scale, family operations that were managed either extensively or semi-extensively as a supplemental agricultural activity. However in the last decade, tilapia production in Honduras has grown rapidly because of market expansion for fresh tilapia fillets in the United States. Additionally, uncertain prices and disease problems that have struck the shrimp farmers to raise tilapia (Engle 1997a).

Tilapia exports from Honduras increased to 792 metric tons in 1999, a 56% increase from 1998 levels (Green and Engle 2000). Nevertheless, exporting tilapia fillets to the U.S. is a risky practice for the small number of brokers handling tilapia, given that the most successful export companies in Central America have developed their own marketing companies in the U.S. (Engle, Neira, and Valderrama 2000).

Domestic markets would provide stability by offering additional market alternatives hence reducing risks associated with one target market. Volume requirements would likely be lower and it might be possible to sell smaller sizes of fish, thereby taking advantage of selling to different market segments. Development of a domestic market would also provide broader economic benefits such as new sources of employment and additional protein sources for Hondurans. No systematic market information is available to provide guidance to identify potential market channels, most promising markets, and efficient marketing strategies.

The study

A comprehensive study was designed to characterize existing supermarket channels for tilapia in Honduras and to seek to identify strategies to further develop supermarket outlets in Honduras for farm-raised tilapia. The survey instrument was designed to elicit information on the types of fish and seafood sold, prices, availability of tilapia, and supermarket buyers' attitudes towards a variety of attributes of tilapia.

The sampling universe for the survey included the names of supermarkets published in telephone listings. Convenience stores were excluded from the sampling universe. A sample of 54 supermarkets was drawn at random and included establishment in Tegucigalapa, Comayaguela, Choluteca, Santa Barbara, Comayagua, Siguatepeque, La Paz, Juticalpa, and Catacamas in the Central-South region and San Pedro Sula and Puerto Córtez in the North region. Direct personals interviews were conducted from August-October, 1999. Interviews lasted from 15 to 30 minutes.

Surveys results

Forty-one percent of the supermarket managers who responded to the survey countrywide stated that they sold tilapia. Also, 24% of supermarket respondents indicated that they used to sell tilapia and 35% of interviewers never sold tilapia. The lack of demand, freshness, and availability in certain times of the year were mentioned as the primary reason for not selling tilapia or for not continuing to sell tilapia. Snook and Red fish were the most preferred finfish and were followed by drum and red tilapia (Figure 1). The top-selling product was fresh whole-dressed (57% of respondents) followed by fresh fillets (20%) and frozen whole dressed (9%). Over half responded that their supply of tilapia has not been consistent.

Over half of the respondents in both regions (Central-South and North) purchased tilapia from wholesalers and twenty percent purchased tilapia from fish farms. Managers of supermarkets that sold tilapia had a more favorable concept of the product in items of supply, availability, patron's preferences, odor, flavor, ease of preparation, and variety (Figure 2). Overall, quality received the highest rating along with ease of preparation. Managers from the North region seemed to be more familiar with the product and had more favorable opinions compared to managers from the Central-South. However responses from the latter still indicated a positive perception toward the product. Most tilapia farms in Honduras are located in the North region, which seems to explain the more positive attitudes observed in this region.

Conclusions

The survey showed the tilapia is a well-known product in Honduran supermarkets. Overall, 50% of supermarket managers responded that they were either somewhat or very likely to sell tilapia the next year. However the lack of demand, freshness, and seasonal availability were mentioned as primary reasons for not selling or having stopped selling the product.

The negative ratings of tilapia by some respondents may be due to the poor quality of the wild-caught product selling on the market. It may be important for tilapia growers to differentiate their products from wild-caught tilapia and promote quality controls programs on tilapia farms and in processing plants. These results suggest that, if tilapia farmers can combine adequate marketing strategies such as intense advertisement campaigns with availability of high quality tilapia, it maybe possible to further develop the domestic market for tilapia in Honduras.

Acknowledgment

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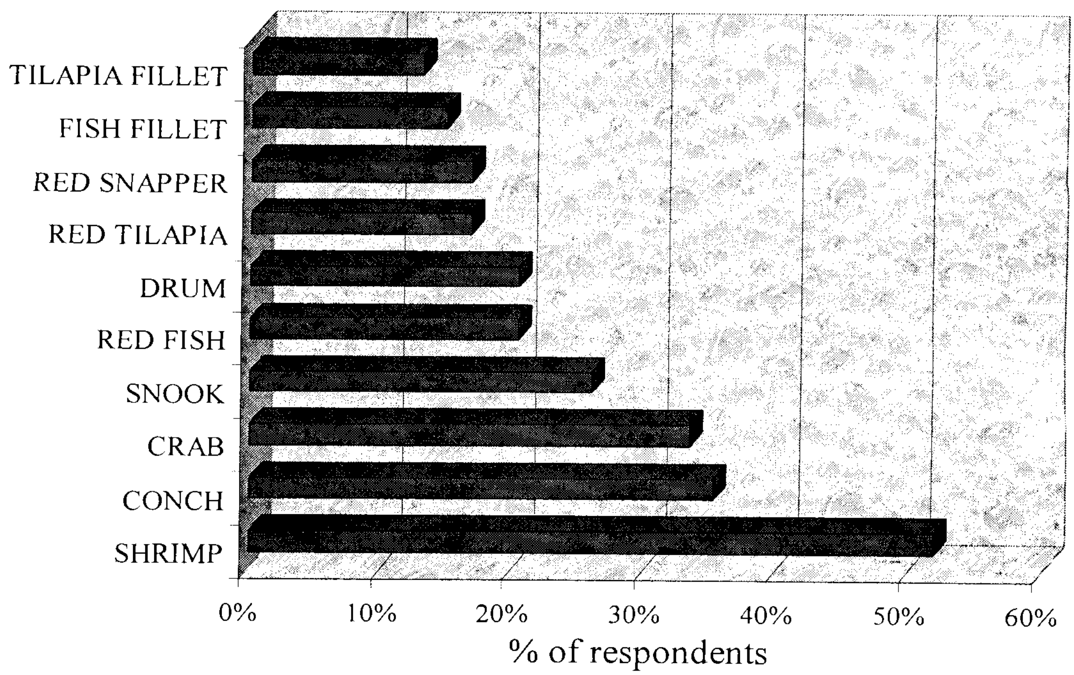

Figure 1. The Top Best Selling Fish and Seafood Items in Supermarkets in Honduras.

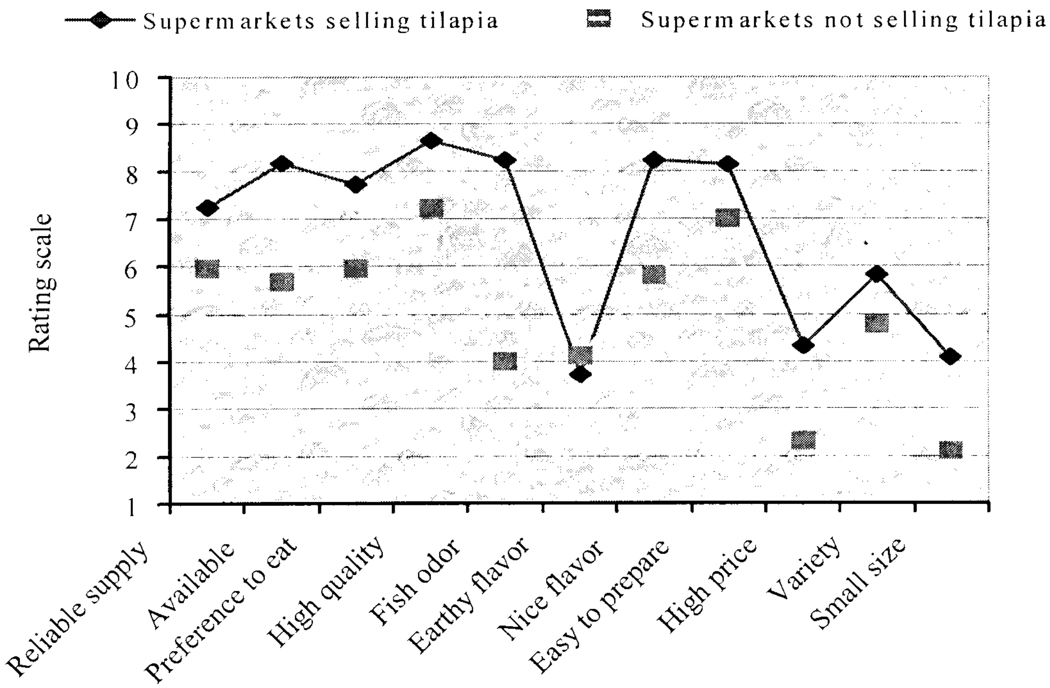

Figure 2. Supermarket Attitudes toward Tilapia Attributes Using a Scale with 1 Meaning Very Strong Disagreement and 10 Meaning Very Strong Agreement.

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Markets for tilapia (*Oreochromis sp.)* in Nicaragua: a descriptive analysis of restaurants, supermarkets and stands in open markets

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Introduction

Commercial aquaculture has developed slowly in Nicaragua. Presently there are 2,407 ha of reservoirs utilized for tilapia production. However, low technology and poor management have resulted in inconsistent harvests; a restocking program maintains fish populations for villagers' subsistence (Durand 1997).

Most of the tilapia farms in Nicaragua are small, approximately 0.01 ha, and are used primarily to produce fish extensively in low volumes for subsistence. Nicaragua is a country with ample resources to develop a farm-raised tilapia culture industry in ponds or cages in lakes and reservoir.

No marketing studies, either qualitative or quantitative, have been done on the potential to develop a domestic market for farm-raised tilapia in Nicaragua. Domestic markets would provide stability by offering additional market alternatives that reduce risks associated with one target market. Development of a domestic market would also provide broader economic benefits such as new sources of employment and additional protein sources for Nicaraguans. The purpose of this research is to perform qualitative analyses of fish buyers such as stands in open markets, supermarkets, and restaurants.

Methodology

A comprehensive study was conducted in Nicaragua of potential buyers of farm-raised tilapia: restaurants, supermarkets, and open-stands market vendors. Three survey instruments designed for marketing studies in Honduras by Engle et al. (2000) were used as a basis for the Nicaraguan studies. Interviews were conducted throughout the populated region of Nicaragua in August and September 2000. The Atlantic Coast was not considered due to its low population density and a dense rain forest with difficult access.

The sampling universe consisted of full-service restaurants registered with the Nicaraguan Institute of Tourism and those listed in the telephone directory. Fast food eating establishments, roast chicken specialty stores, catering shops, and pizza stores were excluded from the sampling universe for the survey. Tables of random numbers were used to select each restaurant in the survey sample. The sample size for the restaurant survey was estimated based on Kinnear and Taylor (1983). Given the similarity in socio-economic and demographic characteristics between Honduras and Nicaragua, data from the Honduran surveys conducted in 1999 by Engle et al. (2000) were used to estimate sample standard deviations used to estimate sample size. The interviews were conducted in 62 restaurants in Managua, including five in Los Pueblos, eight in Masaya, five in Granada, four in Boaco, three in Jinotega, three in Matagalpa, eight in Estelí, six in Chinandega, eight in León and six in Rivas were interviewed. A complete census of supermarkets was conducted in the major urban and rural population centers. In 2000, there were approximately 23 supermarkets in Managua, four in Los Pueblos, two in Masaya, two in Granada, two in Boaco, five in Jinotega, four in Matagalpa, three in Estelí, three in Chinandega, one in León and four in Rivas. The fish market survey was a complete census of fish market vendors with a stand in the open-air markets. In Managua there were five open-air markets in 2000. Central (Roberto Huembes) with six stands, Oriental with twenty-three stands, Israel Lewites (Boehr) with thirteen stands, Ivan Montenegro with four stands, and Mayoreo with three stands. There were four stands in Pueblos Pequeños, 14 in Masaya, 10 in Granada, two in Boaco, one in Jinotega, three in Matagalpa, two in Estelí, 16 in Chinandega, 14 in León and five in Rivas.

All data were entered into a computer using Survey Pro® software. The data were cross-tabulated by two regions (the South-Central region comprised the capital, Managua, and the main cities of Rivas, Granada, Masaya, Boaco, Estelí and Los Pueblos. The Northwest region comprised Matagalpa, Jinotega, León and Chinandega). Data were cross-tabulated by locales that sold and did not sell tilapia, and by the regional origin of the fish.

Results

Approximately 20% of the restaurant managers, 66% of the stands in open-air markets, and 23% of the supermarkets sold tilapia. Red snapper, drum and tilapia were the most popular species of fish sold by restaurants. In supermarkets drum, tilapia, and red snapper were most popular, while red snapper, tilapia, and mojarra were the most popular in open-air markets (Figure 1). Restaurants, supermarkets and open market vendors generally had positive attitudes towards tilapia (Figure 2). Both restaurant and supermarket managers disagreed that the price was too high. Restaurant and supermarket managers' agreed that their patrons liked the variety that tilapia would add to the menu or for their stores. Restaurants, supermarkets, and open-air market vendors that used to sell or never sold tilapia indicated that negative consumer attitudes (such as contamination of lakes, off-flavor, etc.), lack of awareness, lack of availability, and lack of demand were the main constraints to sales of tilapia. In the Northwest region, few people were familiar with tilapia. In the South-Central region, people had positive attitudes toward tilapia, but were afraid of contamination of tilapia from Lake Managua. Overall, 86%, 79%, 50%, respectively of restaurants, supermarkets, and open-air market vendors were likely to sell tilapia the next year, if a promotional campaign would emphasize the safety of farm-raised tilapia.

Conclusion

Preliminary results showed that tilapia is well known in Nicaragua, but restaurants were reluctant to admit selling tilapia. More than half of all respondents indicated they were likely to add tilapia to their menu or store within the next year. Managers who had never sold or who had stopped selling tilapia had positive attitudes towards it, but did not sell primarily due to lack of availability. It may be important for tilapia growers to differentiate farm-raised from wild-caught tilapia. According to the managers interviewed, consumers perceive tilapia as a freshwater fish caught in a polluted lake, and are unaware of the advantages of a high quality farm-raised fish. Another negative perception of consumers is that wild caught tilapia from the lakes, rivers, and reservoirs have off-flavors.

Tilapia farms and processors in Nicaragua will need to guarantee and ensure the flavor, quality, and safety of their product and promote these attributes. Broad-based consumer education and labeling programs may be needed to assist consumers to differentiate between farm-raised and wild-caught tilapia.

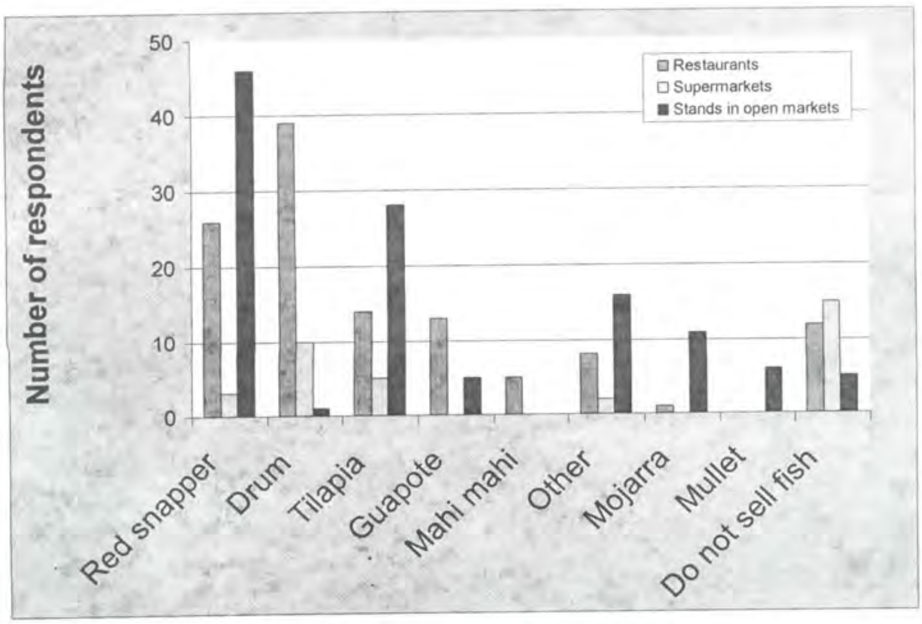

Figure 1. Most popular finfish sold in restaurants, supermarkets, and stands in open-air markets.

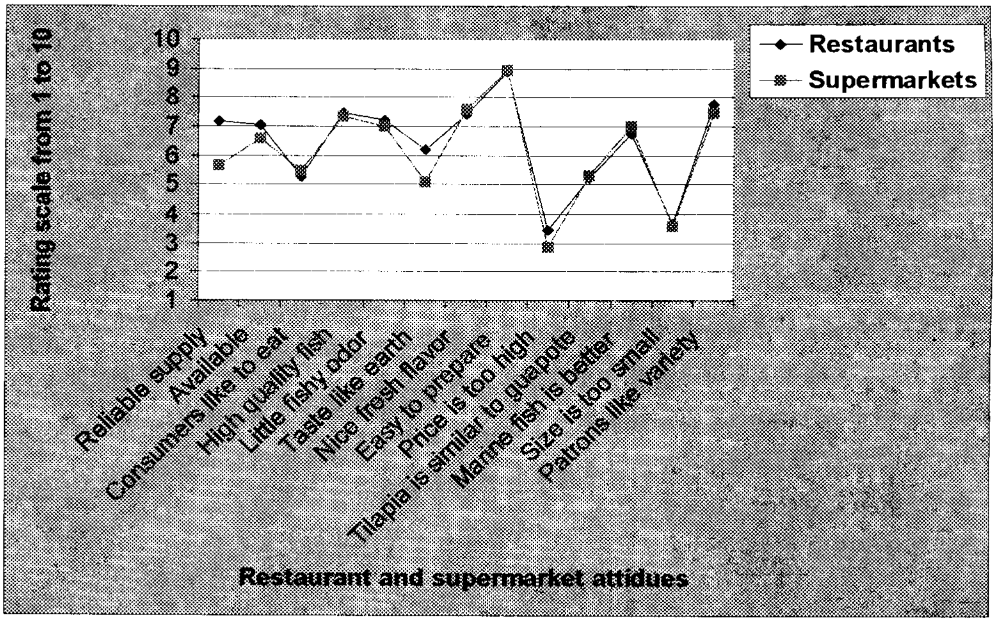

Figure 2. Overall restaurant and supermarket attitudes towards tilapia attributes using a scale from 1 to 10, where a score of 1 means strongest disagreement with the attribute and a score of 10 means strongest agreement.

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Proceso del filete fresco de tilapia para la exportación

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Condiciones de la biomasa para proceso

Uno de los puntos críticos para poder procesar tilapia en condiciones seguras es que preferiblemente, esté sana y viva al momento de llegar a la planta de procesamiento. Caso contrario, el pez se elimina de la línea de proceso específicamente en la etapa de clasificado de la tilapia.

La biomasa viene de las unidades de producción dela finca en un tanque móvil con agua y oxígeno para garantizar la buena calidad y seguridad de la materia prima, y por ende del producto final. A continuación se hará una descripción general de las operaciones del proceso comercial de la tilapia para lograr un producto que cumpla con las exigencias del mercado.

Proceso de matanza

Aturdimiento: El aturdimiento se logra sumergiendo los peces en agua fría a una temperatura entre 10 a 15°C durante un periodo promedio de 8 minutos. La finalidad es reducir la movilidad de los peces, y hacer más fácil su manejo durante la siguiente etapa del proceso.

Degolle y clasificado: La biomasa de tilapia es trasladada a la mesa de degolle, donde se procede a clasificar los peces según los estándares para poder ser procesados. Luego se le cortan las arterias que irrigan las branquias.

Desangrado: La finalidad de esta etapa es la de drenar la sangre del cuerpo de la tilapia. Esta se efectúa colocando el pez ya cortado en un tanque con agua fresca. Su residencia en el tanque es de un tiempo promedio de 15 minutos.

Descamado: Los peces ya desangrados son descamados de forma manual o mecánica. Con respecto al descamado mecánico, los peces son enviados a una descamadora giratoria. Estos se descaman los peces al rozar con las paredes perforadas del tambor giratorio.

Descabezado: Consiste en remover manualmente la cabeza del cuerpo de la tilapia, utilizando un cuchillo. Existen máquinas de descabezado, pero nosotros preferimos hacer este trabajo a manualmente.

Eviscerado: Esta etapa se efectúa por medio de pistolas que están conectada a un tanque de vacío. Después de haber abierto el pez por otro corte en su parte ventral, por medio de la pistola de succión se eliminan las vísceras del cuerpo. Este trabajo se puede efectuar de forma manual.

Enfriamiento: Una vez descamado y eviscerados, los peces son enviados a un tanque provisto de agua enfriada con hielo. Esta agua se debe mantener a una temperatura de 5°C. El objetivo de mantener esta temperatura baja es de controlar el crecimiento de micro-organismos indeseables. Aquí empieza la cadena de frío en la línea de proceso comercial de la tilapia. Los peces ya enfriados son transferidos a bandejas plásticas y estas son llevadas a la sala de fileteo.

Sala de fileteo

Mesa de fileteo: Esta etapa del proceso es manual, utilizando un cuchillo especial y se desarrolla en dos etapas:

1. Se hace un corte en la parte dorsal de los peces a ambos lados de su aleta y columna vertebral.
2. Se separa el filete de cada lado del cuerpo, evitando cortar la cavidad corporal del pez en la cuál estaba el tracto digestivo.

Despielado y desolle: Esta operación se efectúa por medio de una máquina despieladora. La máquina está provista de un rodo dentado que expone los filetes a una cuchilla estacionaria.

Una vez que los filetes son despielados, se depositan en bandejas con hielo. Esta actividad se puede realizar manualmente pero la eficacia y operación no es regular. El filete debe ser blanco, no incluyendo a la línea "simétrica" o de sangre. Para la remoción de la línea de sangre es necesario el despielado profundo del filete, que equivale a decir que toda la membrana muscular roja subcutánea se elimina.

Mesa de terminado o maquilado: En esta fase se revisa la apariencia del filete. Se retira el tejido sobre puesto en la parte dorsal del filete. Con un corte en forma de "V", se eliminan las espinitas y se le da forma perimetral al filete. Estos trabajos se realizan manualmente con un cuchillo especial.

Mesa de clasificado: Una vez que el filete es terminado, se transporta en bandejas con hielo a las mesas de clasificado. En las mesas de clasificado se selecciona el filete por tallas, utilizando balanzas por las cuales se pesa todo el filete individualmente. Así se garantiza el envío de la talla que los clientes han pedido.

Los filetes son separados en cinco grupos o clasificaciones:

- filete con peso de 7-9 onzas (200-250g)
- filete con peso de 5-7 onzas (140-200g)
- filete con peso de 4-6 onzas (115-170g)
- filete con peso de 3-5 onzas (85-140g)
- filete con peso de 1-3 onzas (30-85g)

Las primeras cuatro tallas son destinadas exclusivamente para la exportación. Las tallas más pequeñas de 1-3 onzas, se consumen localmente, aunque pueden también ser exportadas en lotes pequeños de vez en cuando.

Lavado y enfriado: Los filetes clasificados se transportan en bandejas con hielo. Son lavados en agua limpia y fresca. Luego son transferidos a tanques con agua fría a 0° C para bajar su temperatura.

Proceso de empaque: De acuerdo a las tallas, el filete es pesado en bandejas conteniendo 10 libras (4.5 Kg). Luego los filetes en las bandejas son empacados en bolsas plásticas y estas se colocan en cajas "mini-master" de poliestireno. Existen varias formas de empacar el filete en la caja mini-master, la mas común actualmente es acomodar el filete verticalmente en pares. Otra forma es colocarlo horizontalmente, utilizando separadores de polietileno.

Se le coloca un "gel pack" congelado en cada caja mini-master. Se sella la caja con cinta adhesiva transparente. Después del empaque se verifica el peso de cada caja mini master.

Se coloca una etiqueta y se codifica cada caja mini-master. Estas se empacan en cajas "master" de 30 ó 200 libras (13.6 ó 91Kg), por lo general.

Las cajas master son "flejeadas" con cinta plástica de media pulgada. Se termina el proceso enviando el producto al cuarto frío (0° C) para permanecer por espacio de 12 a 20 horas antes de su transporte.

Sub-productos

Los sub productos del proceso de la tilapia son utilizados para producir harina y aceite de pescado. Las siguientes partes anatómicas del pez son los sub-productos generados en el proceso de la tilapia:

- esqueleto con tejidos adheridos
- cabeza
- vísceras
- piel
- escamas
- tejidos y las orillas cortados del filete procesado

Requerimientos legales y sanitarios

Para que una planta pueda procesar tilapia, se necesita la aprobación del gobierno, a través de la Secretaria de Agricultura y Ganadería (SAG), cuyos órganos contralores, como el Servicio Nacional de Sanidad Agropecuaria (SENASA) y el Servicio de Inspección Oficial de Productos de Origen Animal (SIOPOA), dan el visto bueno si la planta cumple con los requisitos sanitarios para poder funcionar. Estos organismos también registran a la planta en sus libros oficiales y le otorgan un número al establecimiento. Otro ente gubernamental exige un estudio de impacto ambiental para abrir operaciones de una planta procesadora de tilapia.

También la planta tiene que contar con un médico veterinario regente que inspecciona la planta y el producto. El médico veterinario se encarga de extender el permiso zoo-sanitario para poder exportar el pescado.

Es de vital importancia la elaboración e implementación del sistema y plan HACCP (Análisis de riesgos y puntos de control crítico), que es exigido por FDA de los EE.UU., SENASA y los clientes en el extranjero. A partir de diciembre de 1995 la FDA emitió regulaciones para productos pesqueros basado en los principios HACCP. Ha sido obligatoria cumplir con esta regulación a partir de diciembre de 1998.

Con el plan HACCP garantizamos que el consumidor final va a adquirir un producto libre de riesgos para su salud. Otro de los requisitos para poder exportar a los EE.UU. es que al menos un técnico de cada planta haya sido certificado en procedimientos HACCP por la ALIANZA NACIONAL DE HACCP EN PRODUCTOS MARINOS.

Los supervisores y los obreros deben ser capacitados en buenas practicas de manufactura, higiene personal, y en procedimientos operacionales estándares de limpieza y sanitización.

Technology for successful small-scale tilapia culture

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Abstract

Tilapia are tropical African fish that adapt well to the artificial conditions of the culture environment. These fish are hardy and resistant to diseases. They gain weight quickly at temperatures between 25 and 30°C and they reproduce on the farm without special management or infrastructure.

Tilapia feed primarily on algae, other small organisms, and organic matter present in pond water and sediments. They quickly learn to consume artificial diets and can adapt to saltwater. Tilapia flesh is firm and white, and has an excellent flavor.

In spite of all the advantages of tilapia, most small-scale fish culture projects established in Central America during the past 30 years have failed. These failures are often related to several fundamental errors committed when establishing objectives for rural development projects, in the site selection process for building new ponds, and in the implementation of fish culture projects in rural areas.

In many instances the aim of the extension or development program is to improve the nutritional status of the rural family by providing techniques for culturing fish. Fish are an excellent source of animal protein for humans. Historically, the emphasis on improved family nutrition has not been sufficient motivation to make tilapia culture a part of traditional agriculture production in rural Central America. There has been too little emphasis on establishing fish culture to improve the economic status of rural families in the region.

We often make the mistake of constructing ponds at high elevation or in situations lacking adequate water resources. A warm climate and a year-round supply of adequate water are requirements for successful culture of tilapia.

Often farmers are unable to obtain fingerlings to continue culturing tilapia in subsequent cycles following the first harvest. Many extension agents promoting tilapia culture do not have adequate knowledge to advise and assist farmers in this new technology. Most farmers do not have the knowledge and skills to manage the use of basic inputs (fertilizers and feeds) for successful fish culture.

Small-scale tilapia production is not a panacea for rural poverty. Fish culture can provide high quality animal protein to improve the diet of rural families. The sale of fish can also contribute to improving the economic status of rural families in the region.

Introduction

Tilapia were introduced to Central America during the 1950's by Taiwanese technicians working with the FAO. For more than 40 years in this region tilapia culture has been promoted by governmental and private agencies primarily as a means to produce low-cost, high quality animal protein to alleviate hunger and malnutrition among the rural poor. Several fundamental errors were commonly repeated in these programs, and most of the effort to introduce and sustain small-scale fish culture in these countries ended in failure.

The programs to promote tilapia culture were implemented by extension agents and technicians with little or no knowledge of the biology of tilapias and of the techniques for managing their culture. During the period from the introduction of these exotic fish through the 80's, there was little locally generated information on proper methods to successfully culture tilapia in Central America using low-cost inputs.

The Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) played a very important role in developing reliable information and simple techniques to successfully manage tilapia culture in the region using low-cost and locally available inputs. We now have a base of knowledge generated locally, on tilapia and its culture, from which we can better implement extension programs that can positively impact rural farmers in this region.

This paper attempts to elucidate some of the common problems and mistakes made in promoting tilapia culture in rural areas of Central America. An effort was made to provide information and suggestions to better assist extension agents in making tilapia culture a viable component of rural farming practices regionally.

Climate and elevation

A great number of fishponds have been constructed at sites that do not have adequate conditions for the successful culture of tilapia. The tilapia are tropical fish and grow quickly when water temperatures are between 25 and 30°C. Many fish ponds in Central America have been built at high elevation (>1200 meters) where water temperatures are generally below the optimum range for fast growth of the tilapia during a large portion of each year. Most fish culturists recommend culturing tilapia at elevations not exceeding 1200 meters in Central America.

During a large portion of each year in Zamorano (750 meters elevation), Honduras, we experience water temperatures below the optimum range for good growth of tilapia (Figure 1). In January and February we often have water temperatures that slow the fish's metabolism and reduce its growth rate considerably.

Water resources for fish culture

The principal ingredient for successful fish culture is a permanent source of water of good quality. In Central America during the past 30 years many ponds have been built in locations without adequate water resources necessary for successful fish culture. The climate in Central America is characterized by distinct dry and rainy seasons. Many streams in the region are temporary, and water flow diminishes, and many streams completely dry up, as the dry season progresses from December thru May.

In Central America the lack of adequate water resources, and proper water resources management, limit human development and agricultural production. Water scarcity during the dry season is one of the primary concerns of local communities and governments.

Occasionally tilapia culture projects are established using water diverted from rural potable water systems to fill ponds. Fish can be an important source of low-cost animal protein and income for rural families, but their culture should not compete directly with the basic human need for potable water. Eventually, potable water sources become limited, and are eventually made unavailable for fish culture purposes.

Long-term technology transfer

Effective implementation of fish culture activities with rural farmers in Central America requires a long-term commitment to offer them technical assistance and training. Fish culture is not a part of traditional agriculture in the Americas. Most NGOs that promote fish culture among rural farmers and communities have limited resources for such a long-term commitment. Often the extension agents have limited knowledge to adequately transfer the technology effectively. Many extension agents are relatively transitory and their permanence in the position and community is often relatively brief.

Loss of fish from stealing and predation

The Central American republics are poor countries with large rural populations. In many areas stealing of agricultural crops can result in tremendous losses for farmers. A widespread point of view is that fish are a common resource.

Several local and migratory avian species are voracious predators of fish. Herons and kingfishers can result in the almost complete elimination of tilapia fingerlings from unprotected ponds (Lagos 2000) (Figure 2). The red varieties of tilapia are more visible in the pond water and especially susceptible to the attack of these predators. We recommend that ponds be protected with strands of plastic string or twine suspended above the pond, to deter birds from visiting pond banks. Commercial bird netting materials are prohibitively expensive for use on small projects.

We also recommend that rural farmers stock Nile tilapia in their production ponds. The more darkly pigmented Nile fish are less visible and are able to better avoid avian predators than the red varieties. Rural fishponds should be constructed close to the family residence to facilitate supervision of the culture and protect the fish from theft and bird predation.

Obtaining fingerlings

The availability of quality fingerlings at reasonable price has often limited aquaculture development. Rural farmers have limited resources and often encounter difficulty in obtaining fingerlings from producers (Aceituno et al. 1997). The availability of quality tilapia fingerlings in most countries is ordinarily limited to a national fish culture station and a few private farms.

For many years in Honduras the principal supplier of tilapia fingerlings was the National Fish Culture Station ("El Carao") in Comayagua. This station produced and distributed hybrid male tilapia fingerlings during the 80's. During the 90's this station was the principal supplier of sex-reversed male fish to small-scale and commercial tilapia producers in the country. The production of fingerlings at the El Carao station generally exceeded 3 million annually, during this period.

The El Carao station supplied fingerlings at subsidized prices to promote fish culture in the country. I believe that these subsidies may have limited the production and distribution of fingerlings from private sources in Honduras during many years.

We should develop simple and straightforward techniques to be used with rural farmers in producing and distributing tilapia fingerlings for sale locally. The tilapia reproduce on the farm with minimal care and management.

Determining the sex of tilapia

The most important step in the successful grow-out of tilapia in static water ponds is establishing a mono-sex population of fish. When mixed-sex culture is attempted with tilapia the resulting reproductive effort of the fish over populates the ponds with fry that compete for food and space with the original fish stocked for grow-out. This results in harvests of mostly small fish (<50g) of little value in local markets.

There are several techniques to reduce the effects of the unwanted tilapia reproduction in grow-out ponds. It is relatively easy to learn to differentiate among male and female tilapia thru visual inspection of their genital orifices (Figure 3). This technique has to be learned and continuously practiced by extension agents and local farmers.

Use of local inputs for tilapia culture

Rural farmers in Central America have scarce resources for use in production. Tilapia can be grown successfully using agricultural by-products (for example rice bran, and many types of animal excrements) as the primary source of nutrients for the fish. The PD/A CRSP has generated an enormous amount of experimental data on the use of organic fertilizers in the production of tilapia (Egna and Boyd 1997).

Tilapia fingerlings can be grown to market size in 6 months by applying chicken litter to the pond at rates up to 1000Kg/ha/week. These ponds are generally stocked with two male fingerlings per square meter of pond water surface area.

Similar to other inputs, we need to add the correct amount of fertilizer to the pond at frequent intervals. We recommend that the farmer think of the organic fertilizer as a substitute for a formulated feed for the fish. The fertilizer should be added to the pond each day and spread across the water surface, as we would do with feeding.

There are several simple techniques to help manage the pond and gauge the fertilization rate, thereby helping us to avoid unwanted problems with low concentrations of dissolved oxygen and possible fish mortalities. These techniques involve periodic evaluations of the turbidity of pond waters and daily observation of the fish “piping” in the early morning hours of the day. These techniques can be easily understood and utilized by rural farmers to prevent serious problems in managing their fishponds.

Commercially available fish feeds are expensive inputs for Central American fish farmers. Feed pellets begin to lose part of their nutritive value upon entering the water. Floating pellets can be used to evaluate the consumption of the feed by the fish, and to feed to satiation.

Sales of fish and marketing

Most rural farmers sell their fish live on the pond bank. This eliminates any processing and transport costs from the production budget and contributes to the profitability of this activity in rural parts of Central America. This profitability will be the incentive to continuing fish culture on rural farms in the region. In order to have enough fish for sales, we recommend that each family culture tilapia in a minimum of $300m^2$ of ponds.

Prices for fresh fish increase during Lent and the Easter week of each year. Fish harvests should be programmed to take advantage of this seasonal increase in demand and higher prices for tilapia in Central America.

Conclusion

Small-scale fish culture can form an important part of production activities on rural farms in Central America. Fish are excellent sources of low-cost animal protein and can provide income from sales to neighbors. Although much effort to promote tilapia culture in the region has not resulted in positive impacts, these fish can contribute to improving the lives of rural families. We now have a wealth of information to assist in training and assisting local farmers in the basic techniques required for successful culture of tilapia in this region.

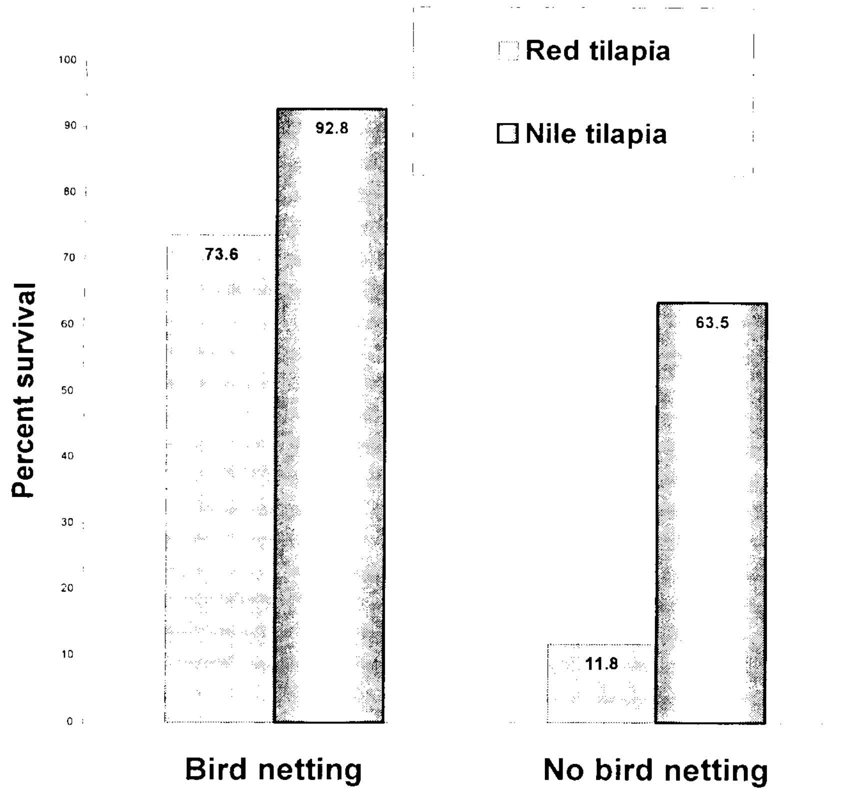


Figure 2. Comparison of the percent survival of red and Nile tilapi: cultured with and without bird netting as protection from avian predators (Lagos 2000).

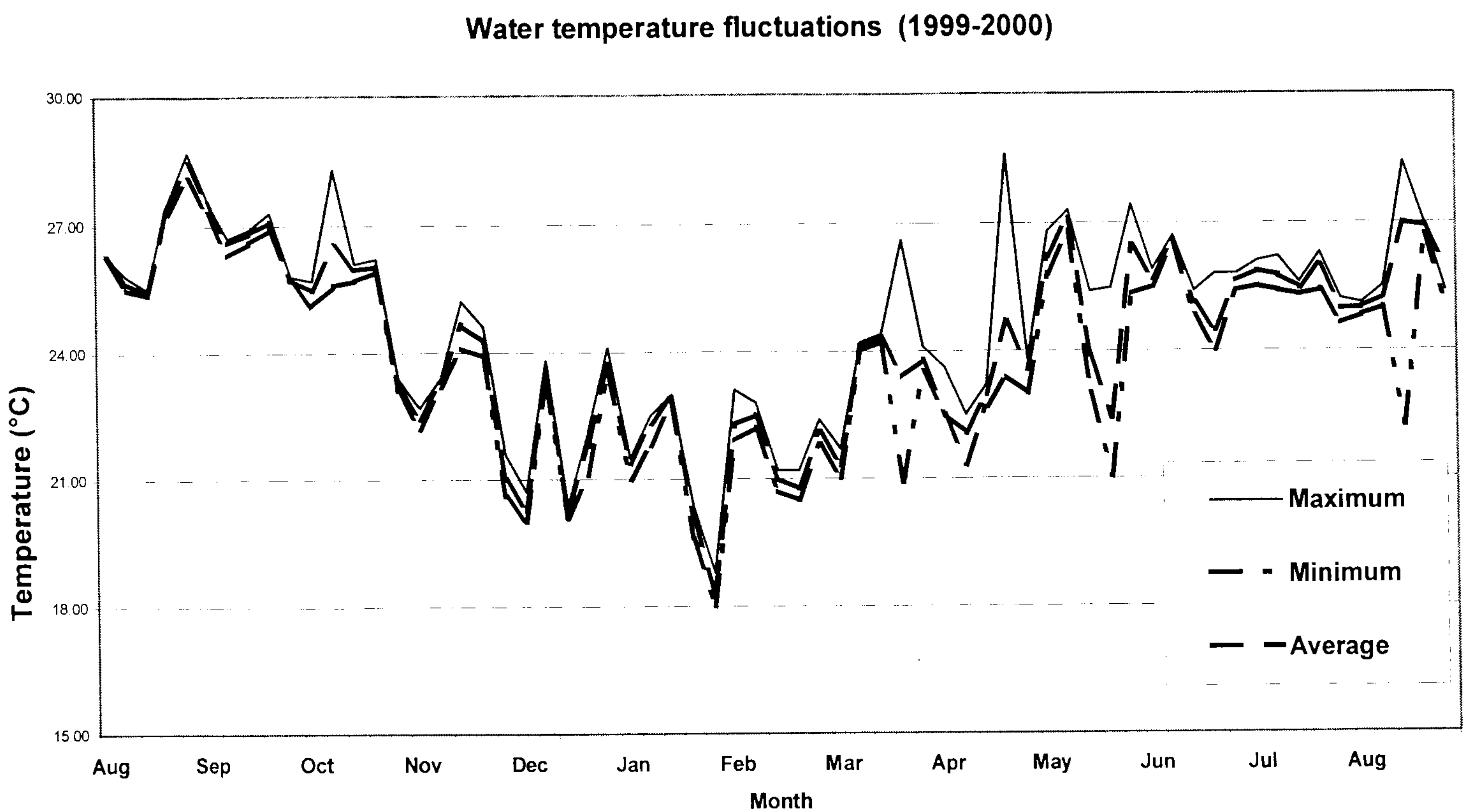
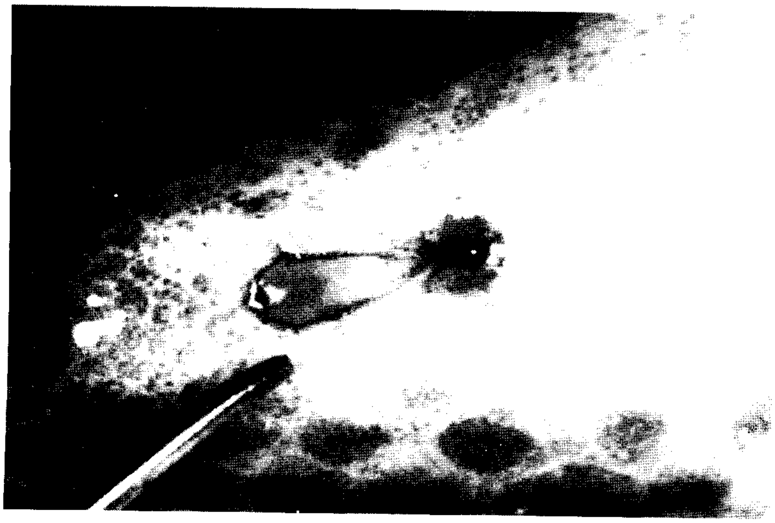


Figure 1. Average water temperature in Zamorano, Honduras.



Genital orifices of an adult male tilapia

Genital orifices of an adult female tilapia

Figure 3. Anatomy of male and female tilapia useful for sex determination thru visual examination.

Las fotografías son Auburn University, USA.

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Production and marketing strategies used by small and medium-scale fish farmers in Honduras: Production Strategies Characterizing Small and Medium-Scale Tilapia Farms

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Abstract

This report examines samples of farms from Honduras departments have and do not have tilapia ponds as part of their farming systems. Data were obtain through personal interviews with 128 farmers, including 64 tilapia producers, in five departments: Olancho, Intibuca, El Paraíso, Francisco Morazán, and Santa Bárbara.

To obtain information about farms without tilapia, farmers were selected at random within the same community as the identified tilapia producers. Interviews were conducted in communities where the small-scale farmers with production of tilapia were located (Casley and Kumar 1988). The data are intended to constitute a representative sample of the population of the Honduran small aquaculture farmers in these departments. The analysis presents basic comparisons of landholding, farm, and personal characteristics of tilapia producers with the mirror sample of the farmers without tilapia. The analysis profiles basic differences between the two categories of farms, the operators, and their households. Younger farmers were more likely to become involved with tilapia farming. Those farmers more dedicated to their work inside

their farm from which they obtain all their income, and whose principal occupation is being a farmer, were more inclined to adopt farming of tilapia. Farmers that use of their land more intensively and who dedicate themselves more to the farming of basic grains were more likely to adopt the farming of tilapia. Since Honduran small farmers tend to be a depressed segment economically, they tend to satisfy first their subsistence necessities by maximizing the use of their resources. The financing for both tilapia growers and nongrowers tends to be a limiting factor because more than 80% of the population works without financing, a clear barrier to farm investments. Tilapia growers participated more in development projects.

Introduction

Rural people in Honduras constitute almost 61 percent of the total population (Stonich 1992, Barham and Childress 1992). They have little access to basic development goods -- food, shelter, potable water, sanitation systems, education, communications, roads, and markets (Rosero 1997). Eighty percent of all rural people live in poverty. Sixty-six percent of farmers who produce basic grains, the country's staple food, have access to only eight percent of all cultivable land. This 66 percent operate, on average, slightly more than one hectare of land to secure a year's supply of basic grains to feed a family with approximately six children, and to produce a surplus for the nation. Given the high levels of poverty in Honduras, it will be particularly important to attend to the problems that small and medium-scale farmers have in realizing the cash potential of their tilapia crop (Green et al. 1992, 2000).

The farming of tilapia was introduced in Honduras during the decade of the 70's. The production of tilapia at that period was primarily small-scale (Teichert-Coddington and Green 1997, Arias et al. 1998). Originally it was groups of families that were primarily participants in tilapia farming in an extensive or semi-intensive form. It was done as a supplementary activity inside their processes of agricultural production. In 1995 it was estimated that a total of 113.6 hectares belonging to small-scale family farmers were operational in Honduras. However, the exact number of small-scale producers is not known (Sacramento and Nuñez 1995). Export-oriented production of tilapia began in 1990 and has had rapid growth in Honduras since that day (Teichert-Coddington and Green 1997). In 1997 there were 15 commercial farms of tilapia with a total water surface of 185.3 hectares, which were producing for the export and the national markets. The Honduran export of tilapia to the United States has grown consistently since 1992 (Poncho 1986, Cerezo 1993).

To illustrate the problems farmers face in rural Honduras, CIAT researchers' account of Yoro, in Central Honduras is helpful. The principal commercial distribution channel is the intermediary or coyote. Such persons generally do not live in the community, instead traveling from San Pedro Sula, Morazán, El Progreso, El Negrito, Comayagua, Siguatepeque or El Salvador. Sometimes the intermediary provides equipment services at high prices and finance at high interest rates. Although there are ponds and aquaculture activities in Yoro, this activity is not described in the CIAT account. The most important marketing problems facing rural producers center on price followed by the availability of opportunities to sell their product on a regular basis (Abbot 1993, Molnar et al. 1996). Rural producers in Honduras face particular difficulties due to setbacks from periodic hurricanes (UNDP 1999), difficult terrain, poor road systems, and fragmentation in the rural sector (Arriaga 1986, Engle 1997).

Although tilapia can be a source of steady income, the enterprise is not likely to generate rapid or large profits. Producers holding exaggerated expectations tend to define normal results as disappointment or failure. Thus, some of the negative sentiment about tilapia in Honduras stems from unrealistic views of the rate of adoption and impacts of tilapia production (Molnar and Lovshin 1995). Small and medium scale farmers may more profitably rely on strategies such as pond bank sales, partial harvesting for local delivery to restaurants or markets, or other niche arrangements that reflect situational opportunities.

At present there are in existence organizations and institutions that are working to support the development of the production of tilapia at a small-scale level in different zones of the country. The support is financed by international agencies and is oriented towards small-scale farmers. The support for medium scale farmers also exists. These organizations have tried to improve the livelihoods of small-scale farmers by implementing and promoting tilapia enterprises in their farm systems, as well as a means to improve the diet of their family members.

In Honduras, many efforts to promote the farming of tilapia have been developed by various development agencies. In addition to the PD/A CRSP, the Christian Commission of Development, the Program of Rural Reconstruction, Proyecto Guayape, El instituto National De information Professional that are prompting the small scale level production of tilapia as an alternative system of production to improve the diet in the families of small farmers. However, up to now there is no detailed characterization of those small scale farmers willing to adopt the farming of tilapia inside their production systems. In this sense, the efforts of promotion may have been less effective by not having good information about the target category of producers. The present work focuses on the investigation of socio-economic conditions of small-scale farmers in Honduras, as its initial step in the development of a more effective program of extension and production.

The objective of this study to compare socio-economic characteristics of small farmers with and without tilapia production system, as one means for understanding the adoption of tilapia farming. The purpose of the research is to identify the social and economic conditions that distinguish small farmers that have incorporated the production of tilapia inside their system of production from those that do not.

Methods and Materials

Given the lack of a national census of the producers of tilapia in Honduras, a partial census managed by specific developmental programs was used as a sampling frame for this study. The frame is incomplete and biased toward households and communities participating in NGO projects, but nonetheless representative of the total population.

The projects that were considered were the following: Program of Rural Reconstruction, National institute of Professional Development, Christian Community of Development, and Watershed Management Unit off the El Cajon dam, and the Experimental Station of el *Carao* at Comayagua. Through these developmental agencies a list of tilapia producers was obtained. No other current list of producers, tilapia or otherwise, is available.

Data were obtain through personal interviews with 128 farmers, including 64 tilapia producers, in five departments: Olancho (Sta. María del Real and Juticalpa), Intibuca (Yamaranquila), El Paraíso (Danlí and El Paraíso), Francisco Morazán (Lizapa and Galeras) and Santa Bárbara (Las Vegas).

To obtain information about farms without tilapia, farmers were selected at random within the same community as the identified tilapia producers. Interviews were conducted in communities where the small-scale farmers with production of tilapia were located (Casley and Kumar 1988). The data are intended to constitute a representative sample of the population of the Honduran small aquaculture farmers in these departments. The analysis presents basic comparisons of landholding, farm, and personal characteristics of tilapia producers with the mirror sample of the farmers without tilapia.

Results

The table compares the characteristics of farm households with and without tilapia, presenting chi-square statistics to suggest what differences are worth considering as significant. In some instances, an ANOVA F-test is reported in the text when an interval level variable is considered.

Age

Age was considered a factor that could have had influential effect in the adoption of the culturing of tilapia. In the case of farmers with tilapia, the average age was 39.5 years significantly younger that the 43.6 years mean age for those without tilapia ($F=3.6$, $p<0.057$). Although older farmers may have more capital, nutrition and food security, younger tilapia farmers may be more amenable to new enterprises and perhaps more motivated to seek alternate uses of farm resources.

Gender

Although 60 percent of the sample was male, there was no difference in the rate at which men and women participated in tilapia culture. About half the respondents of each gender in the sample were tilapia growers.

Marital Status

Marital status was related to whether or not farmers grew tilapia ($X^2=9.8$, $p<0.01$). The married farmers were more likely to grow tilapia. It can be said that those legal married families present more stable socio-economic conditions, which made it easier for them to adopt a technology that would affect their system of production. This is why projects of development should focus their work to the incentive production of tilapia in those families where there exists family stability.

Income

Tilapia farmers reported higher average annual incomes than non-tilapia growers (18,918 Lempiras versus 17,811 Lempiras). However, this difference was not statistically significant ($F=0.127$, $p< 0.7$).

Principal Source of Income

Farmers were asked about their principal source of income: agriculture, day labor, and small food store business. Apart from this, other sources of income such as the sale of items sent from abroad among others were considered. The chi-square test showed significant more farmers with tilapia obtain their income principally from agriculture ($X^2=23.7$, $p<0.001$). Those without tilapia have more income coming from working as day laborer, and others depend on income coming from profits made from a small food store or tavern.

It is common in farmers from Latin America that agriculture is their main source of income, they depend on it for their subsistence. A study carried out in Guatemala about small scale farmers showed that the principal source of income is from agriculture (Castillo et al. 1992). Meanwhile the production of tilapia should be promoted to those whose principal income is from agriculture, in this study, farmers with tilapia have less amount of land and that is why they have a more intensive management in their farm. At the same time, they are more productive and prefer to work their lands instead of going out looking for work, as is the case of farmers without tilapia.

Size of Farm

The amount of land available between both tilapia growing showed significant difference consequently, the size of the farm could be a factor of influence in the adoption of the farming of tilapia. Farmers without tilapia had more land in comparison to those without tilapia, on average they have 2.45 hectares and those with tilapia an average of almost 3.5 hectares ($F=4.8$, $p<0.03$). Those with tilapia had smaller farms.

Apparently, the intensity of the use of the land is greater as the size of the farm diminishes. In this case, it is true that those farmers with small farmers have a tendency to diversify their operations. Similarly, Castillo et al. (1992) found that Guatemala farmers with less than 2 hectares of land were more likely to farm tilapia.

Type of Crop

Tilapia farmers differed with the type of crop that they plant. The majority of farmers with tilapia showed a combination of annual and perennial crops. This could be because they have less availability of land than the traditional farmer does and they utilize it better for a greater productivity for their survival. The type of combination observed in farms is one in where farmer's plants: corn, beans and have part of their land with coffee plantation as a perennial crop.

Use of Land

The association between both tilapia growing and the use of the land was not significant difference (X^2=11.1, p<0.1). Nonetheless, programs of development in system of tilapia farming should have emphasis on the farmers who have a combination of annual and perennial crops, who are the majority of those who adopted the system of tilapia. The previous result signifies that those farmers with system of production more stabled and diversified would be willing to adopt mew technology.

Principal Occupation

Dependence on farming as a principal economic activity is important because it may affect adoption of the farming of tilapia because farmers with more or less continues presence on their operation may have more time and inclination to attend to a farm pond. This variable was significantly related to tilapia growing (X·=11 1, p<0.1). Farmers with shops or labor employment were less likely to be involved in tilapia culture.

Principal Farm Enterprise

The nature of the main farm enterprise was not associated with tilapia growing (X^2=5.5, p<0.1). Although more respondents reported coffee as the principal activity of their farm, the differences were not significant. Perhaps not detected in these data, there may be some link between the conditions that are favorable for coffee production; particularly soil quality and rainfall sufficiency also may be more conducive to fish culture. Generally coffee areas have at least somewhat fertile soils and sufficient rainfall to replenish ponds and the watersheds that supply ponds.

Project Participation

Development agencies such as missionaries, nongovernmental groups, and units of the Honduran government often conduct training programs and provide technical assistant intended to improve and diversify the livelihoods of rural producers. Often these activities feature fish culture among the array of alternatives that are supported. The data suggest that these efforts bear greatly on whether small farmers become involve in the promoted technology. There was a strong association (X^2=28.3, p<0.001) between farmers who have tilapia and participation in NGO projects.

Organized programs of technical and organizational assistance may influence the adoption of the farming of tilapia. For one, such endeavors may provide technical assistance for fish culture. Others may provide low interest loans or access to pond construction services that might not otherwise be available in a locale. Such projects are often a central audience for PD/A CRSP research results and technical assistance efforts. The training programs they organize and the regular contacts that NGO technicians have with fish farmers are important conduits of information about fish farming. PD/A CRSP scientist participation in technician and farmer training are central mechanisms for propagating research results.

Discussion

Development agencies should take into consideration the findings of this study in their programs of extension and research, in the promotion of tilapia, and planning for rural people. One central insight of the study is the need to consider the role of financing to small farmers. Small loans can help producers acquire technology and infrastructure that can make a long-term contribution toward developing their well-being. The results show that the majority of farmers work with their own finance and this is a limitation for them.

Honduras is a diverse country, but the several different sites chosen for investigation augment the durability or robustness of the findings. Nonetheless, it remains necessary to investigate the possibilities for tilapia production in other zones of the country in relation to the socio-economic characteristics of small farmers and the kinds of production strategies appropriate to their conditions.

Anticipated Benefits

The results of this provide additional guidance to the technology development and outreach efforts of the PD/A CRSP research program in Honduras. There is a growing recognition of the need to focus and target outreach efforts that encourage farmers to undertake tilapia culture. Understanding how tilapia farmers differ from the general population of producers in terms of their personal and household characteristics, coupled with knowledge about appropriate soils and water-holding capacity, can lead to more effect presentation and use of PD/A CRSP research results. Enhanced understanding of production barriers, distribution difficulties, and disincentives to participation in tilapia culture are important ingredients in efforts to assist farmers in selecting tilapia as a farm activity and in increasing their production. The project must understand and anticipate those factors that give farmers reservations about the benefits they will receive from new or reactivated fish ponds.

Fish culture has a future in Honduras. The government can help best by doing a few things well and otherwise staying out of the way where it does not have the resources or commitment to act effectively. The donor community can share information with each other and the farmers, paying particular attention to the small- scale sector. Our project can help the nongovernmental community to train its technicians and to develop its capabilities for the day when PD/A CRSP will not be in Honduras. Tilapia is something Hondurans will eat and an identifiable segment of operators is capable of growing. The market will work if the broad array of public institutions, nongovernmental organizations, and large-scale firms are enlisted in improving the distribution of information about opportunities to grow and sell tilapia in Honduras.

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Levee pond design model

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Abstract

The levee pond model is an Excel® spreadsheet that computes a volume balance on a levee pond. The model is organized into the following pages: Directions and overview, table of contents, input, pond model, results and principal spillway. The design is based on answers to 15 key questions on the Input page. Each question has guidance in the form of a comment that becomes visible when clicked upon. The model computes a volume balance on the pond as shown in a drawing on a "Drawings" page. The model is designed to assist competent NGO personnel in helping small to medium producers.

After completing the initial inputs, proceed to the "Results" page. Maximum, Average and minimum pond volume changes based on net Inflow and net Outflow are computed. The pump in rate with zero pump out is used to determine the water balance required to satisfy evaporation, seepage and rainfall. One iterates on the pump in rate to achieve the desired near zero target for net outflow volume change. Volume changes based on net outflow should be zero to positive for the pond not to lose volume. Values on the results page are copied from the "Pondmodel" page that shows detailed computations. Most users would not be concerned with the computational details.

Volume changes based on net inflow should approach the volume change target set based on the level of management anticipated. After achieving the initial water balance, one adjusts both the pump in and pump out rates to achieve the desired volume change targets. The pump in rate exceeds the pump out rate by the initial volume balance in order to preserve the initial volume balance. Adjust these inputs until the desired volume changes are achieved based on net inflow. One may then proceed to the "Principal SW" page for a pipe-riser spillway design.

The intent of the levee pond model is to develop a complete volume balance on a pond with a recirculation target, which may range from 0 to any number of volume changes per month. The recommended procedure is to first set the output pump rate to zero. One may then determine the inflow pump rate necessary to balance seepage, rainfall and evaporation In a given climatic region, based on net monthly net outflow as shown on the "Pondmodel" page.

Monthly rainfall and evaporation are used in the monthly balances. Soil seepage is included, which should be determined from a soils analyses or seepage tests. Volume balances on net input should be near zero to have a sustainable pond. Next one may determine the pump out rate and pump in rates to meet the volume change target. This process begins by inputting a trial pump out rate. Input the initial pump in rate determined above, plus the trial pump out rate for the new trial pump in value. The volume balance based on net output should be near the volume change target. Maximum, average and minimum volume ratios are reported, based on monthly ratio computations. The principal spillway design is included. There is no watershed supply; therefore an emergency spillway was not included.

If springs or stream flow are not adequate for your desired pond size and management, one may wish to consider a watershed pond or a hillside pond for water harvesting. Another model, "Hondurascatchmentpond" is available for this application. Water harvesting is dependent on diverting runoff from a watershed collection zone to the pond. The design of the watershed pond or hillside pond is very site specific. You are strongly encouraged to consult with a competent pond designer. Ask a local NGO representative for help.

Experience suggests that valleys with available springs are the best levee pond candidates. Valleys frequently have soils of adequate clay for sealing purposes. Elevations above 1000 m become problematic for finding springs. In Latin America, there seems to be a correlation between both coffee and rice production with water availability. Areas with nearby hardwood forests tend to bode well for water availability.

Training and technical assistance in warm-water fish culture

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Abstract

A central issue for aquaculture development in Honduras is fingerling supply. Previous PD/A CRSP research reported that farmers in remote places found that fingerlings were difficult to obtain but did not consider this sufficient reason for withdrawing from fish farming. The Zamorano PI and his technician in this project confirmed that the Comayagua research station "El Carao" was not a reliable supplier of fingerlings for producers. Private fingerling producers are few and generally geared to supply large-scale commercial operations. The overriding objective of our work was to provide technical assistance and training to current and potential fingerling suppliers to small- and medium-scale tilapia producers in Honduras.

A Peace Corps program of technical support to fish farmers was possibly the most focused on-farm assistance to small-scale fish farmers in Honduras, but this program ended in 1995. The national extension program in aquaculture has a presence in many regions, but the effort is fragmented and under-funded. A large number of nongovernmental organizations (NGOs) have been active in rural development projects in Honduras, including several promoting fish farming, but expertise in this activity is often insufficient to provide critical technical information required for proper pond management.

During November 1999, we consulted with 13 representatives of national and international, government and non-government organizations. From these consultations, a strategy and timetable were developed for implementing technical assistance and training of fingerling suppliers and technicians working with NGOs currently, or potentially involved in small- and medium-scale fish culture development. At least 33 small- and medium-scale tilapia producers (each with 150 - 12,000 m^2 of water surface) and 26 restaurants were subsequently interviewed by the technical team to assess the production and marketing demands for tilapia in Honduras. With the collaboration of a local NGO, we invited representatives of NGOs with actual or potential interest in

aquaculture development to a one-day seminar to describe opportunities and constraints for family-scale fish culture in Honduras. The Zamorano team continues to identify and provide technical assistance to regional fingerling producers and organizations involved in aquaculture extension. During the life of this activity three technical workshops were provided by Zamorano and Auburn for actual and prospective fingerling producers and extensionists. More than 30 publications on fingerling production and pond management practices have been incorporated in a web-based information system developed by a local NGO, primarily in response to needs of local NGOs.

Introduction

A critical issue in the development of tilapia farming in Honduras is fingerling supply. Molnar and Lovshin (1995) found that fingerlings were hard to obtain for many farmers, but fingerling supply not a reason for withdrawing from fish farming. For many farmers in remote areas, fingerling transport may be difficult, costly, and hard to organize. These conditions underscore the importance of increasing the number of private fingerlings suppliers, enhancing autonomous fingerling production among small-scale producers in remote locales and stabilizing the public and non-governmental sectors as brood stock suppliers. Given the historically uneven performance of the public sector, it is vital that private sources of seed stock become the foundation for the industry. The objective of our work was to collaboratively assist in providing technical information required to develop and strengthen small- and medium-scale producers of tilapia fingerlings.

A Peace Corps program of technical support to fish farmers was possibly the most focused on-farm assistance to small-scale fish farmers in Honduras, but this program ended in 1995. The national extension program in aquaculture has a presence in many regions, but the effort is fragmented and under-funded. A number of NGOs have been active in rural development, including several actively promoting fish farming projects, but technical expertise is often insufficient to provide critical information required for proper pond management. An analysis of previous fish culture development projects involving family-scale fish culture in Latin America where aquaculture is not well established, emphasized that such development projects require many years of effort before fish farming becomes a stable agricultural activity (Castillo et al., 1992; Lovshin et al., 2000). Interruptions in the development process have often led to disillusion and a generalized rejection of fish culture by participants. Given the relatively short horizon of our project, we concluded that we must work collaboratively with local organizations with long-term vision and commitment to development. The objective of our work was to identify the NGOs and agencies interested in incorporating small-scale fish farming in their development programs and then to provide technical assistance and training to their field staff.

Methods and Materials

Planning. In November, 1999, the Principal Investigators from Zamorano, the University of Georgia, and Auburn University, visited directors and representatives from fifteen educational and national and international governmental, nongovernmental, and private agencies involved in tilapia culture in Honduras. During this visit, a strategy and timetable were developed for implementing technical assistance and training of fingerling suppliers and NGO extensionists.

Implementation. In early 2000, at least 33 small- and medium-scale tilapia producers (each with 150 to 12,000 m^2 of water surface) and 26 restaurants were interviewed by the team members to assess the production and market demands for tilapia in Honduras. With the collaboration of a local NGO, the team invited representatives of NGOs with actual or potential interest in aquaculture development to a one-day seminar to describe opportunities and constraints for family-scale fish culture in Honduras. Based on this information exchange, these organizations could better decide about the appropriateness of fish farming in their development program.

In September 2000, a two-day fingerling production technical workshop was presented by Zamorano and Auburn for approximately 20 actual, and prospective, fingerling producers. The workshop included an analysis of conditions and fingerling demands, formal presentations on production techniques, and roundtable discussions.

In March 2001, a one-day workshop for approximately 15 tilapia producers and NGO representatives was held at Zamorano to discuss potential production techniques and to develop an interactive mechanism by which the economic impact of pond management practices could be assessed. The biological production characteristics of a given management can reliably be extrapolated from results obtained in regions with similar climates, but profitability is highly variable due to variation in the value/cost of individual inputs and outputs. Spreadsheets were therefore developed for each potential management practices in which production inputs and outputs were fixed but the per unit value/cost of each line item could be entered by the user. Economic conclusions were expressed as Return to Labor above Variable Costs and Return to Labor per unit of Labor Expended.

Institutionalizing access to technical information. In conjunction with another activity in this project and in collaboration with a local NGO, the "Red de Desarrollo Sostenible - Honduras" (RDS), more than 30 documents related to tilapia fingerling production and growout techniques for small- and medium-scale operations were installed in a Spanish-English website (www.aquacultura-ca.org.hn). Sources of the documents include theses, manuscripts published by the International Center for Aquaculture and Aquatic Environments (ICAAE) at Auburn University, Southern Regional Aquaculture Center (SRAC), and original documents prepared by project PIs.

Results and Disucssion

During the 1999 planning activity in Honduras, attended by all project team members, fifteen officials from relevant organizations and entities were consulted, including:

Angel Carcamo	Global Village.
Raquel Isaula	Director, RDS - Network for Sustainable Development
Raul Zalaya	World Neighbors
Mike Giles	CARE
Carlos Zelaya	FAO, Director of the local office
Carlos Elvir	FAO, Coordinator of Local Watershed Management
Marco Lopez	Former Minister of Agriculture (MOA), Honduras
Marco Polo Micheletti,	Ministry of Agriculture, Honduras
Adalberto Sorto,	Director General of National Development Program
Marc de Lamotte,	National Director of Human Resources
Cesar E. Duron,	Human Resource Manager, Honduras
Arthuro Galo,	Coordinator of Development Projects, MOA
Dennis Sharma,	USAID Honduras

All officials visited expressed a commitment and willingness to collaborate in the development of small- and medium-scale fish culture in Honduras, but an overriding concern was the budgetary commitment for a long-term effort. The need for a team approach was obvious.

With the collaboration of one of the local NGOs visited (RDS), the Zamorano team invited representatives of (50+) NGOs with actual or potential interest in aquaculture development to a one-day seminar to describe opportunities and constraints for family-scale fish culture in Honduras. Based on the informal discussions during and following this meeting, about 20 NGOs expressed their determination to incorporate aquaculture development in their program, provided their outreach personnel could receive adequate training.

A two-day fingerling production technical workshop was organized at Zamorano for approximately 20 actual and prospective fingerling producers. The workshop included an analysis of conditions and fingerling demands, formal presentations on fingerling and grow-out production techniques, and a roundtable discussion with participants. The technical competence of the participants was highly variable. A single workshop appeared to be sufficient for some participants, but follow-up sessions, including additional hands-on field experience, seemed appropriate for the majority of the participants.

In conjunction with another activity in this project and in collaboration with a local NGO, "Red de Desarrollo Sostenible - Honduras" (RDS), more than 30 documents related to tilapia fingerling production (Popma and Green, 1990) and growout techniques (Bocek, 1989; Green et al., 1994; Popma and Lovshin, 1996) for small- and medium-scale operations were installed in a Spanish-English website (www.aquacultura-ca.org.hn). The majority of the documents were installed on the website during the period February-August 2001. The number of publication-"hits" on the relevant documents as of August 9, 2001 has been 398. The affiliation and objectives of the users and their perception of the usefulness of the information are yet undetermined.

Conclusions

Personnel of the International Center for Aquaculture and Aquatic Environments and PIs in this project have dedicated more than 110 person-years of effort to development projects in 97 countries. One "lesson learned" from these experiences was that the development of family-scale fish farming in regions where aquaculture is not a traditional farm activity has a higher failure rate than large-scale commercial aquaculture enterprises and can not be accomplished in a few short years. Constraints faced by prospective farmers relate to: infrastructure (roads, electricity, etc.), availability of production inputs, access to markets, economic status of both producers and potential consumers, business management skills, and timely access to technical information. The cost of pond construction (cash or family labor) requires that ponds be utilized intensively. To accomplish this, ponds may have multiple functions (fish farming, irrigation, integrated animal husbandry, etc.) or nutrient inputs can be increased. Feeds are used on most commercial farms but are physically or economically unavailable for most small, family-scale farms with little land. The use of fish feeds, are profitable when available, add a large degree of economic risk often inappropriate for resource-limited producers with little business management skill. For farmers with little land, on-farm available nutrients (manure, agricultural by-products, etc.) are sufficient for only small ponds. The opportunity to generate cash income is a strong motivator for prospective small-scale producers, but transport of the fish harvest to market is often difficult and potential consumers often lack the cash to purchase the product. In spite of these constraints, a fish farming development program can lead to the most productive use of small plots of land, provided the development effort is committed, competent, and sustained.

Constraints faced by a group promoting the development of family-scale aquaculture in a non-traditional region are many. Low fish production from small, relatively isolated ponds makes an extension program very expensive in terms of cost per ton of fish produced. The transition in converting fish farming from non-traditional to a traditional farm activity is slow during early development, because cash-poor and over-worked producers are reluctant to invest scarce resources in questionable enterprises. The cost-benefit ratio of the outreach effort during early development may prematurely break the will of sponsoring groups, resulting in a development failure and disillusioned producers that reject any subsequent fish farming effort.

The assessment of the appropriateness of fish culture and the training needs of a development group requires an understanding of the socio-economic characteristics of the community and the cost and availability of potential aquaculture inputs. The selection of appropriate culture species and management practices are critical. Contrary to operations utilizing nutritionally complete feeds, the species selected for most small, family-scale farms must be able to effectively utilize natural food organisms to supplement the nutritional deficiencies of agricultural by-products and on-farm available nutrients. Transportation and economic constraints also impose the eventual need for regional independence of fingerling supplies. This implies the selection of a species and production techniques appropriate for many local producers.

Information is often limiting on the biologically and economically most appropriate production strategies. Experimenting with resource-limited farmers in the target region is a dangerous development strategy because it often places them at unacceptable risk, and a failed experimental management practice often leads to a generalized rejection of fish farming. Expected production results can often be accurately extrapolated from experiences in other regions with similar climate and conditions, but economic results may be highly variable because of regional differences in input costs and the market value of the fish. Pond management practices should not be promoted until adequate information is available on the biological and economic benefits.

Successful fish farming development projects require a team effort. Local NGOs often have long-term vision and mid-level extensionists with generalized agricultural and development skills but little specialization in fish culture. Specialized training and case-specific research is often provided by another group. Training must be cost-effective, dynamic and responsive to developing questions.

This CRSP project does not have the long-term horizon required to undertake fish farming development in regions where there is little previous tradition. Our objective was to assist in "training the trainers", those individuals with direct contact with prospective producers and with long-term commitment to the community. The mechanisms for accomplishing this include case-studies to assess local conditions and to perform research on incompletely understood management practices, offer short-courses, and provide information to incorporate into a dynamic and interactive web-based network.

Anticipated benefits

The described anticipated benefits of these two activities were improved quality and quantity of fingerlings for the private sector, including small- and medium-scale producers, and an increased understanding by NGO technicians and independent producers of the benefits and constraints of low-input tilapia farming. A high percentage of outreach personnel working in rural development often have an understanding of the overall needs of their target constituents and a broad, general knowledge of many potential agricultural enterprises. However, they often have a poor understanding of fish farming, leading to unrealistic expectations or off-hand rejection of the potential benefits of this activity. In regions where fish farming is non-traditional, the benefits of "training the trainers" can vary from a simple rejection of an outreach effort where inappropriate to a slow transition of fish farming into a profitable and widely accepted farm activity.

A historic analysis of such development efforts worldwide reveals mostly failures, especially where efforts were not sustained for several years. However, the high risk of failure is balanced by the understanding that the target group is faced with the greatest constraints and is in greatest need of improving their nutritional, health and economic status.

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Web-based information delivery system for tilapia for sustainable development of aquaculture in Honduras

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Abstract

The project was focused on identifying and developing methods to create an enabling environment for sustainable development of aquaculture on Honduras. Honduras has large network of NGOs operating at village level, an exceptional educational institution in Zamorano with commitment to extend training and knowledge in aquaculture and an established in-country sustainable development electronic network operated by Red de Desarrollo Sostenible-Honduras (RDS-HN). We develop the concept of training the trainers (NGOs working with farmers at village level) by bringing together Zamorano and RDS-HN and developing a Web-based Information Delivery System for Tilapia (WIDeST). In this approach WIDeST capture on the developed electronic information technology network and capacity of RDS-HN while providing a means to provide easy to use information developed

by Zamorano. Furthermore, it provides a way to connect local NGOs, farmers, decision-makers for exchanging information and enabling them to make informed decisions. The WIDeST provides information on Tilapia production and related topics, natural resources of Honduras, contact information of NGOs, and chat room facilities for conducting virtual forums and discussions. The email facility enables the user to ask questions which is answered by an expert. Since the inauguration session in March 2001, the Website has had more than 6800 hits, and more than 300 individuals formally registered to receive information. The participants at training and workshop sessions have found this to be an easy and useful approach and have provided strong encouragement for adding new information. The number of individuals already reached as evidenced from the numbers of visits to the Website provide a strong evidence that is may be a way to build capacity of local institutions in developing and environment that enables farmers to adopt aquaculture as an alternative in their farms.

Introduction

The concept of an enabling environment has been identified as a key prerequisite for sustainable aquaculture development (Shehadeh and Pedini 1997). Experiences in natural resource management initiatives for the hillside regions of Latin America (CIAT, 1997) suggest that creating partnerships among stakeholders involved in managing and/or using natural resources is part of the process of fostering an enabling environment. Another aspect is to adopt an integrated decision-making framework for use in such environments (Nath et al., 1999).

Implementing small and medium scale aquaculture on a widespread and sustained basis is a long-term process (Harrison 1991, Molnar et al., 1991). Consumer demands and dietary preferences are not obstacles to fish culture in Honduras nor are sales problems necessarily a reason for abandoning ponds. Tilapia is widely acceptable as a consumer item. In a 1996 survey, a majority of Honduran farmers noted "my understanding" as the major obstacle to obtaining larger harvests from their ponds (Molnar et al., 1996). Thus, there exist an opportunity for sustainable development of small and medium scale aquaculture in Honduras.

The “Red Nacional de Acuicultura” (National Aquaculture Network) created by the Food and Agriculture Organization (FAO) in 1992 was an effort to integrate international institutions and the private and public sector of Honduras. Among the participants were: Dirección General de Pesca y Acuicultura (DIGEPESCA), Universidad Nacional Autónoma de Honduras (UNAH), Escuela Agrícola Panamericana El Zamorano, Escuela Nacional de Agricultura (ENA), Agriculture School John F. Kennedy, Peace Corp Honduras, Federación de Productores y Exportadores (FPX), Asociación de Acuicultores de Honduras (ANDAH), and Instituto Nacional de Agricultura (INA). In place for about a year, FAO organized the network with the intention of eventually withdrawing in favor of Honduran management. Unfortunately, leadership problems caused most organizations to *suspend* participation and FAO moved on.

We realized the need for a systematic method for enabling communication to reawaken the dialogue. In this context the University of Georgia and its collaborators from Zamorano and Auburn University identified that a successful approach for developing will be one in which the following three already existing elements in Honduras is brought together for effective communication and organized decision making.

1. Host Country Non-governmental Organizations (NGOs). Currently numerous NGOs in Honduras are extending advise to small- and medium-scale farmers and are keenly interested in providing information on aquaculture systems. However, they are in need for information and educational materials.

2. Escuela Agrícola Panamericana El Zamorano is a well-established academic institution with outstanding programs in agricultural sciences. In addition to educating students, Zamorano has active programs and commitment for extending knowledge to local farmers.

3. The Red de Desarrollo Sostenible-Honduras (RDS-HN). RDS-HN was created with the initial grant from the United Nations Development Programme (UNDP) in response to the 1992 Earth Summit which mandated assistance to "developing" countries for establishing in-country Sustainable Development Networks (SDNs). These networks were envisioned to provide infra-structural support for rapid communication through electronic information technology. The RDS-HN was among the first to establish network and now provides the Internet services to over 700 customers and hosts numerous Websites in such areas as forest and natural resource systems. Similar SDNs have been created in other Latin American countries, e.g., Costa Rica, Dominican Republic, Nicaragua, Panama, Guatemala, Haiti, Mexico, Guyana, Bolivia and Columbia. Together these SDNs can constitute a formidable information network to facilitate exchange and contact among farmers, government and non-government organizations as well as private entrepreneurs.

Thus, we believe there is a unique opportunity for capacity building and institutional strengthening for aquaculture in Latin America by providing an enduring method that integrates NGOs, Zamorano and RDS-HN into a team. In this team Zamorano leads in providing current knowledge on aquaculture systems, RDS-HN leads in making accessible the knowledge to the users *via* electronic information technology, and the NGOs use the knowledge to educate and advise small and medium scale farmers on aquaculture systems. In other words, the task in this project was to identify and implement those methods that will provide information to small and medium scale fish farms to ensure that they can be sustained as a productive enterprise in Honduras.

The objective of this project was to create an enabling environment for developing linkages among organizations and to build institutional capacity for providing information expeditiously to small and medium scale farmers for sustainable development of aquaculture. This report presents a new approach with the use of electronic information technology for developing a Web-based Information Delivery System for Tilapia (WIDeST). The complementary training sessions provided information to NGOs and farmers on aquaculture systems and introduced them to the use of WIDeST. This approach provides to diminished dependence of small and medium scale farmers on technical assistance from outside sources. It will enable host country NGOs and private firms to provide services and Zamorano to provide technical assistance locally. This approach could fortifies partnership between Zamorano, RDS-HN and host country NGOs and their ability to sustain aquaculture development in Honduras.

Materials and Methods

Sample and data collection

The first meeting of the collaborative investigators took place in Honduras at the inception of the project to interact over the objectives and timetable of activities. The meeting was devoted to understanding local capacity and familiarizing with the host country activities. In Zamorano we toured facilities, met key faculty and administrators and assessed outreach capacity of the institution. We visited twelve national and international NGOs, extension agents, governmental officials and policy makers to evaluate their interest and capacity in aquaculture. We visited Comayagua research station in El Carao, a site of earlier work supported by PD/A CRSP, to evaluate possibility of utilizing these facilities for training. And we visited small, medium and large farms to understand limitations for adopting aquaculture in their farming decisions.

Based on the observations of the first meeting a working session was set up with RDS-HN to discuss in detail the capacity of electronic information technology in Honduras and the role it could play to meet the project objectives. As a result of these discussions it was concluded that a method should be developed that makes information available to local NGOs and extension agents and they in turn train small and medium scale farmer on aquaculture systems. The method should also have features to receive questions and comments from farmers, NGOs and others to identify stakeholder needs and provide responses in a timely basis.

Developing web-based system

The method selected was to develop a Web-based Information Delivery System for Tilapia (WIDeST). The WIDeST includes developing a partnership between RDS-

HN and Zamorano for reaching out to NGOs, extension agents and farmers via the use of Website, focus groups and training meeting and printed documents for making aware of the Website for information. Additional features to be included were capacity to conduct electronic meetings through "chat" facility, whiteboard for posting questions and observations for public viewing and links to other significant Websites with pertinent information on aquaculture as well as resources in Honduras.

To receive input from stakeholders a workshop was arranged in Zamorano with 87 participants who were directors and coordinators of NGOs, farmers, educators, representatives of government agencies and decision-makers with interest in Tilapia. An overview of the concept of WIDeST was presented the participants provided inputs identifying the content and needs for making this method successful. Also, a questionnaire provided interest and judgment of stakeholders on Web-based approach in general and WIDeST in particular. The response was highly supportive.

RDS-HN, in collaboration with Zamorano and project investigators, was engaged in developing the WIDeST. A formal announcement of the Website and exposure to the decision-makers was also planned. The target time was set to be in the first quarter of the 2001 to be followed with a formal training session on the use of the WIDeST towards the end of the project in July 2001. It was anticipated that in the duration of this project the Website will become useful but much improvement will be needed in terms of having a more complete information base on Tilapia, pond design, methods of assessing availability of water and other resources, and ease of use. Also, making some critical material available currently available in English translated into Spanish may not be completed due to time and resources.

Results and Discussion

The beginning project meeting with all Co-Principal Investigators in Honduras led to the following observations:

- There is a large network of NGOs in Honduras operating at the village level.
- These NGOs do not have good communication among themselves and linking them could increase the effectiveness of their work.
- Many NGOs are interested in adding technical assistance capabilities in Tilapia culture.
- NGOs and governmental policy makers are interested in water, water harvesting and hillside stabilization which directly impact aquaculture development.
- The Comayagua research station in El Carao can be an appropriate site for training NGOs technicians and extension personnel.
- The current limited capacity of fingerling production is an impediment to aquaculture development.

- Women and children play key role in farm families and are key to aquaculture development.
- Home consumption and local markets are primary outlets for small-scale aquaculture.
- There is a need for a "manual" with simple instructions for pond siting, design and construction for local use.
- RDS-HN, with its electronic information technology network, can be an important NGO in developing communication among various extension agents and decision-makers. It can also provide Web-based system for delivering information about
- Innovative methods for delivering information are needed which are developed through significant input from the stakeholders and which permit informed decision making at the local level.

These observations and the follow-up discussions with RDS-HN helped reach the conclusion that using electronic information technology capacity of RDS-HN and the excellent educational capacity of Zamorano in partnership can be an effective way to develop aquaculture in Honduras. This approach will also enable local NGOs to develop aquaculture and institutionalize capacity of the host country.

A Website has been developed and is hosted by RDS-HN. It can be accessed at http://acuacultura-ca.org.hn. The following welcome statement state the overall purpose of the Website, the collaborators and the source of support.

> Acuacultura CA is the result of an important collaboration among several universities and the Sustainable Development Network Honduras. Our purpose in establishing this interactive website was to provide a versatile linkage point to assist NGOs and individuals to attain success in small-scale fish culture projects utilizing low-cost inputs.
>
> The materials presented in the website are from diverse sources. They have been selected with the objective of providing information comprehensible to persons with some training in the agricultural and natural sciences, possibly beginning fish culturists.
>
> In addition, the website offers the possibility to establish a fluid communication between persons with an interest in learning about fish culture and experts in the different fields of aquaculture. The universities collaborating on this work are: the University of Georgia and Auburn University, both of the USA, and Zamorano in Honduras. The principal source of financing for this website comes from the Pond Dynamics/Aquaculture Collaborative Research Support Program of USAID.

The Website is organized to provide information on Tilapia in the following eleven categories. These categories may change as more is learned about the needs of the farmers and decision-makers. Currently more than 100 documents are available. Also an Excel-based pond design model developed in another activity of this project provides a user the ability to estimate the watershed size, available water based on local rainfall estimates and the design of pond for his/her local conditions.

1. Ponds. Includes information on methods for assessing watershed and water availability, pond design and management of ponds for fish culture.
2. Biology of Tilapia. Includes introductory materials on history, fish biology and reproductive biology.
3. Fingerling Production. Includes information on fingerling production, sex reversal, transportation and other related subjects.
4. Growing-out of Tilapia. Includes information on all aspects of Tilapia production.
5. Pathology and Diseases. Includes information on fish diseases and control methods..
6. Water Quality and Aquaculture. It has four sub-categories in Aquaculture, Fertilization, Fish Culture and Polyculture.
7. Production Quality. Includes fish quality, processing and controls.
8. Production System and Costs. Includes information on economics of fish production systems.
9. Tilapia and Development. This includes sub-categories in host country policy and agreements, relevant projects and current research, and a description on WIDeST.
10. News and Events. Provides a place to make user aware of the interesting information and useful upcoming activities.
11. Fish Gallery. Provide a location to present attractive specimen of fish for visual recognition and satisfaction.

The Website provides a chat room facility to conducting meetings and exchanging information. The project leaders used the chat room on several occasions to discuss the content of the Website where participants were in two locations in Athens, Georgia, two locations in Auburn, Alabama, in Zamorano and at RDS-HN Tegucigalpa location in Honduras. The real-time conversations provided an excellent means to interact. This facility will be useful for holding stakeholder meetings/discussions with experts and decision-makers. This capacity will not only provide information on Tilapia but permit users to communicate those needs that hamper the development of aquaculture.

The WIDeST was formally inaugurated on March 3, 2001 on Zamorano campus. The participants included representatives of government agencies, farmers, NGOs, extension agents and educators from Zamorano. The activity included an explanation of the WIDeST and a description and demonstration of the Website, hands-on exercise for the participants, and a chat session in which participants asked questions and an expert responded in real-time. The participants quickly learned the use of the Website as well as the use of chat room facilities. The participants, without exception, provided great encouragement to move faster in this direction and include materials that will be useful to commercial farmers.

However, this project is focused on small and medium scale farmers and this need can be met only with a more focused support perhaps in a separate but complementary project.

Since this time inauguration, the Website has had more than 6800 hits, more than 300 have registered to enter documents available to registered guests only, nearly 25 emails sent to the Webmaster and nearly 30 emails with questions sent o experts. This is a reasonable response at this time with little publicity and general awareness of the Website. The final meeting with stakeholders in August to be held in conjunction with Asociación de Acuicultores de Honduras (ANDAH) in Tegucigalpa will provide opportunity to describe the project and the Web-based system. The scheduled hands-on exercises and the exposure to the conference participants will add to understanding and assessing the value Web-based approach for institutionalizing aquaculture in Honduras as well as other low-income countries.

Conclusions

An enabling environment for sustainable aquaculture development will require a partnership between Escuela Agrícola Panamericana El Zamorano and the national and international NGOs in Honduras. In this partnership Zamorano will lead in providing scientific and technical information through training workshops and literature for the electronic information technology network for NGOs, decision-makers and farmers. The NGOs will then work directly with small and medium scale farmers for developing aquaculture on their farms. This "training the trainer" concept can be institutionalized by using a Web-based information exchange system. Also in this system information from the farmers is also shared with other farmers and users. Furthermore, this will enable the identification of needs and impediments in the sustainable development of aquaculture in Honduras and perhaps in low-income countries in Latin American region.

In this project, the Web-base Information Delivery System for Tilapia (WIDeST) developed with a host country NGO [Red de Desarrollo Sostenible-Honduras (RDS-HN)], was developed that is accessible at <http://acuacultura-ca.org.hn>. This Website has already received much attention. Furthermore, the participants at the training workshops and inauguration events provided enthusiastic encouragement. Low-income countries are also deficient in communication and transportation infrastructures and the electronic communication network is a powerful way to bridge the gap. By providing information in usable form through the Web to local NGOs, extension agents and decision-makers helps them make informed decisions. Access to information and ability to make informed decisions are fundamental to building capacity of local institutions. The work in this project is beginning a new approach that appears to very feasible. Additional work and longer experience with this approach are needed before its impact can be fully measured.

Anticipated Benefits

The partnership between Zamorano and RDS-HN is expected to enable host country NGOs in increasing their capacity to train farmers on aquaculture development. The Web-based system will increase communication among NGOs, decision-makers, farmers, Zamorano and other researchers. This will increase capacity to provide useful information to farmers. Also, needs for developing the enabling environment for developing aquaculture in Honduras will increase. Finally, this work could likely serve as a model for other Latin American countries to utilize their in-country Sustainable Development Networks (SDNs) which were established with an initial grant from the United Nations Development Programme (UNDC).

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Marine fish culture prospects in Latin American and Caribbean countries: review of candidates species and technological advances.

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Introduction

Aquaculture currently contributes with almost 30% of the total world fisheries production and has been increasing at an impressive annual growth rate of approximately 10%. By the year 2030, aquaculture will dominate fish supplies and less than half of the fish consumed is likely to originate in capture fisheries (Food and Agriculture Organization, 2001). The same report estimates that the role of capture fisheries in the economies of the wealthier countries will be further reduced as developing countries increase their share of production. Aquaculture will have expanded geographically, in terms of species cultured and technologies used. It is very unlikely that Asia will continue to dominate production to the extent that it did during the 1990s. Mariculture will account for a larger share of total production, particularly if offshore culture technology becomes viable (FAO 2001). High-value marine finfish landings are and will remain inadequate to meet worldwide demand. Imports into developed nations have risen dramatically within the past decade, and the prospects of replacing imported wild-caught fish with a farm-raised product are excellent.

Commercial operations for raising high-value marine fish will inevitably be established within the next few years in the offshore areas of the SE United States, Gulf of Mexico, Latin American and Caribbean countries. Most countries throughout these regions have appropriate offshore areas with great potential for the development of this emerging industry. Adequate utilization of available areas and infrastructure can lead to the development of unexploited resources with the potential of generating a large number of jobs and enormous social and economic benefits to these regions. Due to greater depth, stronger currents and distance from shore, environmental impacts are considerably lower in the open ocean, suggesting that offshore cage systems are among the most environmentally sustainable methods for commercial marine fish culture.

This paper reviews recent technological progress in marine finfish aquaculture and evaluates the levels of feasibility of native candidate species and suggests the use of environmentally-friendly technology such as recirculating systems and offshore cages. Focus is given on applied technology for the development of a commercially feasible and environmentally sustainable marine fish aquaculture industry in Latin America and the Caribbean.

Species

Emerging technologies on the artificial propagation of marine finfish species endemic to Latin American and Caribbean countries have brought the establishment of marine fish aquaculture industry a step closer to reality. Considering recent technological advances and marketing, the candidate species with the brightest potential for commercial aquaculture development in coastal and offshore areas of Latin American and Caribbean countries are the snappers (Lutjanidae, *Lutjanus spp*), dolphin fish or mahi mahi (Coryphaenidae, *Coryphaena hippurus*), jacks and pompanos (Carangidae, *Seriola spp, Caranx spp* and *Trachinotus spp*), tunas (Scombridae, Thunnus *spp*), cobia (*Rachycentrum canadum*), groupers (Serranidae, *Epinephelus spp*), snook (Centropomidae, *Centropomus spp*), mullets (Mugilidae, *Mugil spp*), drums and corvinas (Sciaenidae, *Menticirrhus spp, Micropogonias spp, Pogonias cromis, Sciaenops spp, Cynoscion spp*), and flounder (Bothidae, *Paralichthys spp*). Several projects dealing with the hatchery and growout stages of these species are currently underway and it is foreseen that three to five of the listed species will be raised commercially within the next few years in these regions.

Broodstock management, maturation and spawning

The basis of every hatchery operation is the maintenance of a healthy group of adult reproductive fish conditioned to spawn year-around as cued by environmental variables such as photoperiod and water temperature. The consistent supply of large number of high quality fertilized eggs can only be achieved by implementing a rigorous protocol aimed to reduce stress levels in the fish from the time of capture through its acclimation to captivity and final maturation. The techniques for capture, transportation, handling, sexing, sampling and acclimating marine finfish can be summarized as follows: prophylaxis using drugs and antibiotics and quarantine are necessary before introducing the fish into the maturation facilities. A detailed description of prophylaxis and quarantine techniques for marine finfish has been provided by Benetti and Alarcón (2001). Recent advances led to improved transportation, handling, sampling and biological control of parasites though symbiosis. Clove bud oil is extensively used as an anesthetic with *Seriola sp* and a number of other marine fish species in Australia and other countries. Some marine fish species at times react negatively to other anesthetics such as MS-222 and 2-phenoxy-ethanol. Clove bud oil at dosages of 20 ppm has been used for anesthetizing *Lutjanus griseus*, *L. analis*, and *S. dumerili* with remarkable results. The use of cultured and wild-caught neon gobies, *Gobiosoma oceanops,* and wild-caught juvenile porkfish, *Anisotremus virginicus,* has proven to be an effective long-term control of ectoparasites on mutton snapper, *Lutjanus analis*, and greater amberjack, *Seriola dumerili*, broodstock in recirculating systems. Following quarantine and acclimation, broodstock fish are stocked in maturation tanks, where they are conditioned to spawn naturally through manipulation of environmental parameters such as temperature cycles and photoperiod. Chillers and/or heat pumps and banks of fluorescent lighting are used for supplying required temperature and light cycles. Hormone-induced ovulation followed by voluntary spawning or manual stripping have also been widely used for several species which do not complete vitellogenesis and ovulation in captivity in response to environmental stimuli alone. In addition to traditional methods of induced spawning by injections of HCG (Human Chorionic Gonadotropin), LHRH-a (Luteinizing Hormone Releasing Hormone - analogue) and/or other natural and synthetic hormones, techniques involving synthetic copolymers and cholesterol pellets used as an inert matrix for GnRH (gonadotropin releasing hormone) and LHRH-a implanted in the muscle tissues of the targeted broodstock fish have been widely used with various degrees of success according to the species. Specifically, either natural or induced spawning of males and mature females have been achieved in all species listed by intramuscular injections of HCG (500-1,500 IU/kg body weight), and LHRH-a (100µg/kg) or GnRH-a intramuscular implants. Captive mutton snapper broodstock have been recently conditioned to spawn voluntarily in maturation tanks at the Aquaculture Center of the Florida Keys using environmental cues alone at a water temperature of 24 °C. Even though this was unprecedented, consistent supply of fertilized eggs has not yet been achieved. Researchers in the U.S. have spawned mahimahi, flounder, red fish, corvina, pompano, and most other species under consideration. In Japan, Australia and Ecuador, spawning of *S. quinqueradiata*, *S. lalandi* and *S. mazatlana* have been consistently achieved in captivity, and research is underway in the U.S. to spawn *S. dumerili*. The Inter-American Tropical Tuna Commission research with yellowfin tuna (*Thunnus albacares*) at the Achotines Laboratory in Panama has resulted in daily voluntary spawns of high quality fertilized eggs and now plans on establishing protocols for the larval rearing phase (Scholey et al. 2001). Induced and voluntary spawning of cobia have been achieved through research taking place at the University of Texas in Texas, Southland Fisheries in South Carolina, and Virginia Institute of Marine Sciences in Virginia, U.S.

Larval rearing

Intensive and semi-intensive (mesocosm) larval husbandry techniques have been used to demonstrate the feasibility of fingerling production of several high-value marine finfish species. Spawns are collected through a surface skimmer installed in the maturation tanks into an egg collector. Eggs are rinsed with sterilized salt water and stocked into incubator tanks where volume and fertility counts are obtained. A 10 ppm formaldehyde solution rinse has also been used on newly hatched eggs to reduce bacterial levels. At 26 °C, eggs hatch within 24 hours and the larvae begin feeding 2 days post hatching (DPH). Yolk-sac larvae are stocked at densities of up to 100 per liter in super-intensive systems, while semi-intensive larval rearing uses stocking densities of up to 20 per liter. Larval feeds consist primarily of microalgae, *Isochrysis galbana* and *Nannochloropsis oculata*, *Tetraselmis sp* and other species, rotifers, *Brachionus sp.* (ss-strain), *Artemia* nauplii as well as enriched metanauplii and subadults. Depending on the growth of the particular species, feeds will be overlapped and moved to the next larger item at a faster or slower rate. Traditional live feeds can be supplemented with wild zooplankton, including copepods of the genus *Acartia* and others.

Probiotics and artificial substrates have been used in mesocosm systems bloomed with phytoplankton and zooplankton to improve larval rates of growth and development. Preliminary results of trials conducted with mutton snapper indicate that, while survival rates remain low, rates of growth and development of *L. analis* are faster in outdoors mesocosm semi-intensive systems than in intensive systems indoors (Benetti *et al.* 2000). High mortalities are still observed during early developmental stages, especially at first feeding and metamorphosis. High mortalities during early developmental stages can sometimes be linked to poor broodstock nutrition. Weaning from live feeds onto artificial diets occurs at an earlier stage in the pelagic species at around 2 weeks post hatching, while mutton snapper and flounder will take up to 40 days post hatching (DPH). Cannibalism during early stages does not constitute a problem in the case of mutton snapper or flounder, while it can be a constraint during early larval rearing of pelagic species especially after metamorphosis. Lower stocking densities, stronger water flow and aeration, and increased number of feedings are some of the strategies used to dissipate this problem. Larval fish are highly susceptible to stress and will not tolerate handling prior to 30 DPH. Intensive larval culture methods have been successfully used to produce significant numbers of juvenile mutton snapper, although commercial feasibility of the operation has not been achieved. The aquaculture of *Seriola dumerili* and *S. mazatlana* are still in the research and development stage, but a survival rate of 9% from eggs to fingerlings of *S. quinqueradiata* has been reported in Nagasaki, and in Australia, yellowtail kingfish (*S. lalandi*) offshore cage aquaculture is currently expanding to commercial scale with fingerlings produced in hatcheries. Tuna larval rearing is a new field emerging after the recent success with spawning of captive adult brood fish. Cobia has proven to be a prime candidate for aquaculture given the latest research conducted in the US, where semi-intensive larval rearing in ponds has resulted in high survival rates and remarkable growth.

Nursery and growout

Of the species being considered in this review, only cobia (*Rachycentron canadum*), in Taiwan, *Seriola spp,* in Japan and Australia, and tuna in Japan, Australia and the Mediterranean Sea have reached the commercial phase in cage growout systems. The industry is moving fast from relaying on wild caught juveniles to hatchery produced fingerlings to stock growout cages. A remarkable cage culture industry based on hatchery produced fingerlings has been developed in European countries, particularly in Greece, with sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*). Currently, there is a major effort towards the development of offshore aquaculture in the SE U.S., the Gulf and the Caribbean. Preliminary results of high-value marine fish cultured in cages are only recently becoming available in this part of the world. In a growout trial recently conducted in the Florida Keys, growth, survival and feed conversion rates of mutton snapper raised in floating net cages have been assessed. Results are summarized as follows: A total of over 13,000 fingerlings produced at ACFK were stocked in two circular high density extruded polyurethane (HDEP) floating net cages moored in a 7-acre saltwater lake in the Florida Keys. The dimensions of the cages used were 10m diameter x 7 m deep (600 m^3) and 7 m diameter x 7 m deep (300 m^3), and both fitted with 1/2" mesh size (stretched). Fish grew from an average weight of 12.25 g to over 300 g in nine months, indicating that the commercial size of 0. 5 kg (over 1 lb) can be achieved within a 1-year growout period. Estimated survival rate was over 70%. Stocking densities were 25 fish/m^3 (3.2 kg or 6.0 lb/m^3) and 5 fish/m^3 (0.72 kg or 1.4 lb/m^3). Fingerlings were fed a 2.5-5.0 mm marine grower (Moore-Clark) pellet containing 50% crude protein and 14% crude fat and a 1/4" pellet (AquaXcel, Burris) containing 53% crude protein and 10% crude fat. Estimated feed conversion ratio (FCR) was 1.4, ranging from 0.79-3.4. Results confirm that *L. analis* has excellent potential for commercial aquaculture development in net cages in the U.S. and the Caribbean. Growth rates of pelagic species such as dolphin fish and cobia are significantly higher. Captive dolphin fish, *Coryphaena hippurus*, grew to almost 5 kg. and 76 cm. from hatching in 9.5 months in a study done at the Oceanic Institute in Hawaii. Cobia is reported to reach up to 8 kg. when grown in cages during a one year period according to reports from Taiwan.

Problems and constraints

The development of reliable techniques for mass production of fingerlings of marine finfish through artificial propagation in hatcheries is necessary for the establishment of a sustainable offshore cage industry in the U.S., Latin America and the Caribbean. Research is currently focused on improving technology in the areas of broodstock nutrition, egg quality, live feeds, first feeding, larval nutrition, and bacterial contamination of live feeds, which are the main constraints for the development of the industry at the hatchery level. Growout technology is readily available. At the growout level, the main hurdle to overcome is the required establishment of an effective and integrated collaborative effort among the private industry, government agencies, non-government organizations, academic and research institutions, as well as stakeholders from different social and professional sectors.

Conclusion

Advances in technology, adequate environment, excellent candidate species, the need for diversification and a growing market demand have brought the prospect of developing an environmentally sustainable and commercially viable marine fish aquaculture industry in Latin America and the Caribbean a step closer to reality. Both private and government sectors recognize that now is the perfect time for the development of high-value marine finfish aquaculture industry in this part of the world. It is difficult to accurately predict the production level and timeframe for industry development. Conceivably, marine fish culture in the Americas and the Caribbean regions could develop to rival the shrimp and salmon aquaculture industries within the next five to ten years.

Recirculating systems for tilapia production in Louisiana

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Abstract

Louisiana tilapia growers have developed semi-standardized, greenhouse-enclosed green-water recirculating systems that have been shown to be cost-competitive when compared to other grow out approaches currently in use throughout the U.S. These systems utilize net pens suspended within lined rectangular growing tanks constructed of treated lumber to facilitate concurrent batch stocking and harvesting, allowing physical isolation of specific size groups within a system. Due to high nutrient levels and almost daily exposure to sunlight, these systems provide substantial nutritional supplementation through algal production. Data from three Louisiana tilapia greenhouse facilities with similar construction and operational procedures were compiled to allow an economic characterization of this particular approach to tilapia production. Feed conversion ratios vary considerably in Louisiana greenhouse tilapia systems. Results indicate overall long-term feed conversions may vary from 1.4:1 to 2:1. The extent to which these differences reflect ration effects as opposed to facility or management effects has not yet been determined. To investigate the impact of feed conversion ratio on system profitability and productivity, the baseline operating budget and cash flow developed for the model facility were altered to reflect a reduction in feed conversion ratio from 1.8:1 to 1.4:1.

Uso de desechos acuícolas en raciones para pollos de engorde y ponedoras

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Introducción

En América latina la industria avícola se enfrenta con el problema de obtener ingredientes para el uso en sus dietas que sean económicamente disponibles y de una nutrición adecuada para soportar las altas tasas de crecimiento y producción. Por esta razón, la búsqueda de otros producto o sub-productos que pueden sustituir fuentes proteicas convencionales principalmente la harina de soya (HS), es esencial. En los últimos años la industria camaronera y de tilapia centroamericana se han expandido extensivamente, lo que ha generado una cantidad significativa de desechos. Estos desechos tienen un potencial de ser usados como fuentes proteicas alternas de dietas en pollos de engorde y ponedoras, parcial o totalmente, reemplazando fuentes convencionales de proteína. La harina de camarón (HC) y harina de tilapia (HT), son compuestos básicamente de desechos secos de las plantas procesadoras. En algunas ocasiones la HC está formada por cabezas de camarón, camarón entero, y un cierto porcentaje de pescados. En cuanto a la HT, básicamente se conforma por el pez entero sin los filetes los cuales son destinados para consumo humano.

Usando la HC a varios niveles en dietas de pollos de engorde y ponedoras, Damron *et al.* (1964), Raab *et al.* (1971), Ilian *et al.* (1985), and Islam *et al.* (1994) no encontraron ningún efecto negativo sobre productividad en ambos casos. Hasta la fecha poca investigación ha sido conducida, así como pocas publicaciones realizadas con respecto al uso de la HC en raciones de pollos de engorde y ponedoras.

De igual manera, la HT que básicamente es un harina de pescado, es una excelente fuente de proteína, energía, minerales y vitaminas para el uso en raciones avícolas. Aunque estudios directamente con HT no han sido realizados, el uso de harina de pescado en dietas para pollo de engorde ha sido extensivamente investigado por; Robertson *et al.* (1940), Atkinson and Couch (1951), Branion and Hill (1953), Rasmussen *et al.* (1957), Harms *et al.* (1961), Waldroup *et al.* (1968), Schumaier and McGinnis (1969), Avila and Balloun (1974), Wu *et al.* (1984), and Hulan *et al.* (1988).

Metodología (HC)

Se realizaron tres experimentos midiendo diferentes niveles de HC en dietas de pollos de engorde y ponedoras. En el experimento (EXP) 1; 0, 10, 20, 30 y 40% de la proteína cruda (PC) proporcionado por la HS en las dietas de los pollos de engorde fue sustituida por la PC de la HC. En EXP 2; 0, 60, 80 y 100% de la PC proporcionado de la HC. Peso corporal, consumo de alimento acumulado, conversión alimenticia, mortalidad, fueron determinados semanalmente hasta los 49 días en EXP 1 y 42 días en EXP 2. Peso y rendimiento de canal pre-enfriado fueron determinados el día de proceso. En EXP 3, la HC sustituyó el 0, 20, 40, 60, 80, 100 % de la PC que proporcionaba la HS en dietas para ponedoras. Producción de huevo, consumo de alimento, conversión alimenticia, peso del huevo, gravedad especifica y pigmentación de la yema fueron determinados durante las primeras 20 semanas de producción. Antes de llevar a cabo la formulación de dietas experimentales, un análisis proximal y análisis de amino ácidos fueron realizados en muestras de HS (extracción por solventes) y HC (secado en túnel) establecidos por la Asociación Oficial de Químicos Analíticos (AOAC, 1990). Un perfil de amino ácidos fue realizado y valores de energía metabolizable fueron determinados usando la metodología establecida por Sibbald (1976). Los resultados son mostrados en el Cuadro 1.

Resultados (HC)

En el EXP 1 no se presentaron diferencias significativas en cuanto a peso corporal, consumo de alimento, conversión alimenticia. Estos datos coinciden con los resultados obtenidos por Damron *et al.* (1964) y Raab *et al.* (1971), quienes utilizaron HC en dietas de pollos de engorde a niveles de 9.1 y 6.8%, sin encontrar efectos negativos en la productividad. Ilian *et al.* (1985) tampoco encontró efectos negativos usando niveles hasta de un 10% en dietas de pollos de engorde. No se encontraron diferencias significativas en cuanto a mortalidad, peso y rendimiento de canal caliente (Cuadro2.)

El segundo experimento (Cuadro 3), efectos de niveles más elevados de HC en las dietas de pollos de engorde fueron evaluados. Los porcentajes en las dietas variaron entre 11.5 a 31.6%. El peso corporal fue mayor ($P < 0.01$) a los 21, 28, 35 y 42 días de edad donde la HC fue utilizada a 100% de sustitución de HS. Respuestas en crecimiento han sido observadas a niveles más bajos de sustitución a los 7, 14 y 21 d. Una de las razones para estos resultados es que la fuente de proteína cruda de origen vegetal está siendo reemplazada por una de origen animal. En general, el contenido de amino ácidos y calidad proteica tiende a ser superior cuando es de origen animal (Green, 1971; Parsons, 1991). Otra razón para esta mejoría en peso en el 100% de sustitución es el método de proceso, ya que éste puede afectar directamente el valor nutricional del producto. La calidad de la materia prima tiene que estar bien preservada para reducir la cantidad de actividad bacteriana, lo cual produce reacciones decarboxílicas, convirtiendo a los amino ácidos de la proteína animal en aminas biogénicas, resultando en efectos tóxicos que afectan la productividad de las aves (Dale, 1994). La naturaleza de la materia

prima es otro factor; el exoesqueleto del camarón en gran parte es quitina y se considera que posee una baja digestibilidad (Austin *et al.*, 1981). Alimentando con quitina y quitosano a pollos de engorde y ponedoras, Hirano *et al.* (1991) observaron que la digestibilidad de los dos ingredientes variaron entre 88 y 98%. Estos resultados nos hace pensar que las aves tienen la capacidad de digerir quitina porque hay quitinasa presente en el sistema digestivo, facilitando la utilización de quitina en la HC.
No se observaron diferencias significativas para consumo de alimento, conversión alimenticia, mortalidad y rendimiento de canal en ninguno de los tratamientos. El peso de canal incrementó un 12% cuando la HC sustituyó el 100% de la HS. Sin duda este resultado está en relación con el peso vivo.

Para EXP 3, no hubo diferencias significativas en cuanto la producción de huevos para los diferentes niveles de HC en la dieta, (Cuadro 4). El consumo de alimento incrementó ($P < 0.05$) cuando el 100% de HC se usó en la dieta. Estos resultados pueden ser atribuidos a los altos niveles de quitina encontrados en la HC. Como se mencionó anteriormente, la quitina forma parte del complejo proteico y se considera de baja digestibilidad. Debido a esta baja digestibilidad, la quitina físicamente bloquea las enzimas digestivas a los lípidos y proteínas, (Castro *et al.* 1989; Karasov, 1990). En el caso de la gallina las cantidades de quitinasa producidas son bajas (Jeuniaux y Comelius, 1978). A pesar que hay especies que producen suficientes cantidades de quitinasa, su valor energético es bajo, debido a la pobre absorción. En vista que la quitina reduce la energía dietética, las ponedoras alimentadas con niveles elevados de HC han tenido que incrementar su consumo para mantener las necesidades energéticas para la tasa de producción de huevos. La conversión alimenticia fue más pobre ($P < 0.05$).

Los pesos de los huevos fueron menores ($P < 0.05$) para este mismo tratamiento (Cuadro 5). La reducción del peso del huevo puede estar relacionada con la baja disponibilidad de energía afectada por la presencia de quitina. Las gravedades especificas fueron más bajas ($P < 0.05$) para todos los tratamientos que contenían HC en las dietas. El color de la yema incrementaba ($P < 0.05$) a medida que incrementaban los niveles de HC en la dieta.

En conclusión, una HC, procesada adecuadamente, puede ser utilizada en niveles relativamente altos, sustituyendo la HS sin causar efectos negativos en la productividad de los pollos de engorde y ponedoras.

Metodología (HT)

Se realizo un experimento midiendo diferentes niveles de HT en dietas de pollos de engorde. En el experimento; 0, 10, 20, 30, 40, y 50% de la proteína cruda (PC) proporcionado por la HS en las dietas de los pollos de engorde fue sustituida por la PC de la HT. Peso corporal, consumo de alimento acumulado, conversión alimenticia, y mortalidad fueron determinados semanalmente hasta los 42 días de edad. Peso y rendimiento de canal pre-enfriado fueron determinados el día de proceso. Antes de llevar a cabo la formulación de dietas experimentales, se realizo un análisis proximal y análisis de amino ácidos en muestras de HS (extracción por solventes) y HT establecidos por la Asociación Oficial de Químicos Analíticos (AOAC, 1990). Un perfil de amino ácido fue realizado y valores de energía metabolizable fueron determinados usando la metodología establecida por Sibbald (1976). Los resultados son mostrados en el Cuadro 6.

Resultados (HT)

La sustitución de la HS con la HT a varios niveles resulto ser significativo (P < 0.05) para el peso corporal, consumo de alimento y conversión alimenticia desde 14 a 28 días de edad. Los pollos alimentados con niveles de 10, 20, y 30% de HT obtuvieron pesos corporales y consumos de alimento más elevados y mejores conversiones alimenticias en comparación con los otros tratamientos. Schumaier y McGinnis (1969) reportaron que adicionando el 4.8 y 12% de proteína adicional proveniente de harina de pescado. Las dietas de inicio aumento el crecimiento de los pollos un 30%. Scott *et al.* (1957) observó resultados similares, pero usando la harina de pescado como fuente única de proteína los pollos demostraron desarrollos más pobre. Harms *et al.* (1961) reportó que 3% de harina de pescado en dietas de pollos de engorde no demostraron efectos significativos sobre los parámetros de producción. Waldroup *et al.* (1965) obtuvo resultados similares cuando el 25 y 50% de la HS fue sustituida por la harina de pescado. Rojas *et al.* (1969) también reportó cambios no significativos para peso corporal, consumo de alimento y conversión alimenticia cuando la HS fue sustituido a varios niveles con harina de anchoa peruana. Avila y Balloun (1974) encontraron que la harina de anchoa usada a varios niveles en dietas de pollos de engorde no demostró diferencias significativas en cuanto a pesos corporales, ni la conversión alimenticia. Reducción en el desarrollo de los pollos fue observada cuando el 100% de la HS fue remplazado por la harina de anchoa. Hulan *et al.* (1989) usando harina de pescado roja a niveles no más de un 12% encontraron efectos no significativos sobre mortalidad y conversiones alimenticias, pero hubo reducciones en los pesos corporales y consumos de alimento. Durante el resto del período del experimento (35 a 42 días de edad) ningún efecto significativo en los parámetros de producción fue observado, esto incluyendo mortalidad, peso y rendimiento de canal (Cuadro 7).

Nuestros resultados con el uso de la HT van de acuerdo con aquellos investigadores que demostraron mejoras en los parámetros de producción en pollos de engorde. Las mejoras en los parámetros de producción que fueron reportados y observados en las etapas tempranas del desarrollo pueden ser atribuidas a la alta calidad de proteína de la HT o la presencia de un factor de crecimiento no identificado, Menge *et al.*, (1952); Branion and Hill, (1953); Rasmussen *et al.*, (1957).

Debido al costo, sabores indeseables (Carlson *et al.*, 1957; Fry *et al.*, 1965; Waldroup *et al.*, 1965) causado por el efecto de niveles elevados de harina de pescado, la inclusión de este harina es limitada. Aunque en el caso de la HT, los costos son más reducidos por el hecho que la harina es producida localmente excluyendo costos adicionales de importación y manejo. Además, una evaluación organoléptico subjetiva fue conducida sin observar ningún sabor o olor residual en la carne de pollo con la inclusión de los diferente niveles de HT.

En conclusión, la HT puede remplazar parcialmente la HS en las dietas de pollos de engorde sin causar ningún efecto negativo en los parámetros de producción o calidad de canal.

Cuadro 1. Análisis proximal y composición de la harina de camarón y harina de soya

Componentes	Harina de Camarón (Secado – tunel)	Harina de Soya (extracción – solvente)
Materia seca[1]	32.38	91.90
Proteína Cruda[1]	50.89	48.90
Extracto etero[1]	6.31	1.90
Ceniza[1]	15.64	6.00
Fibra cruda[1]	8.92	3.50
Calcio[1]	5.21	0.26
Fósforo disponible[1]	1.47	0.25
EMVn, Kcal/kg[2]	2,397.00	2,230.00
Amino ácidos[3] (%)		
Metionina	1.08	0.75
Lisina	2.93	2.90
Arginina	3.40	2.71
Tripofano	0.51	0.60
Treonina	2.05	1.89
Ac. Aspartico	4.88	5.48
Serina	2.17	2.07
Ac. Glutámico	6.28	8.36
Prolina	2.24	2.48
Glicina	2.87	2.11
Alanina	2.61	2.16
Cistina	0.39	0.74
Valina	2.19	2.43
Isoleucina	1.85	2.60
Leucina	3.16	3.80
Tirosina	1.61	1.75
Fenalalanina	2.24	2.72
Histidina	2.93	1.80

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Cuadro 2. Efecto de los diferentes niveles de HC[1] sobre peso corporal, consumo y conversión alimenticia, mortalidad, peso y rendimiento de canal de pollo de engorde a los 49 d de edad, Exp1

Parámetros	0% HC	10% HC	20% HC	30% HC	40% HC
Peso corporal (g)	2325	2363	2354	2314	2338
Consumo (g/ave)	4783	5100	4804	4816	4693
Conversión	2.05	2.12	2.10	2.09	2.00
Mortalidad	5.09	5.58	5.19	6.79	7.52
Peso canal[2] (g)	1633	1612	1663	1633	1645
Rendimiento canal[3] (%)	70.0	68.20	70.0	70.50	70.30

[1]HC = Harina de camarón
[2]Pre-enfriado
[3]Sin menudos

Cuadro 3. Efecto de los diferentes niveles de HC[1] sobre peso corporal, consumo y conversión alimenticia, mortalidad, peso y rendimiento de canal de pollos de engorde a los 42 d de edad, Exp2

Parámetros	0% HC	60% HC	80% HC	100% HC
Peso corporal (g)	1939[b]	2020[b]	1952[b]	2065[a]
Consumo (g/ave)	3767	3727	3717	3815
Conversión	1.97	1.84	1.90	1.85
Mortalidad	1.86	1.42	1.47	1.54
Peso canal[2] (g)	1260[b]	1317[b]	1276[b]	1413[a]
Rendimiento canal[3] (%)	65.00	65.10	65.4	68.6

[ab] Medios en la misma fila con diferentes letras difieren significativamente (P<0.01).
[1]HC = Harina de camarón.
[2]Pre-enfriado.
[3]Sin menudos.

Cuadro 4. Efecto de los diferentes niveles de HC[1] sobre producción de huevos, consumo y conversión alimenticia en ponedoras desde 18-38 semanas de edad

Parámetros	Producción de huevos	Consumo de alimento	Conversión alimenticia	
	(%)	(g/ave)	(g huevo: g alimento	(kg/dz)
0% HC	87.3	96.2[a]	.557[a]	1.55[a]
20% HC	89.3	96.2[a]	.565[a]	1.52[a]
40% HC	84.3	105.3[ab]	.522[a]	1.75[ab]
60% HC	89.2	101.6[a]	534[a]	1.61[a]
80% HC	88.6	109.1[ab]	.490[a]	1.72[ab]
100% HC	86.9	112.7[b]	.468[b]	1.82[b]

[ab]Medios en la misma columna con diferentes letras difieren significativamente
[1]HC = Harina de camarón (P<0.01).

Cuadro 5. Efecto de los diferentes niveles de HC[1] sobre peso del huevo, gravedad específica y pigmentación de yema en ponedoras desde 18-38 semanas de edad

Parámetros	Peso de huevo (g)	Gravedad específica	Pigmentación de yema[2]
0% HC	52.3[a]	1.088[a]	1.4[a]
20% HC	53.6[a]	1.086[b]	3.5[b]
40% HC	52.5[a]	1.086[b]	4.4[c]
60% HC	52.6[a]	1.087[ab]	8.0[d]
80% HC	52.1[a]	1.087[ab]	9.2[e]
100% HC	50.6[b]	1.088[a]	10.1[f]

[ab]Medios en la misma columna con diferentes letras difieren significativamente (P<0.01).
[1]HC = Harina de camarón
[2] Roche abanico de colores, F. Holffmann – La Roche Ltd., Basle/Switzerland

Cuadro 6. Efecto de los diferentes niveles de HT[1] sobre peso corporal, consumo y conversión alimenticia, mortalidad, peso y rendimiento de canal de pollos de engorde a los 42 d de edad

Parámetros	0% HT	10% HT	20% HT	30% HT	40% HT	50% HT
Peso corporal (g)	1853	1887	1850	1861	1842	1865
Consumo (g/ave)	3355	3245	3328	3182	3250	3244
Conversión	1.81	1.72	1.80	1..71	1.76	1.74
Mortalidad	1.74	2.43	1.39	2.08	1.74	2.08
Peso canal[2] (g)	1260	1343	1305	1309	1259	1290
Rendimiento canal[3] (%)	66.8	69.3	70.5	70.4	68.4	69.2

[1]HC = Harina de tilapia.
[2]Pre-enfriado.
[3]Sin menudos.

Cuadro 7 Análisis proximal y composición de la harina de tilapia y harina de soya

Componentes	Harina de tilapia	Harina de Soya (extracción – solvente)
Materia seca[1]	94.60	89.90
Proteína Cruda[1]	63.50	46.00
Extracto etero[1]	10.80	1.90
Ceniza[1]	18.50	6.00
Fibra cruda[1]	0.58	3.50
Calcio[1]	5.73	0.26
Fósforo disponible[1]	3.40	0.25
EMVn, Kcal/kg[2]	2,600.00	2,230.00
Amino ácidos[3] (%)		
Metionina	1.58	0.75
Lisina	3.71	2.90
Arginina	5.01	2.71
Tripofano	0.41	0.60
Treonina	2.44	1.89
Ac. Aspartico	5.30	5.48
Serina	2.86	2.07
Ac. Glutámico	8.36	8.36
Prolina	1.81	2.48
Glicina	8.18	2.11
Alanina	4.87	2.16
Cistina	0.99	0.74
Valina	3.14	2.43
Isoleucina	2.37	2.60
Leucina	4.16	3.80
Tirosina	1.43	1.75
Fenalalanina	2.27	2.72
Histidina	1.14	1.80

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