TILAPIA FINGERLING PRODUCTION IN HONDURAS

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THESIS ABSTRACT

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The availability of good quality seed continues to be a factor limiting aquaculture development. The lack of an adequate supply of all-male tilapia fingerlings has been identified by fish farmers as a principal constraint to small and medium-scale fish culture development in Honduras. Procuring a reliable supply of high quality seed for stocking local and remote sites is critical to continued development of tilapia culture.

A survey of tilapia fingerling producers was conducted in Honduras as part of the Aquaculture Collaborative Research Support Program (PD/A CRSP) during 2003 and 2004 to gain a better understanding of the factors that can contribute to improve seed quality and availability for fish farms, as essential to advance the practice of fish culture.

Sixteen farmers were identified and interviewed with the objective of evaluating their fingerling production techniques, the characteristics of the fingerlings they produce, and the attributes of the individuals and their farms. The farmers were visited during the period from September 2003 to July 2004 to assess the physical facilities (ponds, tanks, etc.) used for tilapia reproduction and fingerling production. Semi-structured interviews were used to obtain information from each known tilapia fingerling producer in Honduras.

At each farm, 1000 fingerlings were purchased and transported to Zamorano's[1] aquaculture research station for evaluation (packing, purchase price, number, uniformity of size, and color). A sub-sample of 250 fingerlings from each farm was grown to a size where sex identification was possible. The sex of each adult fish was determined to ascertain the percent of males and females in each sub-sample.

The results of this study clarify the socioeconomic characteristics of tilapia fingerling producers, their production techniques, as well as their needs for training and technical assistance. The author suggest some strategies for Non-Governmental Organizations (NGOs), government agencies, and other institutions that support aquaculture activities in Honduras and regionally. The broader objective is to foster more appropriate subject matter and technical content for training fingerling producers and extension agents.

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[1] Zamorano also known as the Pan-American Agriculture School and the Escuela Agrícola Panamericana (E.A.P.).

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I. INTRODUCTION

Aquaculture

Aquaculture is defined as the farming of organisms in water; this could be plants (seaweeds and phytoplankton) and/or animals (crustaceans, fish and mollusks) and can take place in freshwater in inland areas or in brackish water or seawater in the coastal areas (Messrs, Martínez and Schückler 2000). FAO adds a distinctive component to the definition of aquaculture, which is the ownership of the stock being farmed. For statistical purposes, aquatic organisms which are harvested by individual or corporate bodies and owned by them throughout their rearing period contribute to *aquaculture* (Edwards and Demaine 1997).

According to FAO definition, aquatic organisms that are exploitable by the public as common property resources, with or without appropriate licenses, are the harvest of *fisheries* (Edwards and Demaine 1997; Messrs et al. 2000). Different from aquaculture, often the exploitation and management of fisheries create struggle among stakeholders about claims for the resource. Empirical studies of fisheries management have found that political struggle over the profits from fishing drive management decisions. Willson, Medard, Harris and Wiley (1999) found in their study of fisheries in Lake Victoria that management measures are weakened when they ignore the needs of groups excluded from the resource.

Aquaculture and Development

Aquaculture has been contributing to food supply and improving health and income levels for centuries through commercial operations that supply urban markets, households, and rural communities. In Asia, aquaculture is widespread part of rural life and much of the production comes from culture systems in homestead ponds, and rice fields (Choudhury 1997). The farming of fish in ponds is an ancient practice, as the earliest known references to pond fish culture are from China, some 4,000 years ago (Messrs et al. 2000). One of the most well known cultured fish in fresh water in the tropics is *tilapia,* mainly the *Oreochromis* species that are originally from Africa, and have been introduced in most tropical countries of the world.

Aquaculture is a relatively new industry in most countries, being from 20 to 50 years old, but has developed significantly in the last 20 years. Edwards and Demaine (1997) argue that this recent growth in aquaculture is due to the growing human populations and the diminishing supply of products caught from the wild. This diminishing supply is caused by over fishing of some species and environmental degradation.

According to Haylor and Bland (2001), the objective of rural development is to facilitate a sustainable rural economy. Aquaculture presents many opportunities for development initiatives it can be implemented with diverse aquatic resources and by a wide range of stakeholders. Its objectives can range from food production, income generation, and wild stock enhancement to recreational uses (Haylor and Bland 2001). It can be from a subsistence level to an intensive commercial level of production within a developed or a less-developed economy.

Beside aquaculture's contribution to food production, it creates employment in the rural areas. The employment generated by fish farming in the world has increased from 3.8 millions workers in 1990 to 7.5 millions workers in 2000 (New 2003). Other important contributions of aquaculture to development include utilizing waste products, contributing to foreign exchange, and making use of land and other resources unsuitable for agriculture and other industries (Jolly and Clonts 1993).

Tilapia Culture

The Nile tilapia (*Oreochromis niloticus*) is a tropical fresh water fish originally from Africa, resistant to many pathogens, and easy to culture even in conditions of poor water quality. In captivity, tilapia will attain sexual maturity at small size (from 50 to 100 g), at an early age (within 6-8 months of hatching), and can spawn frequently year-round in warm water (25 to 30 ºC) (Meyer 2003; Phelps and Popma 2000).

Tilapia are highly opportunistic feeders; they have shown to ingest a wide range of items: algae, zooplankton, detritus, insect larvae, fish eggs, and embryos (Beveridge and McAndrews 2000). It is simple and inexpensive to produce tilapia through a program of pond fertilization with different by-products from the farm, making food available for the fish using low cost inputs (Meyer and Triminio 2002). Tilapia also can be grown using different combinations of farm by-products with a formulation of feeds using basic grains, as well as industrial prepared feeds and fertilizers (Edwards 2000; Meyer 2004).

Tilapia is a fish favored for human consumption because of its white meat, mild flavor, and highly nutritious characteristics. The species provides all 10 essential amino acids in relatively high concentrations and is rich in certain vitamins and minerals. Tilapia is low in cholesterol and high in polyunsaturated fatty acids in particular omega-3 (Edwards and Demaine 1997; Kent 1987).

The increase of tilapia production, popularity, and contribution to the food supply on a global scale is reflected in U. S. imports from developing countries such as China, Ecuador, Costa Rica, and Honduras. In 1997, imports of tilapia were 24.5 thousand Metric Tons (MT) compared to 113 thousand MT in 2000, 4.7 times the amount imported 7 years earlier (Josupeit 2005). The interest in tilapia culture seems to be increased by the global demand and popularity of tilapia (Stickney 2005).

Culture of Tilapia in Honduras

The first reports of aquaculture in Honduras date from mid 1930s when broodstock of Nile tilapia (*O. niloticus*) was introduced from El Salvador. In 1955, the government through the Secretariat of Natural Resources created the (aquaculture sub-station) Sub-Estación Acuícola "Jesus de Otoro", for the culture of fresh water shrimp (*Macrobrachium rosembergii*). In 1958, due to various problems, it was discontinued. In 1968, the station resumed activities, this time oriented to the tilapia culture. Later, other two aquaculture sub-stations were created, Sub-Estación Acuícola El Picacho and Sub-Estación Acuícola of Santa Bárbara (FAO 2002).

In 1977 with the construction of the "Fish Culture Research Center El Carao" in Comayagua, Honduras initiated a national program of fish culture, conducting extension programs and distributing of tilapia fingerlings, as well as carp species and guapote

(*Cichlasoma*). The program directed from El Carao also extended to the sub-stations of Jesús de Otoro, Santa Bárbara and El Picacho. The subsistence level fish culture was extended to all the country, through by groups of farmers, community organizations, and small projects by individuals (FAO 2002).

The development of tilapia culture in Central America was supported by the Food and Agriculture Organization (FAO) through social programs that had as main objective to improve access to animal protein for the poor population (Perez 1999). Fish production is viewed as a way to advance development through food security and income generation. Honduras NGOs, development programs, public and private universities, and governmental authorities all have promoted tilapia culture at various times and various ways (Molnar, Hanson and Lovshin 1996b).

Until about 10 years ago, fish culture was intended centrally for home consumption and sales within local communities. Lately, the demand for this product in national and international markets has helped tilapia culture emerge as a rapidly diffusing non-traditional and profitable farm activity. According to Molnar, Hanson and Lovshin (1996a), tilapia has become an export commodity generating foreign exchange as well as a subsistence crop for the agriculture sector.

Table 1 shows an estimated number of tilapia enterprises that have emerged in Honduras. The small scale farmers are the majority, their production system is based on low input costs and the use of on-farm byproducts to feed the fish. Their practice is artisanal and uses experience-based knowledge; their production is mostly for consumption.

Despite increases in the production of tilapia by commercial farms, many small scale farmers often encounter difficulties in obtaining yields of tilapia that will feed their families and make extra cash income. Unlike most commercial farms, many small scale farmers in Honduras often combine fish culture with other farm activities, such as grain, cattle, coffee production, and wage labor. With the fall in the price of traditional enterprises like coffee in the international markets, many small farmers that depended on this crop as the primary income source have looked into fish culture as an alternative crop to help them survive.

Constraints to Tilapia Farming

A major constraint to tilapia culture development identified for many years by farmers and other stakeholders alike has been the inadequate availability, difficult accessibility, and poor quality of tilapia seed. (Aceituno, Meyer and García 1997; LSU AgCenter 2001; PD/A CRSP 2002; Triminio Meyer 2001). The lack or limited access to pertinent information and insufficient training opportunities, also have been identified as major constraints in improving farmers' capabilities to culture tilapia more efficiently and profitably (Lutz 2002; PD/A CRSP 2002; Triminio Meyer 2001).

In one recent assessment of the aquaculture sector in Honduras, stakeholders agreed that the first constraint to aquaculture development among medium and small scale level farmers was the low quality and availability of fingerlings (Triminio Meyer 2001). A second assessment by Louisiana State University in 2001, identified the inadequate availability and quality of seed stock as one of the most important impediments for aquaculture development (Lutz 2002).

Table 1. Tilapia Enterprises Developed in Honduras, Fingerling Producers, 2003-2004

Farm Type	Market Type	Estimated [1] Farms (Number)
Industrial-scale (export market)	Sale of fillets	4
Medium-scale (> 1000 m^2 water surface area)	Sale of whole fish	1000
Small-scale (< 1000 m^2 water surface area)	Home consumption, and some sales	1500

[1] Estimated developed based on fingerling producers' client's accounts and an inventory of tilapia farmers carry out by Zamorano between 2001 and 2004.

Problem Definition

For this study, the problem to be analyzed is that fish farmers in Honduras often have difficulty obtaining all-male tilapia fingerlings for stocking their ponds following each harvest. Tilapia fingerlings are not produced in all areas of Honduras and the supply available is not adequate to satisfy the demand. Farmers often have difficulties restocking their ponds, and when they are able to restock, they often experience unsatisfactory results. Ideally, every farmer would have access to viable fish seed of homogeneous size, color, and gender composition to start or restock their tilapia ponds.

Little is known about the number and characteristics of fingerling producers, or the techniques and approaches they employ to produce fingerlings. There are several private farms, national fish culture stations, and universities in Honduras that specialize in tilapia reproduction and distribution of sex-reversed fingerlings (Green and Engle 2000). The quality and sales price of fingerlings varies by supplier and region (Aceituno et al. 1997). Yet, the actual levels of production and impediments to improvement have not been documented.

Purpose of the Study

The study evaluates tilapia fingerling production in Honduras and examines the factors that influence the way farmers produce and distribute fingerlings. The study provides recommendations to improve the quality and availability of and access to local production of fingerlings.

Significance of the Study

The lack of good quality seed continues to limit the development of aquaculture in Central America and other parts of the world. There is a documented unsatisfied demand for tilapia seed in many areas of Honduras (PD/A CRSP 2002; Molnar, Trejos, Marínez, Triminio Meyer, Meyer, Tollner and Verma. 2002; Triminio Meyer 2001). In Honduras small-scale fish farms are widely distributed throughout the country. Much of the country is mountainous (about 80 percent) with limited and difficult road access to communities, with many roads useable only during the dry season. This makes the acquisition of tilapia seed difficult for small-scale fish farmers in many parts of the country.

Production of all-male tilapia fingerlings can be a very profitable business for local fish farmers. The level of profitability in fingerling production is dependent on utilizing appropriate technologies and the proper management of fish and other inputs (Engle 1986; Popma and Green 1990).

Until now, small-scale tilapia farmers of Honduras have been dependent on NGOs to assist them in aquaculture activities to obtain and transport their seed (Trejos 2003). The development of fingerling production capabilities in additional areas of the country will provide a greater degree of independence for the farmers to obtain seed locally, without subsidy by NGOs. This should contribute substantially to making tilapia culture more viable and sustainable in rural areas of Honduras.

Small-scale fish farmers would benefit from having local sources of tilapia seed available for stocking ponds following a harvest. Long transport distances increase costs and reduce the viability of fingerlings stressed by temperature swings and low oxygen levels.

Specific Study Objectives

1. Describe the tilapia fingerling production and marketing system including: the number of producers and their spatial distribution in Honduras, the facilities and techniques utilized in reproducing adult fish and sex reversing of fry.

2. Evaluate the quality of tilapia fingerlings produced in Honduras, assessing homogeneity of color, size and male gender.

3. Evaluate the factors that influence fingerling production such as the socioeconomic characteristics of the farmers (education, experience and training) and the characteristics of the farm (size, type of operation and input accessibility).
4. Develop extension principles that can be used to increase the number, and improve the performance of, fingerling producers in Honduras and Central America.

II. CONCEPTUAL FRAMEWORK

Social Change and Development

Social change is a process of evolution that society experiences through time. Some theorists define it as evolving from one type to another, from one form to another, from the past to the present, from the *Gemeinschaft* to *Gesellschaft* or from mechanical to organic solidarity (Appelbaum 1970; Lyon 1989). One common aspect of these changes is their impact on the structure and the function of social systems that create differentiation in societies (Kinloch and Mohan 2000).

The increasing society's differentiation is reflected in ideologies, represented by a growing variety of cultural and economic subgroups which have developed heterogeneous viewpoints and perspectives, contrasting to the homogenous type of consciousness typical of earlier and more unified societies. Hence, ideologies should be seen as the product of societal differentiation and development, particularly the economic stratification in society. Different ideologies underlie different reactions to social change and development (Kinloch and Mohan 2000).

The paradigm of development during the 1960s and 1970s is reflected in Roger's (1972) definition: "*Development* is a type of social change in which new ideas are introduced into a social system in order to produce higher per capita incomes and levels of living through modern production methods and improved social organization"(Rogers and Burdge 1972:403). Based in this definition, we can classify the less developed countries as those with low per capita incomes and low levels of living, and the developed countries as those with higher per capita incomes and higher levels of living. According to Rogers, the less developed countries are the majority, which includes all of Latin America, Africa and Asia with the exception of Japan.

Even though there is heterogeneity among less developed countries, Rogers and Burdge (1972) point out some common characteristics of the people living in less developed countries compared to those living in the more developed countries:

- Their life expectancy is only about one-half of that in more developed countries.
- They suffer from malaria, dysentery, tuberculosis, trachoma, and other diseases.
- Their daily food intake is about one-third less, measured in calories, compared with that of the more developed countries.
- Only a minority has the opportunity to attend school and one in five is literate.
- Their average incomes are less than one tenth of those in the U. S.
- Their rate of population growth is much higher than that of more development countries.

In regard to the people that live in the less developed countries, Rogers and Burdge (1972:416) say that “peasants are the major portion of the population in less developed nations. At least three fourths of the populations in most developed countries are peasants, together Asia, Africa and Latin America have 1.75 billion peasants." *Peasants* are subsistence agriculture producers and traditionally oriented rural villagers who consume the major portion of the food or articles they produce. Therefore, the terms *peasants* and *subsistence farmers* can be used interchangeably.

In order to promote "*development*" to the less developed countries, national and international governments and organizations (UNESCO, FAO and USAID among others) actively look for mechanisms to target the majority element in less developed nations, *the peasant population*. Over a period of several decades, the word *Modernization* came to play a very important role in the development world vocabulary. Rogers and Burdge (1972:404) state that "[m]odernization is the process by which individuals change from a traditional way of life to a more complex, technologically advanced, and rapidly changing life style." The assumption under this process was that *modernization* at the individual level will correspond to *development* at the societal (country) level.

Communication was the main instrument to introduce modernization, as new ideas crossed the threshold of peasant villages and their lives (Rogers and Burdge 1972). These new ideas were spread to these countries aimed to solve the problem of insufficient food production to feed the undernourished as the basic objective. In this context, *modernization* was in the 1960s and 1970s as what 23 years later Rogers calls it *diffusion of innovations* (Rogers 1995; Rogers and Burdge 1972).

Development Today

Twenty years later, the definition of development by Rogers (1995) has a broader foundation. It now includes subjects as equality, participation, freedom, disadvantaged groups, and the environment. He states that development is a “widely participatory process of social change in a society intended to bring about both social and material advancement (including greater equality, freedom and other valued qualities) for the majority of people, through their gaining greater control over their environment (1995:127).” Today this process targets the rural and urban poor, and those in disadvantaged social positions such as women and ethnic or indigenous populations.

According to the United Nations (UNDP 2004), progress in human development between 1960 and 2000 was dramatic and unprecedented. Life expectancy in developing countries increased from 46 to 63 years and mortality rates for children under five were more than halved. Between 1975 and 2000 adult illiteracy was almost halved and real per capita incomes more than doubled.

But despite this progress, massive poverty remains. More than 800 million people suffer from undernourishment and some 100 million children that should be in school are not, 60 million of them girls. More than a billion people survive on $1 a day (UNDP 2004). When these indicators are disaggregated between rural and urban, they document more progress in human development and less poverty for people in urban areas than for those in the rural areas (UNDP 2004). For example, the Human Poverty Index (HPI) in 1996 for rural Uganda was 43 percent and 21 percent for urban Uganda (UNDP 2000).

Diffusion and Adoption of Innovations

In less developed countries, national and international programs of planned change are conducted to introduce technological innovation (Rogers and Burdge 1972). These initiatives aim to support poor rural populations to improve their quality of life by improving their agricultural production and making efficient and sustainable use of their scarce resources.

The route to agricultural development, according to Hayami and Ruttan (1985) is through more effective dissemination of technical knowledge and narrowing of the differences among individual farmers and among regions. Hayami and Ruttan (1995) also state that the diffusion of better husbandry practices and of crop and livestock varieties has been a major source of increased productivity in agriculture.

The diffusion model of agriculture development has been used since its emergence in the second half of the nineteenth century and has provided the major intellectual foundations for the research and extension efforts in farm management and production economics (Hyami and Ruttan 1985). Innovation, as expressed by Rogers (1995:11), "is an idea, practice or object that is perceived as new by an individual or other unit of adoption." It does not really matter if the idea has been developed a long time ago or if it is known to other individuals, what matters is that the idea communicated is new to the particular individual. Therefore, innovation is something new that adds to the body of knowledge of the individual.

Diffusion can be understood as a tool to communicate the innovation or as Rogers (1995:5) states: the "process by which an innovation is communicated through certain channels over time among the members of a social system." Thus, in plain words, diffusion of innovation is the communication of new ideas that adds to the wealth of knowledge of an individual. In this context and according to Browns' *structure and market perspective*, there are two factor of equal importance involved in the diffusion of innovation: the supply factors (infrastructure) that is comprised by the "*diffusion agency*" and the demand factors (market) comprised by the "*potential adopters*" (Brown 1981).

Supply Factors

The supply factors are related to the *diffusion agency*, which is the private or public entity that takes the task to make innovations available to the adopters. As it is important to know the behavior of the adopter, it is important to understand the institutional behavior of these entities. They are the ones that make the decisions about what innovations are available for the population or which individuals or household should benefit from them (Brown 1981).

Brown (1981) points out that the *diffusion agency* enters into the process of diffusion of innovations in two ways: one, by determining when and where the innovation will be available, outlining the spatial pattern of the diffusion and the *diffusion agency establishment* (based on a geographic area). The second way is by conceiving and implementing a strategy to promote adoption among its population in its market area, called the *agency operating procedures* (based on the adopter's characteristics). The *diffusion agency establishment* as well as the *agency operating procedures* are elements considered by the diffusion agencies as marketing tools to favor success in their enterprises, *the adoption* of the innovation intended.

To achieve a higher degree of *adoption*, Brown (1981) recommends that the *diffusion agency* considers that many of the individual characteristics related to adoption also are associated with the modern society such as literacy, cosmopolitanism, communication channels orientation, achievement motivation or entrepreneurship. Thus, he makes two important points. "First, the *appropriateness* of an innovation and the likelihood of extensive diffusion are in part dependent upon its congruence with the level of development of the population to which has been introduced. Second, *personal characteristics* related to innovativeness will vary accordingly to the level of societal development" (Brown 1981:264). This can be illustrated by examples such as: literacy might be related to diffusion in a modern society but it may not be in a traditional society. Population age may be related to diffusion in a modern society but not in a traditional society.

Sources and Channels for Diffusion of Innovation

Innovation as well as its diffusion originates from different sources and uses different channels to pursue its main objective, which is the adoption of new ideas by the intended individual. Land Grant Universities in the U.S were founded to carry out research and experimentation in order to produce innovations for the modernization of agriculture, as well as the subsequent diffusion of those innovations among farmers in the U. S. (Zimdahl 2003).

The Land Grant University system was created by the bill introduced in the Senate by the State of Vermont Representative Justin Morrill passed on December 16, 1857. The Morrill Act stated that these universities "leading object [should] be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanics arts" (Zimdahl 2003:104) .

In 1887, the Hatch Act provided complementary funds to establish experimental stations in the colleges of agriculture. In 1914 the Smith-Lever Act established the Cooperative Extension Service, a collaborative effort between the Land Grant

Universities and the U. S. Department of Agriculture to promote the diffusion of innovations produced by the Land Grant Universities.

With the era of modernization of agriculture, this model of diffusion of innovation was exported to other countries, largely to those less developed. Through agreements with the governments in those countries, USAID financed programs to promote the modernization of the agricultural sector. Many researchers from the Land Grant Universities went to those countries to help establish and train government officials and researchers. They focused on programs such as introduction of improved seed for grain production and the development of management capabilities and personnel (CRSP 2004; Douglas 1980).

There have been many successful programs but also many sad ones. Many of these seed varieties did not do well in a different environment from the one in which they were developed. Consequently, research centers were created and links between local universities and Land Grants Universities were established in order to develop appropriate technology and validate innovations before they were transferred to the farmers (CRSP 2004).

Diffusion of Innovation in Aquaculture

During the 1980s and 1990s, the diffusion of innovation in aquaculture, particularly in Honduras, was characterized by large investments in the national hatchery station “El Carao” as well as in research (Berrios 1982). At the beginning of the 1980s, agreements between the Government and Auburn University mobilized researchers to Honduras to start research activities (Green, Teichert-Coddignton and Hanson 1995). At the same time Honduran technicians received training (Berrios 1982).

The Overseas Development Institute (ODI 1999) argues that performance in the introduction of aquaculture innovations has had the same pattern in most of the less developed countries in that "significant investments in large public sector hatcheries, linked to extension and credit services, have failed to deliver the intended gains from aquaculture. Hallwart and Gupta (2004) recognized that some common problems related to seed production and distribution are seed quality, genetics, hatchery management and administration, transportation and stocking and it is best to involved as many people as possible in decentralized production and distribution of fish seed. Attention has now turned to the role of the private sector, both commercial and none commercial (ODI 1999).

The introduction of aquaculture innovations drew attention to aquaculture in less developed countries; however, it failed to deliver the intended objective, to increase household food supply to the rural poor. Many reasons are behind this. In Latin America, the instability of governments has played an important role in the short duration and limited efficacy of programs initiated by the public sector. Every time there is a change of government, leadership turnover is nearly complete, from the minister of agriculture to the cleaning person in the most remote governmental office. What was yesterday's priority may not be significant for today's government. The reported failure of the administration to deliver progress is often due to instability and lack of continuity of the policies for development (Berdegué and Marchant 2002).

The limited financial resources dedicated to extension and research and a lack of skilled personnel and organizational capacity have highlighted the need for alternative suppliers of development services, the private sector. The most active organizations and institutions in the private sector are the NGOs, higher education centers, and some international donors.

The NGOs are private for profit and private non-profit enterprises that operate in developing countries. They use funds, private donations or are contracted by national and international funding sources to carry out services for the promotion of development. The NGOs play an important role in the diffusing innovations in aquaculture as an integral part of the development process (Molnar 2001; New 2003).

Extension

According to Rivera and Zijp (2002), contracting for extension services reflects the reform of the public sector via decentralization and privatization. It also favors progress to a demand driven, bottom up approach to agricultural information access. This process tends to promote greater transparency and accountability (e.g., certification processes, financial audits and performance appraisals) in the administration of extension.

Rivera and Zijp (2002) point out that contracting extension services contributes to cross sector and within sector partnerships, and involves institutional pluralism. When both the public as well as private sector provide extension services, self reliance and problem-solving capacity is built among endusers, administrators, and extensionists. An effective extension program in fish culture requires a long-term commitment to provide useful information for decision- making and continued motivation of beginning fish farmers (Meyer, Molnar, Tollner and Verma 2003).

Van den Ban and Hawkins (1996:25) defined this model as an Agriculture Knowledge and Information System (AKIS). An AKIS is: “[t]he persons, networks and institutions, and the interfaces and linkages between them, which engage in or manage the generation, transformation, transmission, storage, retrieval integration, diffusion, and utilization of the knowledge and information and which potentially work synergistically to improve the goodness of fit between knowledge and environment, and the technology used in agriculture."

The general idea of an AKIS is that farmers will take advantage of information available provided by any source that allow them to make decisions to improve their production and manage their farms. This knowledge can come from research institutes, practitioners, extension specialists or any other actors. AKIS tries to analyze how these actors support the farmers, how they interact with them, how they get the knowledge needed to support the farmers and the conflicts that may arise between them (Van den Ban and Hawkins 1996).

This is the common type of model of delivery of development services in Honduras' aquaculture sector. There are multiple interventions in extension services with different approaches and methodology. Some institutions have more interventions than others as well as more or less interconnections between them. What is clear, is that there is a wide interest from the service providers, beneficiaries, and financers in supporting the culture of tilapia in Honduras as well in others countries of Central America.

Institutions-Actor for Tilapia

Table 2 shows a classification of actors involved in diffusion of innovations for tilapia culture in Honduras. It describes the nature of the provider, the type of organization, source of financing, names of some of the more active institutions or agencies, beneficiaries of their efforts and the type of service provided. There is a wide spectrum of services provided such as training courses, field visits, symposiums, newsletters, websites, and written manuals. Most of the providers are not exclusively aquaculture extension providers; they cover other activities within agriculture such as crops, education, health, and credit.

Different organizations that participate in the aquaculture AKIS of Honduras have a considerable number of interventions with different approaches, funding, and activities. In the area of *research*, universities primarily produce information utilizing student research theses to find answers to farmers' problems and needs. The main universities are: the Autonomous National University of Honduras (UNAH), the National School for Agriculture (UNA previously known as ENA), and Zamorano (EAP). The Taiwanese Mission also conducts some experimentation as part of its program of assistance to aquaculture in Honduras.

Demand Factors

Fowler (2000:4) states that "today, poverty can be seen as a human condition where people are unable to achieve essential functions in life, which in turn is due to their lack of access to and control over the commodities they require." In consequence, poverty reduction should address the process through which people can progressively gain control over commodities in a sequence related to, first, *survival* such as food and shelter; second, *wellbeing*, such as health, literacy and security, and third *empowerment*, in the sense of self esteem and status, exercising influence over decisions which affect their lives as well as the lives of their families (Fowler 2000).

The success of diffusion is measured based on the rate of adoption and the impact that those innovations induce in an individual and the social change in social systems

(Rogers 1995). The main objective of the diffusion in developing countries is to cause a positive social change focusing in poverty reduction through innovations in agriculture.

Not all innovations are proper for everybody. Roger (1972:404) states that: "[u]ndoubtedly many people in less developed nations wanted improved technology, higher levels of living and all other benefits of a modern life, but with modernization also comes pain, conflict and relative disadvantage." He points out an example of farmers being "*tractored off*" their small farms and having to migrate to city slums and also those who have gone to work for bigger farmers also being displaced by labor-saving new technology for farming and harvesting. This means that the diffusion of innovation in these cases missed the "target" population that was intended to help, or the innovation was not proper to the population's socioeconomic characteristics.

The pace and extent to which an innovation will diffuse or be likely to be adopted will depend upon the *perceived attributes of the innovation* (relative advantage, compatibility, complexity, trialability, and observability), *its congruence with the development level*, and *personal characteristics and social norms* associated with the target population (Roger 1995). The lack of consideration of these factors in the past has driven many development programs to failure.

Innovation Failures

Rossi and Freeman (1993) state that, in some cases inappropriate programs were designed because the problem was incorrectly identified. In other cases the intervention did not fail; it was just not delivered because the target population did not exist. In other cases, the program made demands and had expectations for activities that the intervention was incapable of meeting.

Table 2. List and Classification of Aquaculture Diffusion of Innovation Providers, Honduras Fingerling Producers, 2003-2004.

Nature of Provider	Type of Organization	Source of Financing	Institution or Agency	Target Groups	Services Provided
Government	Public	International loans, donations, and national funds	Ministry of Agriculture through Aquaculture station El Carao, some Municipalities	Small and medium scale farmers	Fingerling providers (sales and donations) and occasional training
Government-private sector	Public	National funds	National Institute for Professional Formation (INFOP)	Small scale farmers	Training, visit and field days
Universities	Private non-profit	International, CRSP[1], USAID[2]	Pan-American Agriculture School, Zamorano	Small and medium scale farmers, NGOs, and government extension agents	Training, field visits to other farmers, field days at the station, support materials, website, phone call advisory, Input sales (fingerlings and feed), symposium organizer
NGOs	Private non-profit	National	Catholic Church	Small scale farmers	Training and visits

[1] CRSP, Collaborative Research Support Program
[2] USAID, United States Agency for International Development

Table 2. List and classification of aquaculture diffusion of innovation providers, Honduras Fingerling Producers, 2003-2004. (continued)

Nature of Provider	Type of Organization	Source of Financing	Institution or Agency	Target Groups	Services Provided
NGOs	Private non-profit	International	US Peace Corps, Action Against Hunger, World Neighbors, USA Churches and missionary organizations, Rural Reconstruction Project	Small scale farmers	Training and visits; providers of inputs
NGOs	Private for profit. Private contractors for private and public development projects, mainly financed by IFAD[1]	National and International	NGOs that are contracted by PRODERCO LEMPIRA SUR and other development projects financed by loans from IFAD and USAID	Small scale farmers	Training and visits
Development programs from international cooperants	Partnership public and private	International	Taiwan and Spain	Small scale farmers	Training and visits. Input providers, credit providers, some research
Farmer organizations	Private	National	Coffee Institute, Aquaculturist National Association (ANDAH)	Coffee producers and shrimp producers, respectively	Training and visits, symposium organizers

[1] International Fund for Agricultural Development

Also, as stated by Rondinelli (1976), an overemphasis on economic and technical criteria in project appraisal and selection, often neglects the administrative, social, cultural and environmental impacts. Diffusion failures in many agricultural development programs were evidenced by low adoption rates by farmers. Those often can be attributed to the fact that decisions on technology or what problems need to be addressed by the innovation are often decided by managers of the supplier organization in a top down manner.

This condition has several implications for farmers. First, the innovation can not be implemented because of the lack of resources associated with the level of development (hybrid seed with demand for fertilizer and pest control). Second, the innovation introduced is something that the farmers are not worried about or is not important to their wellbeing or preferences (e.g., new bean varieties may produce a better yield but taste unacceptably different than the ones habitually eaten).

Third, the innovation has cultural contradictions associated with social norms (e.g., construction of dams in places with cultural or religious significance).Finally, communication between supplier of services (change agents) and farmers may not be at the similar level of understanding because of marked differences on education and social status (Rogers 1995).

The measure of the adoption of an innovation can be based on the years of practicing the technology, the increase on output, the quality of the products and the socio-economic impact in the practicing unit. The most common measure of the diffusion of innovation is the *rate of adoption,* which is defined by Rogers (1995:250) as "the relative speed with which an innovation is adopted by members of a social system."

Thus, innovation rate is generally measured as the number of individuals who adopt a new idea in a specified period, such as a year.

Farmer Decisions

Technical change has been seen for a long time as the transfer and application of scientific knowledge to agriculture in the form of introduction of new varieties, methods of culture, new machinery, and new crops. Nonetheless technical solutions alone will not solve the problem of poverty in the rural areas (Ellis 1988). There is an array of factors, in particular socioeconomic and natural, that will affect the success or failure of a recommended technical change.

There are several reasons why farmers will be attracted and motivated to change their practices or introduce a new activity onto their farms. Ellis (1993) mentions two important factors. According to the *induced innovation approach (*Hayami and Ruttan 1985*)*, technical change is pursued as an endogenous response to change in key economic variables, specifically the *relative factor prices* (land/labor price ratio) and *changing size of market* for different agricultural inputs and outputs. In other words, farmers will be interested in adopting or making changes if changes will assure an increase in income or benefits.

Adoption of Innovations in Aquaculture

According to Rogers (1995), the innovation decision process occurs when an individual or other decision-making unit engages in activities that lead to a choice to adopt or reject an innovation. Adoption is a decision to make use of an innovation as the best course of action available. On many occasions the adoption does not occur at once;

the farmers are afraid of risks and tend to avoid losses, trying out the innovation on a small scale first to ensure than he or she understands it and can make it work.

Edwards (2000) states that recent experiences in Asia and Africa indicates that poor farmers adopt aquaculture where certain predisposition conditions are meet:

- Consumers (including farmers themselves) must perceive the value of fish and this must be reflected in market demand
- Farmers should own or be able to rent agricultural land to become involved in aquaculture.
- Farmers should have knowledge of appropriate technology.
- A supply of seed is crucial and is often a major constraining factor for adoption of aquaculture.
- Institutional support is usually required for new entrant farmers in the form extension advice, inputs and seed.

The diffusion of innovation or transfer of technology related to aquaculture in Central America started in the 1950s, supported by FAO through different development projects aimed to improve food security for the rural poor (Pérez 1999). Since then, the interest in growing tilapia has grown and extended to different production scales and farm sizes, developing into a strong flourishing activity that has helped the poor an the not so poor (Molnar et al. 1996a).

In Honduras, the diffusion of tilapia culture has used different channels, different formats, and a variety of models. Continued efforts for several decades by NGOs, the government, international organizations and educational institutions have developed a wealth of knowledge and experiences among stakeholders (Molnar 2001; Molnar et al.1996b).

Even though there are a considerable number and forms of intervention to support tilapia culture among small and medium scale farmers in Honduras, many farmers still struggle to succeed, and for others, bad experiences have resulted in abandonment of the activity. Lovshin, Schwartz and Hatch (2000) argue that the abandonment or poor performance of the aquaculture activity in Guatemala and Panama resulted from a combination of technical, economic and social factors, each playing on and amplifying the other.

This study will evaluate one of the most important variables in tilapia production, the availability and quality of fingerlings (seed), identified by farmers as a constraint to efficiency in their fish production. The study will provide information on factors that can positively and negatively affect the production and availability of fingerlings.

A common worry for many individuals and organizations that supply diffusion of innovation services is to find ways on how to speed up the rate of adoption of an innovation. Therefore, this study will analyze some of the factors from the demand side (farmers, clients) that can help to explain why some tilapia fingerling farmers adopt better and faster than others. The underlying argument of the study is that fingerling quality is an indicator of adoption of fingerling production as an aquaculture innovation. It assumes that those that have better quality of fingerlings have adopted more practices and techniques.

Conceptual Model and Hypotheses

Dependent Variable: Fingerling Quality

For successful farming, farmers should begin with good quality seed. For any activity in agriculture or in aquaculture for this matter, the crop that starts with good seed will have better chances of obtaining a good harvest. There have been successful programs all around the world that aim to increase the availability of seed for farmers to cultivate. As stated by Douglas (1980:1) “seed is not just something planted by farmers. It is the carrier of the genetic potential for higher crop production.”

In tilapia production, “fingerlings” is the name given to the small fish ready to be grown for harvest. Fry is the fish larvae barely visible swimming along the edges of the pond or the tank, and ready to begin the second phase as fingerlings. Fingerlings are the seed for stocking the culture media (ponds, tanks, cages).

Quality is a matter of perception, “understanding different perceptions is important to identify what research and development needs are most urgent and to improve the feedback to the people whose livelihoods are based on production and consumption of tilapia” (Little 2004:5). The “quality” of the fingerlings depends on the opinion of the stakeholders who include: fingerling farmers, the farmers that grow-out the fish, fish vendors in public markets, supermarkets, and at the end, the final consumer.

Poor quality of fingerlings are judged by farmers by low survival rate after stocking, slow growth, or low productivity at the harvest (Huy, McNiven, Tu, Bhujel and Little 2003; Little 2004). Honduran tilapia farmers also assess the quality of fingerling by their survival rates (farmers’ comments during visits and courses). However, the low survival rate may have different causes such as: stress for handling and during transport, poor pond management, or predation. For this study and based on the opinions of the stakeholders during the collection of the information, it was considered to analyze the *quality of fingerlings* based on *uniformity of fingerling size*, *uniformity of fingerling color*, and the *uniformity of male gender* in the batch purchased.

Uniformity of Fingerling Size

For farmers it is important to have fish of the similar size at the moment of harvest, fish of widely varying sizes tend to obtain lower price than fish of uniform size, especially if it sold to restaurants (interview with farmers; Fúnez, Neira and Engle 2001: Martínez 2004). Stocking ponds with fingerlings of different sizes will produce a harvest of different size of fish. Fingerlings of bigger size have advantages over small fingerlings in procuring food. The combination of different size fingerlings increases the level of cannibalism (Beveridge and McAndrews 2000).

Uniformity of Fingerling Color

Farmers demand uniformity of color for two reasons: First, demand from the market. Honduras consumer prefer uniformity of color in the individual fish because they can recognize the freshness and type of fish. When tilapia has spots, people ask what kind of fish is or think that has a sort of disease (personal conversation with a vendor in the public market of Tegucigalpa, March 2004).

Second, protection from predators and thieves. When there is a mixture of colors within a batch of fingerlings, the problems are in the grow-out phase. Fish of different color, particularly with red pigmentation will be easier to spot by predators especially birds and thieves (farmers observations). In a study carry out in Zamorano, the grey tilapia without net protection had a survival rate of 87 percent compared to 52 percent of the red tilapia under the same conditions (Garcés 2001). Hence, farmers seek to produce batches of fish of standard color to comply with market preferences for standard commodity.

Uniformity of Male Gender

When culturing tilapia, early maturation and frequent spawning are management challenges. Male tilapia fingerlings are preferred for culture because of their faster growth (Phelps and Popma 2000). Female tilapia invest energy for reproduction and therefore grow more slowly than males. Unwanted reproduction results in overpopulated grow-out ponds where fish compete with each other for space, dissolved oxygen, and food, causing a stunting effect on the originally stocked fish. Small fish have less market value that larger fish. The small fish can be used for home consumption; it also can be processed for fish meal for later use, or can be used to feed other animals on the farm. But if the farmer’s intentions are to sell fish, he or she will prefer to harvest marketable size fish. Thus, the higher the percentage of male fish, the higher the quality of the fingerling batch.

Independent Variables: Farmer and Farm Characteristics

For this study, several socioeconomic characteristics have been identified as factors that can affect or influence the way farmers produce fingerlings. These have been grouped into *Farmer Characteristics* and *Farm Characteristics*. For Farmer Characteristics, the study will focus on factors such as *education, time culturing tilapia, time culturing fingerlings, previous training in tilapia production,* and *previous training in fingerling production*. For *Farm Characteristics*, the focus will be on *farm size, type of operation, hormone acquisition problem,* and *other farm activities.*

Farmer Characteristics

Education

Education is an important social component in the life of any individual to lead richer lives and establishment of better social relationships among themselves (Roger 1972). When individuals are educated they are more open to take advantage of opportunities that are presented to them. The more educated the individual is, he/she expresses curiosity, wants to learn and the learning process becomes easier. Education enables individuals to make decisions that will improve their lives. Freire (1973:33) states that education "would enable men to discuss courageously the problems of their context and to intervene in that context; it would warn men of danger of the times and offer them the confidence and the strength to confront those dangers instead of surrendering their sense of self through submission to the decisions of others."

Jamison and Lau (1982) evaluate the effects of formal education received by farmers and their subsequent efficiency as farm operators. The argument of the study centered on education in basic competencies such as literacy, numeracy and general cognitive skills formed through the schools. They used data from Korea, Malaysia and Thailand and reviewed some related findings from several countries from Africa, Asia, and Latin America. Their overall conclusion is that farm productivity increases on average by 8.7 percent as a result of 4 years of education rather than none.

In the light of the preceding evidence, the farmer's years of schooling is expected to have a positive effect on the quality of the fingerlings produced.

Hypothesis 1. Education is positively related to fingerling quality.

Time Culturing Tilapia and Time Culturing Fingerlings

The experience of farmers related to farming fish, is considered here as an important factor that can have an impact on the outcomes of their fingerling production. Van den Ban and Hawkins (1996:74) define learning "as acquiring or improving the ability to perform a behavioral pattern through experience and practice." Also, state that people will learn more if they try a wider range of different actions, and they will try these actions depending on the rewards they have received in the past for trying something new. If farmers have experienced success in the past, they will be open to trying new technology and will be more likely to persist in their practice of that technology. Van den Ban and Hawkins also state that poor farmers with little education often are rather apathetic, because all attempts to improve their situation have failed in the past due to lack of resources, lack of power and/or lack of knowledge of innovations.

Farmers that have been successful have what Van den Ban and Hawkins call *self efficacy*, which is the perception people have of their ability to perform a certain task well. If farmers with high *self efficacy* fail to obtain a desired result they will try again or try to discover what they can do better, meanwhile farmers with a low level of *self efficacy* will soon stop trying. Consequently, the farmers will assess their self efficacy from their past experiences of performing the same or similar task as well as the interpretation of such experiences. For this reason, this study will evaluate the experience of the farmers in culturing tilapia and producing fingerlings, measuring the time that they have been practicing these aquaculture activities. I consider time practicing tilapia culture and time producing fingerlings as indicators of self-efficiency.

<u>Hypothesis 2</u>. Time culturing tilapia is positively related to fingerling quality.

Hypothesis 3. Time culturing fingerlings is positively related to fingerling quality.

Previous Training in Production and Reproduction

The training that the farmers have received is important in measuring the effect on the quality of fingerlings that are produced. The farmers that have been exposed to training could or could not be adopters but in most cases the curiosity about the new technology causes them to participate in training courses or field days organized by institutions interested in the diffusion of new technology or innovations. As stated by Rogers (1995:165) the innovation-decision process is essentially an information-seeking and information processing activity in which the individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation. The farmer will be interested in knowing “What is the innovation?”, “How does it work?” and “Why does it work?”, categorized by Rogers (1995) as the *awareness-knowledge phase*, that is followed by the phases of the persuasion stage and decision stage.

Thus, the training as evaluated here, covers the awareness-knowledge stage, as farmers have been exposed to courses, field days or other agent contact focused in the culture of tilapia and the production of fingerlings. I consider that there is a relationship between farmers being exposed to any of this training and the production of good quality fingerlings.

Hypothesis 4. Previous training in tilapia production is positively related to fingerling quality.

Hypothesis 5. Previous training in fingerling production is positively related to fingerling quality.

Farm Characteristics

Farm Size

The area size of the farm is described as the physical quantity of land used for production. For this study, we defined farm size as the quantity of area assigned to the production of fish (grow-out or fingerling production). Farm size was estimated by calculating the total water surface of all culture media (ponds and cement tanks) in the farm.

The theoretical concept underlying the positive relationship between size of the farm and quality of fingerlings is that farmers with larger holdings demonstrated their capacity to finance and run the enterprise. Large farmers are able to access credit with lower interest rates from formal credit institutions where collateral is required. In contrast, small farmers depend on local moneylenders, traders, or other landowners as source of credit at interest rate and condition particular to each transaction (Ellis 1993). Thus, larger farm owners and operators will be economically better off in order to have access to inputs and to attend training courses than small farmers.

Hypothesis 6. Farm size is positively related to fingerling quality.

Type of Operation

Type of operation refers to the farms operated by family groups versus farms operated by organizations (e.g., NGOs, firms, national stations, universities). Farmers that operate their own farms are aware of their reputation and consider this as their best tool for marketing their products. In the peasant economy, marketing is done mostly by word of mouth communication among villagers and villages. Consequently, farmers that produce fingerlings may be more concerned about what the customers will say about his/her product because this also says a lot about the farmer's character and integrity as a person. Workers at government installations or other institution may be less attentive to the technical aspects of fingerling production.

Hypothesis 7. Type of operation is positively related to fingerling quality.

Hormone Acquisition

In order to have an all male population of fingerlings, most Honduran fingerling farmers practice masculinization by using hormone treatment of fry (offspring) as one of the most efficient methods to obtain higher populations of male fingerlings. Meyer (1990) conducted two experiments on the use of the hormone methyltestorerone (MT) to produce all male tilapia fingerlings; he states in conclusion that "the results of these two experiments demonstrate that MT-treatment can be used to consistently produce all-male populations of tilapia, additionally, the MT- treated tilapia grow faster than non-treated control fish"(Meyer 1990:55)."

At times, farmers in Honduras encounter difficulties in acquiring this hormone, causing problems in feeding at the right time, in turn preventing them from having the expected results. I expect farmers who have difficulty obtaining this key ingredient will have lesser quality fingerlings.

Hypothesis 8. Hormone acquisition problems are negatively related to fingerling quality.

Other Farm Activities

In most of the rural aquaculture systems in the developing world, tilapia farming has been introduced as an integrated agriculture-aquaculture activity. According to Edwards and Demaine (1997:18) "Small-scale farms are typically nutrient-poor, rain-fed, resource-poor and crop-dominated in developing countries, at least in the humid tropics where aquaculture has greatest potential." In this system, farms usually depend on one strong agricultural crop (corn, cattle) and other secondary crops (vegetables, coffee) that receive primary attention regarding the assignment of resources and time. Consequently, aquaculture will receive what is left from other activities, and systems based on poor quality on-farm inputs may also be unsustainable (Edwards and Demaine 1997).

Although farmers will consider diversification of activities on the farm to minimize risks, aquaculture or in the case of fingerling production, any new activity must compete for resources and time with more established farm activities.

Hypothesis 9. Number of other farm activities is negatively related to fingerling quality.

The next chapter outlines the procedures used to measure the dependent and independent variable. It also describes the tests that will be used to examine the hypotheses developed in this chapter.

III. RESEARCH METHODS

Sample and Data Collection

The data for this study were collected during the period from July 2003 to July 2004. The research project was funded by The Pond Dynamics Aquaculture Collaborative Research Support Project (PD/A CRSP) and conducted by the Aquaculture Section of Zamorano in Honduras.

Sample

Twenty Honduran fingerlings farmers were identified during farmers meetings, courses, and through telephone conversations with NGOs, government, and universities' staff involved in fish culture activities. The 20 farmers identified were contacted by phone or by visiting the farms to verify that in fact they were producing and selling fingerlings. It was determined that 16 farmers were producing and selling fingerlings, 3 were producing fingerling solely for their own operation, and one has ceased. Sixteen farms that produce and sell tilapia fingerlings were visited, and the owners or operators interviewed about the operation. The 16 cases represent the population of farms fingerlings sellers in Honduras.

Data Collection

The respondents provided information about their socioeconomic background, including information about their education, training, and experience in producing fish. Also respondents were asked to describe their fingerling production practices and marketing experiences. They were asked about their needs for training, technical assistance, and training materials. The characteristics of the farm were also recorded.

From the 16 farms visited, 13 were producing all male tilapia fingerlings. From each of the farms and in the manner that would be used by a typical producer, a minimum of 1000 fingerlings were purchased and transported to the aquaculture station at Zamorano for evaluation (count, uniformity of size, and uniformity of color). A sub-sample of 250 of the fingerlings purchased from each farm was reared to a size when sex identification was possible. The sex of each adult fish was determined by visual examination of the genital papilla to ascertain the percent of males in each sub-sample.

Measures

Dependent Variable: Fingerling Quality

Table 3 summarizes three indicators of *fingerling quality* and its composite index. An overall Fingerling Quality Index (FQI) was derived from the measurements of the ratios of uniformity of size, uniformity of color, and male gender fingerling indicators; however, for reasons outlined below, was not used for further analysis. The data and the calculation of the indicators are presented in Table 5.

Uniformity of Size of Fingerlings

The coefficient of variation of the size distribution is the definition of the *uniformity of size*. The size of the fingerlings was determined by measuring the length of each fingerling in sub-samples of 100 fingerlings using a ruler in cm and calculating the average length, standard deviation and coefficient of variation of the sample (CVS). The CVS reflects relative variation by calculating the degree of dispersion relative to the mean of the distribution. The CVS is the percentage ratio of the mean to the standard deviation (Frankfort and Nachmias 2000).

In order to compare and facilitate the analysis of this variable together with uniformity of color and male gender, an Uniformity of Size Index (USI) was developed using the formula USI = (100 - (CVS * 100)). The higher the USI the more standardized the size of the fingerling batch.

Uniformity of Color

Tilapia fingerlings normally are in three colors: grey, red, and white. The uniformity of the color reflects the quality of the fingerlings, as mixed colors suggests lack of good management. *Uniformity of color* was assessed visually from the same sample, by separating and counting the number of fingerlings of each color and calculating the percentage of each color. Codes were assigned as X_1 = percentage grey, X_2 = percentage red, X_3 = percentage white and X_4 = percentage mixed color. The largest percentage of a uniform color was recorded as Uniformity of Color Indicator (UCI).

Uniformity of Male Gender

Uniformity of male gender is the third indicator of fingerling quality used in this study. According to Phelps and Popma (2000) male tilapia are preferred for culture because of their faster growth. To determine the percent male fingerlings, a manual sex determination was made of the sub-sample fish that were reared. The proportion of male individuals determined the uniformity male gender indicator (MGI). The higher the MGI, the better.

Survival Rate

Often the farmers judge the lack of quality in the batch of fingerlings based on the low survival rate at the harvest of their fish (farmers comments during visits; Huy et al. 2003; Little 2004). We recorded the survival rate at the comment of sex determination, about two months after stocking. This variable is not analyzed in this study as a characteristic of fingerling quality because there are other post-purchase factors that may be the cause of low survival such as poor handling of fingerlings, long travel distances, temperature and oxygen level swings, and predation, among others. The Observed survival rates are presented in Table 5.

Independent Variables: Farmer and Farm Characteristics

Table 4 summarizes the independent variables used to describe the characteristics of farmers and their farms as well as their expected effect on the dependent variable, fingerling quality. The farmer characteristics include: education, experience, and training received. The farm characteristics include: farm size, type of operation, hormone acquisition problem, and number of other farm activities.

Table 3. Dependent Variable Definition for Hypotheses Evaluation, Honduras Fingerling Producers, 2003-2004.

Variable	Measures	Indicator
Dependent		
Fingerling Quality	A Fingerling Quality Indicator (FQI) is a composite index of uniformity of size, color and male gender indicators	The higher the Fingerling Quality Indicator (FQI), better the quality of the batch
Uniformity of Size	Coefficient of Variation of the size distribution of a 100 hand sorted sample, measured in cm (CVS)	The Uniformity of Size Indicator (USI = (100 - (CVS * 100))) is formed as followed: First, the Coefficient of Variation (CVS) was multiplied by the number 100 and second, the result was subtracted from the number 100. The higher the Uniformity of Size Indicator (USI), the more uniformity of size in the sample
Uniformity of Color	Percentage of each color in the same sample used for uniformity of size evaluation	The Uniformity of Color Indicator (UCI) is represented by the largest percent among the solid colors
Uniformity of Male Gender	Sex ratio for a sample of 250, after grow-out	The Uniformity of Male Gender Indicator (UMGI) represents the percentage of male fingerlings

Farmer Characteristics

Education

The variable *education* referred to formal education. The information was obtained as a response to the question, “What level of education does the farmer or responsible person have?”; responses were measured in number of years of schooling from primary to university education. Codes 1 to 5 were assigned: 1 equals no formal education, 2 equals less than four years, 3 equals four years to 6 years, 4 equals 6 to 12 years, and 5 equals more than 12 years of schooling.

Time Culturing Tilapia

The measure of *time culturing tilapia* was obtained as a response to the question: “How long have you been culturing tilapia?”; the Farmer’s number of years culturing tilapia was recorded.

Time Culturing Fingerlings

The measure of *time culturing fingerlings* was obtained as a response to the question: “How long have you been producing fingerlings?”; the farmer’s number of years culturing fingerlings was recorded.

Previous Training in Tilapia Production

The tilapia production training received by farmers was measured based in the response to the questions: “Have you received any tilapia production training?”; the responses were coded as: Yes =1 No = 0.

Previous Training in Fingerling Production

The fingerling production training received by farmers was measured based in the response to the questions: “Have you received any fingerling production training?”; the responses were coded as: Yes =1 No = 0.

Farm Characteristics

Farm Size

Farm size was indicated by the total water surface area in square meters, which was the measurement of all culture media (ponds and cement tanks) in the farm. The farmers were asked “Please describe the area of your ponds?” and “Please describe the area of your cement tanks?”, recording both responses in m^2. The indicator is the sum of both items, the total surface area in square meters of culture capacity.

Type of Operation

This variable was used to differentiate farms operated by a family group from those operated by organizations or firms. The respondents were asked “Who operates the farm? (family group or organization?)”, assigning the following codes to the responses: Family group = 1; Otherwise = 0.

Hormone Acquisition Problem

The utilization of a masculinization hormone (Methyl Testosterone (MT)) treatment is one of the most common approaches producing all male fingerlings. In the case of Honduras, the hormone is an imported product and is sometimes difficult to acquire. Respondents were asked “Have you experienced problems obtaining MT hormone?”; the responses were coded Yes =1, No=0.

Other Farm Activities

In the case of small and medium scale farmers, they dedicate time and resources to other activities such as cattle rising, grain cropping, and tilapia production among others. In the case of organizations, they are involved in development activities as well as training, teaching, and research. The question to the respondents was "What other production/business do you have?"; the enterprises mentioned were recorded. The number of other income producing activities mentioned by the producer is the indicator.

Analysis

To analyze the data, the SPSS statistical computer program was utilized. In order to calculate the descriptive statistics and frequency distribution of the study variables, a distribution analysis was performed and the results are displayed in Table 6.

To examine the effects of the independent variables in the quality of fingerlings (dependent variable), and to test the hypotheses, a bivariate correlation analysis using Kendall Tau-*b* one tail correlation was utilized and the results are displayed in Tables 7 and 8.

The use of plots makes information more visible and easy to understand presenting a visual analysis of the tendencies of the dependent and independents variables. The Excel program from Microsoft Office was used for data table construction, data calculation, and plotting. A map of Honduras is used to show the location of tilapia farmers and fingerling producers, intended for displaying their geographic distribution in the country.

Table 4. Independent Variables Definition for Hypotheses Evaluation, Honduras Fingerling Producers, 2003-2004.

Variable	Measures	Expected Effect on Fingerling Quality
Independent		
Farmer Characteristics		
Education	Categories of education (1= 0), (2 = < 4), (3 = > 4 < 6), (4 = > 6 < 12), (5 = > 12 years of schooling)	(+)
Experience		
Time culturing tilapia	Number of years culturing tilapia	(+)
Time culturing fingerlings	Number of years culturing fingerlings	(+)
Training		
Previous training in tilapia	1 if farmer has received any training, 0 otherwise	(+)
Previous training in fingerling	1 if farmer has received any training, 0 otherwise	(+)
Farm Characteristics		
Farm size	Number of m^2 of water surface area	(+)
Type of operation	1 if it is family operated, 0 otherwise	(+)
Hormone acquisition problem	1 if there are problems, 0 otherwise	(-)
Other farm activities	Number of other income generation activities	(-)

IV. RESULTS

This chapter describes the tilapia fingerling production and marketing system. It examines the number of producers and their spatial distribution in Honduras, the facilities and techniques utilized in reproducing adult fish, and sex reversing of fry, and discuss the results from the analysis of the study variables. It also tests the hypotheses stated in chapter II.

Fingerling Production System in Honduras

System Description

Figure 1 shows the map of Honduras and the geographic distribution of the 16 tilapia fingerling producers in the study. Some concentration of seed production occurs in valley areas of Olancho in the eastern part of the country, in the Comayagua Valley in the center of the country, and in the Sula Valley in the north.

The physical facilities utilized for fingerling production on Honduras farms are of three types: earthen ponds, concrete tanks, and the combination of both. The number of ponds is highly variable between farms; ponds often are used interchangeably for grow-out of tilapia.

Seven fingerling farms are family-owned, four are private companies, one is a cooperative, one is operated by a non-profit organization (NGOs), another run by a university and two by the government. In aggregate, they produce approximately 15.3 million fingerlings a year. Most (75 percent) of the fingerling producers interviewed also raise tilapia, produce other aquaculture species, and have other farm enterprises.

Nile tilapia (*O. niloticus*) is grown on 13 farms, red tilapia on 15 farms, and white tilapia (pearl tilapia) on two farms. The predominant species are the Nile and the red tilapia. Even though the growth and reproduction of red tilapia present some additional problems, the demand from restaurants for red fish motivates many farmers to grow this variety (Tanaka 2003).

The strains of tilapia maintained by the farms are lines brought into the country at least 10 years ago, with exception of the white tilapia that came about 3 years ago. The farmers have obtained brood fish from the El Carao National Station and Zamorano, as well as commercial sources outside the country.

Respondents felt their brood stock had too much inbreeding, leading to reduced reproduction efficiency. Many (75 percent) farmers practice genetic selection of their brooders. They select brood fish to reflect the demand and preferences of their clients. They look for adult fish that present the most typical and original characteristics of the species, such as color, with no lesions, and robust body shapes.

Thirteen farmers culture other freshwater aquaculture species such as guapote (*Cichlasoma managuense*), common carp (*Cyprinnus carpio*), apple snails (*Pomocea sp*.) and channel catfish (*Ictalurus punctatus*). One of the fingerling producers practices polyculture of tilapia and marine shrimp assisting a group of farmers on the south coast of the country. In many cases, aquaculture has been a secondary economic activity that farmers have tried as a way of diversifying their operations operations.

Fingerling Production Practices

The sex-ratio for reproduction is 2 to 6 females per male fish. The adult fish are stocked at a density of 0.66 to 7 brooders per 1 m^2 of tank space. The size of the brood fish is highly variable between farms. Brooders are rested between cycles by 12 of the farmers; the other four keep them in continuous reproduction.

Fingerling sex reversal with hormone-treated feed is practiced by 14 of the 16 farmers. Alpha methyl testosterone (MT) is the hormone used for sex reversal typically applied at a dose of 60 mg MT/kg of feed. The fry are offered feed containing MT for a period of 23 to 30 days. The MT feed commonly is provided to fingerlings in feeding trays made from 10 cm diameter PVC pipe cut in half lengthwise. Fry are fed *ad libitum*. Producers report fry survival rates between 30 and 90 percent. Final average weight of the fingerlings varies between 0.05 to 2.00 g each.

Packing and Sales

Fingerling farmers utilized tube-like plastic bags to transport the fingerlings. They cut and tie in the ends with rubber bands, add water, fingerlings, and finally inject oxygen. Twelve of the 13 samples were packed with oxygen. In one case, higher mortality was due to the farmer not having pure oxygen; instead, the plastic transport bag was inflated with a bicycle pump. Producers typically add from 1 to 10 percent more fingerlings to compensate for losses in transport or otherwise. Considering counting errors and survival rates, 7 of the 13 samples produced a proportion of net available fingerlings less than 100 percent of what was ordered, ranging from 75.6 to 126 percent.

The majority of farms do not manage any type of accounting records. Therefore, it is difficult to determine the real cost of their fingerlings. Farmers who have some idea of their costs report that the expense of producing a fingerling of size between 0.05 to 3 g is between USD 0.005 to 0.020. The most important component of that total cost is the fish feed. The sales price for fingerlings varies from farm to farm, with prices ranging from USD 0.02 to 0.03 for sizes ranging from 0.05 to 3 g. Some farms have pricing systems based on species, red fish having a higher sales price, about 30 percent more than the grey Nile fish. Prices also vary according to fingerling size and number purchased.

Tilapia fingerling production in Honduras is seasonal due to cycles in rainfall and ambient temperatures; the higher production season is from March to July. Total annual production of tilapia fingerlings in Honduras from these 16 producers is estimated in 15.3 million. Of this total, 65 percent is sold to 2,316 tilapia farmers for grow-out. The remaining fish are used for on-farm production.

In the opinion of the farmers, there is always an unsatisfied demand for fingerlings in Honduras. If they could produce more fingerlings, they would be able to sell them easily. The demand is strongest during the months when cold temperatures tend to inhibit fish reproduction (November to February). Fish farmers stock their ponds in November to have fish available for Easter Week (April-May), when due to religious tradition, fish consumption increases in Honduras.

Most of the interviewed fingerling producers do not advertise in any way. Several farmers have roadside signs. One interpretation is that each farmer acquires a local reputation based on the quality of their fingerlings. Sales of fingerlings are promoted largely via word of mouth. Internet contacts and knowledgeable individuals in universities and public agencies also connect growers to fingerling vendors.

Needs

Respondents were concerned about the lack of training opportunities. Fourteen of the 16 fingerling producers expressed the need to learn more about production techniques. They also think that there is an urgent need for new genetic material for tilapia in Honduras.

Another important problem for the tilapia farmers in general is the acquisition of some important inputs. Although there is availability of prepared feed in local markets, the prices are high, often fluctuating suddenly without apparent reason. They feel that the companies that produce and distribute fish feed charge high prices. The farmers observe that the big commercial fish farms receive a better price because they buy larger quantities of feed each month.

Fingerling farmers reported having problems with the acquisition of the MT hormone. As an imported product, it is not generally available in Honduras. Many do not have a secure provider of MT; most obtain MT from another farmer or from the fish feed distributor who is willing to sell hormone. Also, they report that a lack of local distributors of equipment and materials for fish culture hinders their progress.

Losses from bird predation are a very important problem. It is not known exactly how much damage birds cause, but the respondents perceive the losses as significant. Several farms hired a watchman to deter predators. Many farms also experience loss of fish due to human action. Neighbors and people from other communities steal fish, sometimes draining ponds, and otherwise causing damage.

Lack of record keeping, accounting problems, and technical questions were reported by several respondents. Without proper records, they do not have information to calculate the costs of production and learn from their experience. They have asked for assistance to establish a record keeping system.

Descriptive Statistics

Table 6 shows the descriptive statistics for the dependent and independent variables in the study.

Dependent variable

Uniformity of color and male gender present larger standard deviation at 17.45 and 16.25 respectively compared with uniformity of size and the composite index with standards deviations of 6.51 and 9.96 respectively. This means that the quality of fingerlings with respect to uniformity of color and male gender are the more variable dimensions of fingerling quality. Uniformity of color has minimum values as low as 50 percent, which means that in a batch of fingerlings only half of them are of any one color (range 50-100) with a mean of 84.8 percent. Uniformity of male gender has a mean value of 84.5 percent (range 43-98). A minimum values of 43 percent which means that 57 percent of the fingerling batch are females, a very unsatisfactory level. Combining the three variables; uniformity of size, color and male gender, the composite quality index mean is 83 percent (range 62-94).

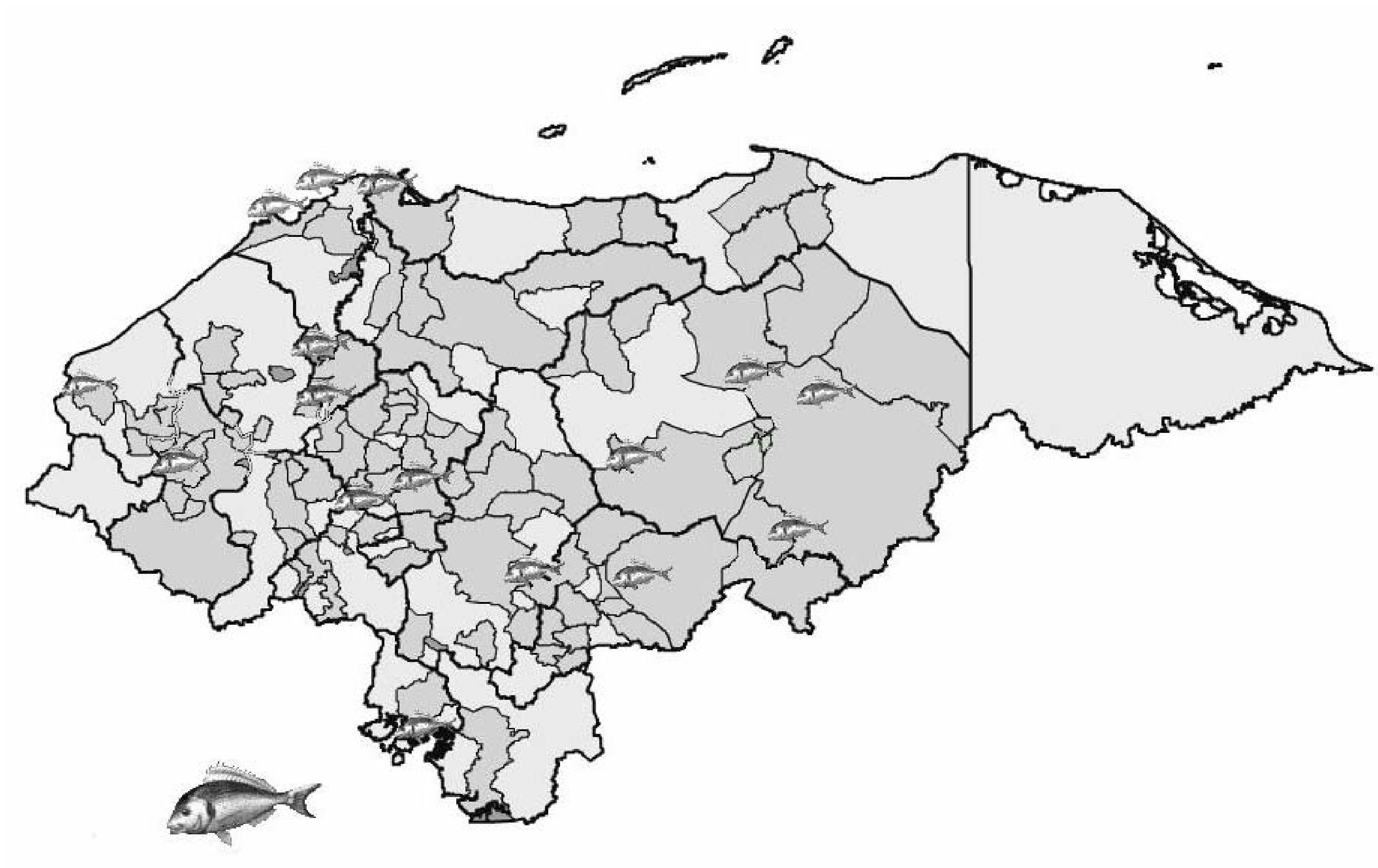

Figure 1. Fish Represent the Location of Each Fingerling Producing Farm and the Dark Areas are Fish Farm Reported Locations During 2003- 2004 in Honduras.

Table 5. Uniformity and Fingerling Quality Indicators for Size, Color and Male Gender, Honduras Fingerling Producers, 2003-2004.

Farmers	Coefficient of Variation on Size (CVS) Percent	Uniformity of Size Indicator (USI)[1] Percent	Uniformity of Color Indicator (UCI) Percent	Uniformity of Male Gender Indicator (UMGI) Percent	Fingerlings Quality Index (FQI)[2] Percent	Survival Rates[3] Percent
1	0.14	86	100	96	94.0	66.0
2[4]	0.24	76	75	98	83.0	39.9
3	0.13	87	100	94	93.7	45.6
4	0.16	84	69	78	77.0	86.0
5[4]	0.19	81	69	87	79.0	44.8
6	0.13	87	92	64	81.0	45.2
7	0.26	74	69	43	62.0	76.0
9	0.16	84	100	90	91.3	42.2
10	0.33	67	50	85	67.3	27.0
12	0.27	73	100	88	87.0	29.0
13	0.26	74	100		87.0	
15	0.20	80	94	96	90.0	20.0
16	0.14	86		96	91.0	61.0

[1] USI = (100 - (CVS * 100))

[2] FQI equal to the mean of (USI + UCI + UMGI)

[3] Survival rate two months after stocking

[4] Average of two purchased batches

For this study, the survival rate was measured at the moment of arrival at the Zamorano aquaculture station. Survival rate was measured at the moment of sex determination about two month later. At the time moment of arrival at Zamorano, the average of the survival rate was 95.4 percent (range 88.7-99). The average survival rate after two months was 48.6 percent (range 20-86).

Independent Variables

For the *farmer characteristics variables*, education shows that fingerling farmers have at least between 4 and 6 years of formal education, which means that they can be offered written training materials. Also, it may suggest that farmers with more education are more motivated to try new technologies.

The variable time culturing tilapia has a mean of 7.8 years, which means that fingerling farmers are experienced tilapia growers; there are some with experience of 27 years. Time culturing fingerlings has mean of 6.7 years and a range of 0.6-25.

The variable previous training in tilapia production shows that 92.3 percent of fingerling farmers have participated at least in one training event on tilapia production. The fingerling production training variable shows that 76.9 percent of fingerlings farmers have attended at least one fingerling production training event.

For the *farm characteristics variables*, the farm size has a mean of 23,107 m^2 of water surface area, being very variable from farm to farm with a range of 220 to 123,168 with a standard deviation of 35,123 m^2. The type of operation variable shows that 46.2 percent are family operated units and 53.8 percent are other type of operation such as governmental, private institution or a firm.

Table 6. Descriptive Statistics for all Variables, Honduras Fingerling Producers, 2003-2004.

Variable	Units	N	Minimum	Maximum	Mean	Mode	Standard Deviation
Dependent Variable							
Fingerling quality (Index)	%	13	62	94	83.33		9.96
Uniformity of size	%	13	67	87	79.92		6.51
Uniformity of color	%	12	50	100	84.83		17.45
Male Gender	%	12	43	98	84.58		16.25
Independent Variables							
Farmer's Characteristics							
Education*	Years of schooling	13	>4<6	> 12		>12 (46%)	0.75
Time culturing tilapia	Years	13	0	27	7.81		8.09
Time culturing fingerlings	Years	13	0.6	25	6.78		7.07
Previous training in tilapia production*	Yes = 1 No = 0	13				Yes (92.3%)	0.28
Previous training in fingerling production*	Yes = 1 No = 0	13				Yes (76.9%)	0.44
Farm's Characteristics							
Farm size	m^2 water surface	13	220	123,168	23,107		35123
Type of operation*	Family =1 Other=0	13	0	1		Other (53.8%)	0.52
Hormone acquisition problem*	Yes =1 No=0	13	0	1		Yes (53.8%)	0.52
Other farm activities	Number of activities	13	0	5	2.62		1.61

* Mode for nominal and ordinal variables

The hormone acquisition problem variable shows that 53.8 percent of farmers expressed to have some kind of problem procuring the hormone for sex reversal. Fingerling farmers, besides fingerling production, have in average of 2.6 other farm activities (range 0-5) with 5 activities being the most common (30.8 percent).

Hypothesis Testing

Dependent Variable

Table 7 summarizes the correlation found between the three indicators of fingerling quality measured and their relationship with the fingerling quality composite index (Item-to-total correlations). For this study, uniformity of size has a positive correlation (Tau- *b* = 0. 38, p = 0.04) with the composite fingerling quality index. Uniformity of color has a positive correlation (Tau- *b* = 0.77, p < 0.01) with the composite fingerling quality index. Uniformity of male gender has a positive correlation (Tau- *b* = 0.54, p = 0.01) with the composite fingerling quality index. The low item-to-total correlation suggests that a composite fingerling quality index would not be warranted for further use, as the individuals' dimensions seem relatively independent.

Figure 2 shows the distribution of the indicators of quality. All of them are above 60 percent with the exception of one outlier on male gender indicator of 43 percent.

Independent Variables

Table 8 shows correlations between three fingerling quality indicators and the composite index of quality and the independent variables. The study hypotheses are tested below.

<u>Hypothesis 1</u>. Education is positively related to fingerling quality.

There is no significant relationship between education and any of the indicators of fingerling quality. Therefore, hypothesis 1 is rejected. Fingerling quality was not related to producer education.

Hypothesis 2. Time culturing tilapia is positively related to fingerling quality.

There is significant relationship between time culturing tilapia and male gender indicator. The correlation is positive, (Tau- $b = 0.46$, $p = 0.05$). Therefore, hypothesis 2 is accepted. This demonstrates that experience in culturing tilapia is a favorable pre-condition for farmers that want to produce fingerlings.

Hypothesis 3. Time culturing fingerlings is positively related to fingerling quality. There is no significant relationship between time culturing fingerlings and any of the indicators of fingerling quality. Therefore, hypothesis 3 is rejected. Fingerling production experience was not related to fingerling quality.

Hypothesis 4. Previous training in tilapia production is positively related to fingerling quality. There is a significant relationship between previous training in tilapia production and uniformity of male gender indicator but the observed relationship is negative (Tau- $b = -0.42$, $p = 0.05$). Therefore, the hypothesis 4 is rejected. Farmers with more training had more variable success in obtaining all male fingerlings.

Hypothesis 5. Previous training in fingerling production is positively related to fingerling quality. There is no significant relationship between previous training in fingerling production and any of the indicators of fingerling quality. Therefore, hypothesis 5 is rejected. Reproduction training was not related to fingerling quality.

Hypothesis 6. Farm size is positively related to fingerling quality. There is no significant relationship between farm size and any of the indicators of fingerling quality. Therefore, hypothesis 6 is rejected. Farm size was not related to fingerling quality.

Hypothesis 7. Type of operation is positively related to fingerling quality. There is no significant relationship between type of operation and any of the indicators of fingerling quality. Therefore, hypothesis 7 is rejected. Type of operation was not related to fingerling quality.

Hypothesis 8. Hormone acquisition problem are negatively related to fingerling quality. There is no significant relationship between hormone acquisition problem and any of the indicators of fingerling quality. Therefore, hypothesis 8 is rejected. Hormone acquisition problem was not related to fingerling quality.

Hypothesis 9. Number of other farm activities is negatively related to fingerling quality. There is no significant relationship between number of other farm activities and any of the indicators of fingerling quality. Therefore, hypothesis 9 is rejected. Number of other farm activities was not related to fingerling quality.

Table 7. Kendall-Tau-*b* Correlations between Fingerling Quality Variables, Honduras Fingerling Producers, 2003-2004.

Variable	Composite Fingerling Quality Index	Uniformity of Size	Uniformity of Color	Male Gender
Composite Fingerling Quality Index	1	0.38*	0.77**	0.54**
Uniformity of Size	0.38*	1	0.24	0.08
Uniformity of Color	0.77**	0.24	1	0.34
Male Gender	0.54**	0.08	0.34	1

* Significant at $p < 0.05$ level (1 tailed)
**Significant at $p \leq 0.01$ level (1 tailed)

Table 8. Kendall-Tau-*b* Correlations between Fingerling Quality Variables and Independent Variables, Honduras Fingerling Producers, 2003-2004.

Variable	Uniformit y of Size	Uniformity of Color	Male Gender	Composite Fingerling Quality Index
Independent				
Farmer Characteristics				
Education	-0.11	0.37	0.21	0.28
Time culturing tilapia	-0.13	0.24	0.46*	0.17
Time culturing fingerlings	0.14	0.19	0.20	0.23
Training in tilapia	0.13	0.12	-0.42*	0.07
Training in fingerling	-0.25	0.19	0.22	0.17
Farm Characteristics				
Farm size	0.32	0.02	-0.17	0.04
Type of operation	0.02	0.23	-0.08	0.16
Hormone acquisition problem	0.30	0.05	-0.11	0.12
Other Farm Activities	0.06	-0.17	-0.15	0.00

* Significant at $p \leq 0.05$ level (1 tailed)

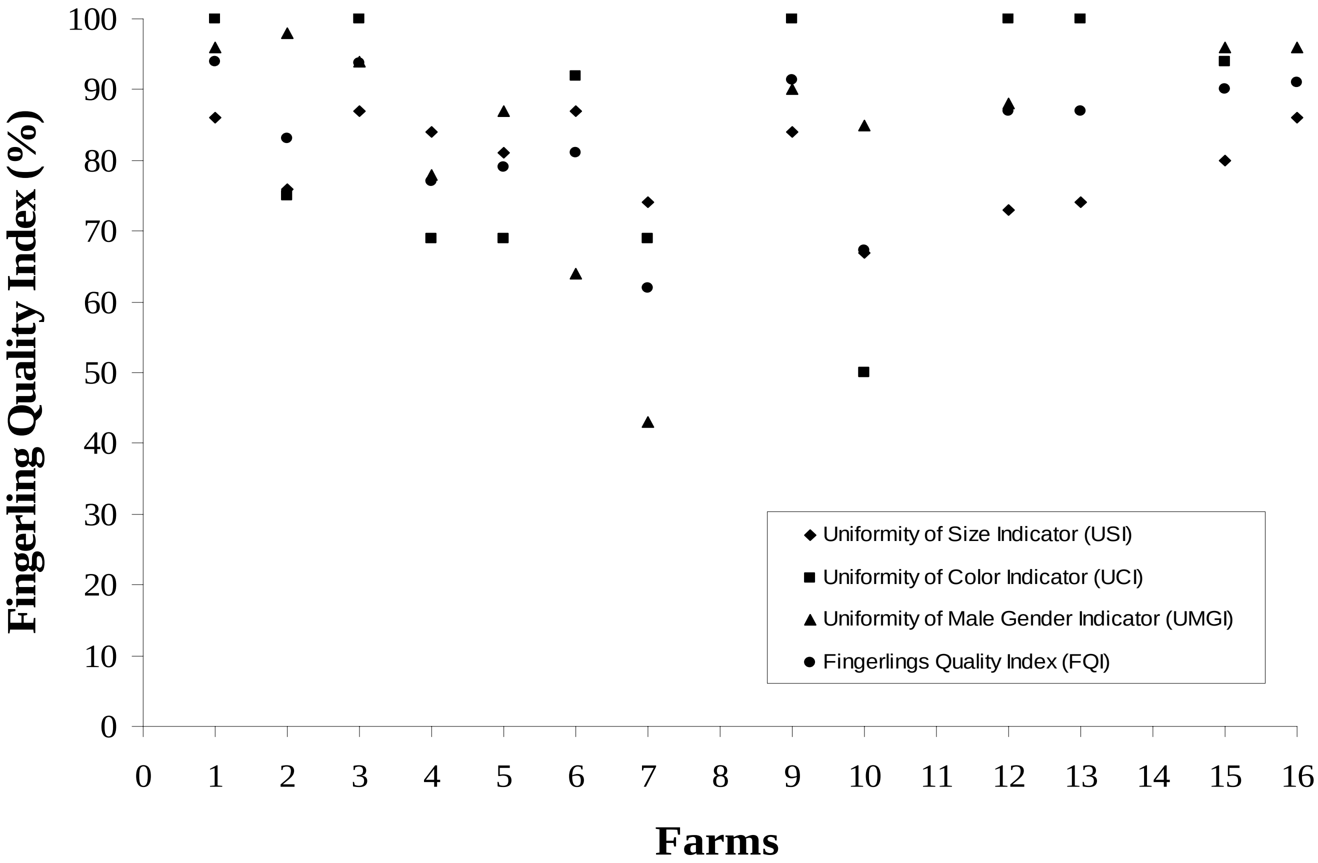

Figure 2. Dispersion of Fingerling Quality Indicators.

V. CONCLUSIONS

This chapter presents a summary of findings, theoretical implications, implications for research, practical implications and suggestions for technical assistance and support.

Summary

This study considers three indicators of fingerling quality (uniformity of color, size and male gender). The results suggest that there is higher variability for color and gender than for size among the fingerling batches evaluated. This variability suggests that the quality of fingerling delivered to tilapia farmers is not as consistent as it must be. Most of the fingerling batches evaluated fall under the 90 percent level of uniformity of size, color, and gender.

In Chapter IV the hypothesized relationship between fingerling quality and the independent variables of farmer and farm characteristics were compared. These results found that only two independent variables have a significant relationship with fingerling quality as dependent variable.

Hypothesis 2, time culturing tilapia is positively related to fingerling quality, was accepted. Time culturing tilapia has a significant correlation with the indicator of male gender uniformity, which suggests that the experience of farmers is important to achieve a better level of quality in their production of fingerlings; in this specific case, to manage properly the practice of sex reversion. Also, it suggests that experience on culturing tilapia is a favoring pre-condition for farmers that want to start to produce fingerlings.

The hypothesis 4, previous training in tilapia production is positively related to fingerling quality, was rejected because even though there is a significant relationship, this was negative one. Previous training was negatively related to male gender uniformity which was not an expected relationship, due in part to the small number of observations and the poor performance of two producers who reported training.

Implications

Theoretical Implications

The study found that farmers that have received training in tilapia production did not necessarily produce good quality fingerlings. The reasons for this could be several, but one important is that producing tilapia fingerlings is an entire different activity for which specialized knowledge is needed. However, the farmer's knowledge in tilapia production is important in order to provide advice to the customers on how to manage the different aspects of tilapia production.

Implications for Research

Most of the hypotheses were rejected due to lack of statistical significance and one due to inverse relationship to the expected. This pattern may be due to the small sample size and two outliers producers whose fingerling samples recorded very low quality in the uniformity of gender of 43 percent and 64 percent respectively; this may have influenced the correlations and their significance. One outlier may have changed dramatically the results of the analysis in the small population examined here. This was the largest farm that was under renovation and new management; even though the manager had a lot of experience and training, he felt demoralized to work for the lack of support to his suggestions. He said that the hormone used was very old and the owner did not want to buy new product.

A very important variable that should be look into more detail is the survival rate after the two first months as farmers some times blamed the low survival rate at the harvest time to the poor quality seed. Some causes of the low survival rate may include the stress caused by the method of handling the fingerlings at the time of sale, as well as the method of packing and transport.

McGee and Cichra (2003), states that excessive stress on fish often leads to disease outbreaks and later mortality, which may not occur until several days after stocking. I did not find much research done in the post harvest, handling and transport of fingerlings. However there is some work done by MacNiven and Little (2001) on evaluation of stress challenges to assess fry quality and a Zamorano thesis (Villacis 2004) that determined the optimal density of biomass for fingerling transport. More research is needed, focused at the small and medium-scale level of fingerling delivery to improve methods of packing and handling.

For future research and when the size of the population allows it, more detailed study on the variability of fingerling quality among the type of farm operations should be conducted. In this study, some type of operations only had one observation, which was not enough to make comparisons and draw conclusions based on the means.

Practical Implications

The higher grade of variability in the quality of fingerlings in the male gender indicator can be attributed to the fact that most farmers do not use standard method of grading their fry and fingerlings by size. This is an area where training can accomplish improvement in the outcomes on the sex reversal practices as well the uniformity of size of fingerling sold.

The method of feeding employed could be another cause of low quality; they do not count the fry in the sex reversal process, thus affecting their calculation of feed served. Some reported that when the demand was high, they sold the fingerlings before the recommended hormone feeding time (28-30 days) was complete.

Even though most farmers used the recommended protocol for the preparation of the hormone treated feed (60 mg MT/kg of feed), some try to save money by lowering the dosage or using alcohol of a different type and cheaper. Other were using outdated hormone (more than 4 years old). One approach that has been working until now for some farmers is to buy the prepared hormone feed from other farmers or institutions with more experience and access to the source of hormone.

Little (2004) states that poor survival post stocking is a common characteristic of tilapia transported over long distances. Figure 1 shows a map of Honduras and the location of the fingerling farms in the country. The tilapia farmers often complain about the long distances and the difficult access to the fingerling sources. Support for the establishment of new fingerlings farmers in areas where there are none will help increase access to seed. Avoiding transport over long distances should increase viability and improve the post stocking survival rate, as well as lowering the cost of transport.

The closer the farmers are to the source of fingerlings, the better. Not only for the easy access to the seed, but also for the access to information that the fingerling provider can offer. The fingerling farmer can be an effective channel for diffusion of innovations. They can provide advice and distribute materials on tilapia production. As contacts for researchers, fingerling farmers are very knowledgeable when it comes to aquaculture activity in the region.

The survival of tilapia fingerlings can be associated with the size of the fingerlings stocked. In Figure 3, it can be observed that there is a tendency for higher survival rates for larger fingerlings. This suggests that it may be useful to conduct research on advance fingerling nursing strategies to produce larger size fingerlings. The research should focus on the economic and technical viability of the operation.

Suggestions for Technical Assistance and Support

Based on the findings of the study, it can be recommended that farmers have a need for fingerling and tilapia production training and assistance. Even though most of them have participated in some kind of training event, qualitative information obtained in the field suggests that they feel the need to learn more. The recommendation here would be that the training alone is not enough to produce better quality fingerlings.

The strategy of diffusion of innovation should start with a pre- evaluation phase, where the farmer's knowledge and needs are assessed. The training should be based on the results of the assessment and should be accompanied by follow up support (visits, telephone contacts). Subsequently, evaluation of progress and an evaluation of impact of the innovation can document the degree of adoption of the innovation.

A problem associated with the implementation of this holistic strategy to the diffusion of aquaculture innovations is the incongruence of best practices for development and the donors' resources available. Fowler (2000) mentions some factors that exemplify this incongruence: conditions and expectations of the giver (especially respect for the receiver's autonomy), method of allocation of funds, continuity and necessary duration, and timeliness of disbursements among others considerations. Until diffusion agencies and resources providers find common grounds that benefit the target user, the farmers in this case; efforts for development will continue to deliver just part of the objectives proposed in the project proposals.

There is a need for institutional coordination among the diffusion agencies. The government should take a more active role in coordinating the diffusion activities as a guide and support for the best use of limited resources. Vandergeest, Flaherty, and Miller (1999) found that the industry self-regulation has limited impacts in the social and environmental problems of shrimp industry in Thailand but government intervention that mobilizes local people might be effective.

The farmers' expressed need for new genetic material should be evaluated in collaboration with national and international research centers (Camacho, Abella and Tayamen 2001) and try to find viable alternatives accordingly to farmers' conditions and needs. National hatcheries play an important role in the distribution of fingerlings in Honduras, but they have had problems through time.

A the time of this study, Honduras government hatcheries are advised by the Taiwanese Mission, which provide technical as well as economic support. But what is going to happen when they decide to leave? The government should undertake a long term strategy to keep the hatcheries functioning efficiently. El Carao station is working in less than half of its physical capacity. The Taiwanese Mission recently has put a hatchery in San Lorenzo into working condition and currently is working in one in La Lima.

The organization of events (field days, farmers visiting other farmers, training courses) are a useful tool for assembling fingerling farmers to facilitate contact among themselves, and with extension agents and researchers. These events serve several purposes. One outcome is bonding and identification among members of a common industry. Farmers will share their problems as well the need to find solutions to common problems. Another impact is that extension agents and researches will receive feedback, and at the same time will learn and expand their vision of the social as well as technical implications of the activity.

The farmers expressed that, by observation they know what is happening but they do not know why it is happening. This suggests a need for training courses, on subjects of reproductive biology, feeding patterns in the reproductive phase of tilapia, and other topics that help clear doubts and enable better decisions.

Farm try outs in methods to elevate the water temperature in the reproduction media during the months of low temperatures will help increase the production of fingerlings during this period. Ballesteros (2001) evaluated the use of black and clear plastic covers over reproduction cement tanks in Zamorano and concluded that use of clear plastic cover elevated the temperature of the water in 3°C.

Another need often mentioned by farmers is the lack of skill in administrative and managerial aspects of the activity; particularly, accounting and technical record keeping. They understand the need to have these records as a tool for analyzing the performance of their business, allowing them to make decisions to improve their efficiency and make it more profitable in the long run.

There is always demand for written materials, particularly materials developed in Spanish. The resources needed are to pay for new editions and reprints. Zamorano has published several Spanish manuals for tilapia culture which are available in the web site www.acuacultura.org (Verma, Tollner, Meyer and Molnar 2002a, 2002b), and the printed versions can be purchased. Currently, Zamorano is developing a Tilapia Fingerling Production Manual in Spanish (Meyer 2005).

Based in the needs stated by the findings, short term actions should include the design and delivery of courses for practicing fingerlings farmers to reinforce the knowledge they already have in order to improve their fingerlings quality. Design and delivery of courses for new fingerling farmers should be conducted, identifying farmers that can provide access to seed to fingerlings in areas where fingerling provider are none existent.

The NGOs may be more effective at stimulating interest and reaching small-scale farmers than governmental organizations (Molnar et al. 1996b). Training extension agents from these institutions is imperative for the appropriate guidance for fish farmers.

After these courses have been delivered, an impact assessment study should be conducted to document the benefits and general outcomes of the intervention. In the long term, revise the impact study assessment and adopt changes if it is necessary to adopt the methodology of the intervention to other countries, primarily in Central America.

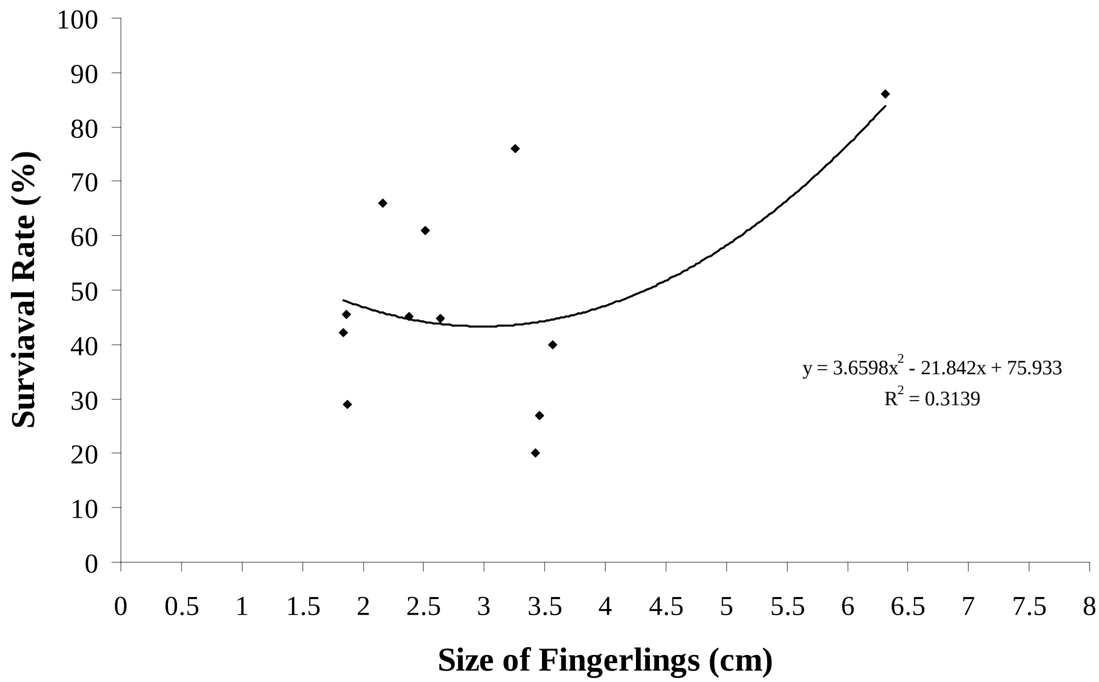

Figure 3. Relationship between Size of Fingerling Stocked and Survival Rate after Two Months of Grow-out. (R^2 = 0.3139, F = 5.5, P< 0.05).

REFERENCES

Aceituno, C., D. Meyer, A. García and J. Barrera 1997. “Evaluación de Alevines de Tilapia Roja Adquiridos en Diferentes Centros de Producción en Honduras.” Pp. 206-208 in *IV Simposio Centroamericano de Acuacultura,* edited by D. E. Alston, B. W. Green and H. C. Clifford III. Baton Rouge: World Aquaculture Society.

Appelbaum, Richard P. 1970. Theories of Social Change. Chicago: Markham Publishing Company.

Ballesteros, Jorge M. 2001. Evaluación de la Reproducción de Tilapia Nilótica en Pilas Cubiertas con Plástico. Tesis para obtener el grado de Ingeniero Agrónomo. Zamorano, Honduras: Panamerican Agriculture School.

Berdegué, Julio A. and C. Marchant. 2002. “Chile: The Evolution of Agricultural Advisory Services for Small Farmers: 1978-2000.” Pp. 21-27 in *Contracting for Agriculture Extension. International Case Studies and Emerging Practices*, edited by W. M. Rivera and W. Zijp. New York: CABI Publishing.

Berrios, Mario. 1982. “Situación Actual de la Acuicultura en Honduras.” *Informe de Pesca 294 Suplemento,* Pesca. Rome: FAO. Retrieved May 26, 2005. (http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/005/AD020S/AD020s08.htm).

Beveridge, Malcom C. and B. J. McAndrews. 2000. Tilapias: Biology and Exploitation. Fish and Fisheries Series 25. The Netherlands: Kluwer Academic Publishers.

Brown, Lawrence A. 1981. Innovation Diffusion. A New Perspective. London: Methuen & Co.

Camacho, A.S., T. Abella, and M.M. Tayamen. 2001. “Fish Genetics Research and Development in the Philippines.” Pp. 71-76 in *Fish Genetics Research in member countries and Institutions of the International Network in Genetics in Aquaculture. Conference Procedures,* edited by M.V. Gupta and B.O. Acosta. Manila, Philippines: ICLARM. Retrieved July 3, 2005. (http://www.worldfishcenter.org/Pubs/Fish_Genetics/chapter%2011.PDF).

Choudhury, P.C. 1997. Preface. Pp.v in *Rural Aquaculture: Overview and Framework for Country Reviews*, edited by P. Edwards and H. Demaine. RAP Publication 36. Rome: FAO.

CRSP. 2004. “Historical Perspectives and U. S. Policies.” INTSORMIL CRSP. Retrieved 25 May, 2005. (http://crsps.org/whycrsps.htm).

Douglas, E.J. 1980. Successful Seed Programs: A Planning and Management Guide. Boulder, Colorado: Westview Press.

Edwards, Peter. 2000. “Aquaculture, Poverty Impacts and Livelihoods.” *Natural Resources Perspectives* 56. London, U.K.: Overseas Development Institute. Retrieved April 7, 2005. (http://www.odi.org.uk/nrp/56.html).

Edwards, Peter and H. Demaine. 1997. Rural Aquaculture: Overview and Framework for Country Reviews. RAP Publication 1997/36. Rome: FAO.

Ellis, Frank. 1993. Peasant Economics. Farm Households and Agrarian Development. Second Edition. Cambridge: Cambridge University Press.

Engle, C.R. 1986. “Costos de Producción de Semilla de Entrega en Panamá.” *Revista Latinoamericana de Acuicultura* 30:43-57.

FAO. 2002. “Fishery Country Profile. Honduras.” *FID/CP/HND*. Rome:FAO. Retrieved May 25, 2005. (http://www.fao.org/fi/fcp/es/hnd/profile.htm).

Franfort-Nachmias, C. and D. Nachmias. 2000. Research Methods in the Social Sciences. Sixth Edition. New York: Worth Publishers.

Freire, Paulo. 1973. Education for Critical Consciousness. New York: The Seabury Press.

Fowler, Alan. 2000. Striking a Balance. A Guide to Enhancing the Effectiveness of Non-Governmental Organizations in International Development. London: Earthscan Publications.

Fúnez, N. Omar, I. Neira and C. R. Engle. 2001. “Supermarket Outlets for Tilapia in Honduras: an Overview of Survey Results.” Pp. 82-86 in *VI Simposio Centroamericano de Acuacultura*. *Memoria: Sesiones de Tilapia*, edited by D. Meyer. Zamorano: Panamerican Agriculture School.

Garcés, Ricardo. 2001. “Comparación y Sobrevivencia de Dos Líneas de Tilapia en Estanques Cubiertos con Malla Contra Pájaros.” Tesis para obtener el grado de Ingeniero Agrónomo. Zamorano, Honduras: Panamerican Agriculture School. Retreived May 31, 2005. (http://www.acuacultura.org/images/T1310.pdf).

Green, B.W. and C.R. Engle. 2000. "Commercial Tilapia Aquaculture in Honduras." Pp.151-170 in *Tilapia Aquaculture in the Americas, Vol. 2,* edited by B.A. Costa-Pierce and J.E. Rakocy. Baton Rouge: World Aquaculture Society.

Green, B.W., D.R. Teichert-Coddington, and T.R. Hanson. 1994. Development of Semi-Intense Aquaculture Technologies in Honduras. Research Development Series 39. Auburn, AL.: International Center for Aquaculture and Aquatic environments, Auburn University.

Halwart, Matthias and M. Gupta (eds.). 2004. Culture of Fish in Rice Fields. Rome: FAO and Penang, Malaysia: The World Fish Center.

Hayami, Y. and V. W. Ruttan. 1985. Agricultural Development. An International Perspective. Revised Edition. Baltimore: The Johns Hopkins University Press.

Haylor Graham and S. Bland. 2001. "Integrating Aquaculture into Rural Development in Coastal and Inland Areas." Pp. 73-81 in *Technical Proceedings of the Conference on Aquaculture in the Third Millennium*. Bangkok, Tailand 20-25 February, 2000. Rome: FAO.

Huy, H., A. MacNiven, N. Tu, C. Bhugel and D. Little. "Tilapia Seed Production in Ho Chi Minh City, Southern Vietnam." *Aquaculture Asia* 7(4): 23-25.

Jamison, Dean T. and L. Lau. 1982. Farmer Education and Farm Efficiency. Baltimore, MD: Johns Hopkins University Press.

Jolly, Curtis M. and H. A. Clonts. 1993. Economics of Aquaculture. New York: Food Products Press.

Josupeit, Helga. 2005. "Tilapia Imports Soar in the US Market." *Seafood Today*. Revista Internacional del Canal de Comercialización de Pescados y Mariscos. Retrieved April 22, 2005. (htt://www.seafood-today.com/noticia.php?art_clave=350).

Kent, George. 1987. Fish, Food, and Hunger. The Potential of Fisheries for Alleviating Malnutrition. Boulder, Colorado: Westview Press, Inc. Little, David C. 2004. "Delivering Better Quality Tilapia Seed to Farmers." Pp. 3-17 in *Proceedings 6th International Symposium on Tilapia in Aquaculture*. Edited by Remedios Bolivar, Graham Mair and Kevin Fitzsimmons. Manila, Philippines: ISTA.

Lovshin, Leonard., N. Schwartz and U. Hatch. 2000. Impacts of Integrated Fish Culture on Resources Limited Farms in Guatemala and Panamá. Research and Development Series 46. Auburn, AL.: International Center for Aquaculture and Aquatic environments, Auburn University.

Lutz, C.G. 2002. Strategic Planning for Development of Honduran Aquaculture. Alianza Presidential Investment Program of Honduras. Baton Rouge: Louisiana State University.

Lyon, Larry. 1989. The Community in Urban Society. Illinois: Waveland Press, Inc.

Kinloch, Graham and Raj P. Mohan. 2000. Ideology and the Social Sciences. Westport, Connecticut: Greenwood Press.

McGee, Michael and Ch. Cichra. 2003. “Fish Fingerling: Purchasing, Transport and Stocking.” IFAS Extension Service. Document FA7. Gainesville: University of Florida. Retrieved May 14, 2005. (http://edis.ifas.ufl.edu/pdffiles/FA/FA01300.pdf).

MacNiven, A.M. and D. Little. 2001. “Development and Evaluation of a Stress Challenge Testing Methodology for Assestment of Nile tilapia (*Oreochromis niloticus L*.) Fry Quality.” *Aquaculture Research* 32:671-679.

Martínez, Pablo. 2004. “Cluster Membership as Competitive Advantage in Aquaculture Development: Case Study of Tilapia Producers in Olancho, Honduras.” Msc. Thesis, Agricultural Economics and Rural Sociology Department. Auburn, Alabama: Auburn University.

Messrs Matthias H., M. Martínez and A. Schückler. 2000. Small Ponds Make a Big Difference. Integrating Fish with Crop and Livestock Farming. Fisheries Department. Rome: FAO. Retrieved July 2, 2005. (http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/003/x7156e/x7156e03.htm).

Meyer, Daniel E. 2005. Producción de Alevines de Tilapia. Mimeo. Zamorano, Honduras: Panamerican Agriculture School.

Meyer, Daniel E. 2004. Introducción a la Acuacultura. Mimeo. Zamorano, Honduras: Panamerican Agriculture School.

Meyer, Daniel E., J.J. Molnar, B. Verma and E.W. Tollner 2003. Regionalizing Training and Technical Assistance for Nongovernmental Organizations. Final Report of Appropriate Technology Research 1 (10ATR1). Corvallis, Oregon: Aquaculture CRSP. Retrieved July 3, 2005. (http://pdacrsp.oregonstate.edu/pubs/workplns/wp_10/10ATR1.html).

Meyer, Daniel E. and S. Triminio Meyer. 2003. Producción de Tilapia en Fincas Integradas. Usando Insumos de Bajo Costo. Mimeo. Zamorano, Honduras: Panamerican Agriculture School.

Meyer, Daniel E. 2003. Acuacultura Manual de Prácticas. Mimeo. Zamorano, Honduras: Panamerican Agriculture School.

Meyer, Daniel E. 1990. "Growth, Survival and Sex Ratios of Tilapia Hornorum, Tilapia Nilotica and their Hybrid (T. Nilotica Female X T. Hornorum Male) Treated with 17-Alpha-Methyltestosterone." PhD Dissertation. Auburn, Alabama: Department of Fisheries & Allied Aquacultures. Auburn Alabama: Auburn University.

Molnar, Joseph J., E. Trejos, P. Martínez, S. Triminio Meyer, D. Meyer, W.E. Tollner and B. Verma. 2002. "Income, Food Security, and Poverty Reduction: Case Studies of Functioning Clusters of Successful Small-Scale Aquaculture Producers." *Tenth Work Plan, Food Security Research 1 (10FSR1) Final Report.* Mimeo. Corvallis, Oregon: Aquaculture CRSP.

Molnar, Joseph J. 2001. "NGOs and Aquaculture Development: Lessons from Honduras and Peru." *Aquanews* 16(3). Corvallis, Oregon: Aquaculture CRSP. Retrieved July, 2005. (http://pdacrsp.oregonstate.edu/aquanews/summer2001/p4.html).

Molnar, Joseph J., T.R. Hanson and L.L. Lovshin. 1996a. "Doing Development by Growing Fish: A Cross-National Analysis of Tilapia Harvest and Marketing Practices." *Fourteenth Annual Administrative Report*. Corvallis, Oregon: Aquaculture CRSP. Retrieved July 3, 2005. (http://pdacrsp.oregonstate.edu/pubs/admin/admin14h/admin14toc.html).

Molnar, Joseph J., T.R. Hanson and L.L. Lovshin. 1996b. Social, Economic and Institutional Impacts of Aquacultural Research on Tilapia. The PD/A CRSP in Rwanda, Honduras, the Phillippines, and Thailand. Research Development Series 40. Auburn, Alabama: International Center for Aquaculture and Aquatic environments, Auburn University.

New, M.B. 2003. "Responsible Aquaculture: Is this a Special Challenge for Developing Countries?" Keynote paper presented at the World Aquaculture Society 2003 in Salvador, Brazil. Retrieved 15 July, 2003. Baton Rouge: World Aquaculture Society. (http://www.was.org/main/FrameMain.asp).

ODI. 1999. "Aquaculture, Key Notes." London, U. K.: Overseas Development Institute. Retrieved April 7, 2005. (http://www.keysheets.org/green_4_aquacult_rev.pdf).

Pérez, Hugo A. 1999. "Estado de la Acuicultura Rural en Pequeña Escala en Centroamérica." Paper presented at the Workshop ARPF, 9-12 November, Temuco, Chile: FAO-Universidad Católica Temuco. Retrieved March 2004. (http://www.red-arpe.cl/document/doc_05.pdf).

PD/A CRSP. 2002. Latin America and the Caribbean Regional Expert Panel Meeting Report. February 1, San Diego, California. Corvallis, Oregon: Aquaculture CRSP. Retrieved May 31, 2005. (http://pdacrsp.oregonstate.edu/pi/LAC_Expert_Panel_Report.pdf).

Phelps, Ronald and T.J. Popma. 2000. "Sex Reversal of Tilapia." Pp. 34-59 in *Tilapia Aquaculture in the Americas Vol. 2,* edited by B.A. Costa-Pierce and J. E. Rakocy. Baton Rouge: World Aquaculture Society.

Popma, T.J. and B.W. Green. 1990. Sex Reversal of Tilapia in Earthen Ponds. International Center for Aquaculture Research and Development Series 35. Auburn, Alabama: Auburn University.

Rivera, W.M. and W. Zijp. 2002. Contracting for Agricultural Extension. International Case Studies and Emerging Practices. New York: CABI Publishing.

Rogers, Everett M. 1995. Diffusion of Innovations. Fourth Edition. New York: The Free Press.

Rogers, Everett M. and R. Burdge. 1972. Social Change in Rural Societies. Second Edition. New York: Meredith Corporation.

Rondinelli, Dennis A. 1976. "Why Development Projects Fail: Problems of Project Management in Developing Countries." *Project Management Quarterly* 8:10-15.

Rossi, Peter H. and H. E. Freeman. 1993. Evaluation. A Systematic Approach. 5th Edition. Newbury Park, California: SAGE Publications, Inc.

Stickney, Robert R. 2005. "Tilapia Update 2004." *World Aquaculture* 36(1):19-21

Tanaka, Willy K. 2003. "Análisis Económico de la Producción de Tilapia en Jaulas en el Lago de Yojoa, Honduras." Tesis para obtener el grado de Ingeniero Agrónomo. Zamorano, Honduras: Panamerican Agriculture School.

Trejos, Elizabeth. 2003. Income, Food Security, and Poverty Reduction: Case Studies of Small-scale Aquaculture Producers in Santa Barbara, Honduras. Msc. Thesis, Agricultural Economics and Rural Sociology Department. Auburn Alabama: Auburn University.

Triminio Meyer, Suyapa. 2001. Report of the PD/A CRSP Aquaculture Stakeholders Meeting. August 21 Tegucigalpa, Honduras. Mimeo. Zamorano, Honduras: Panamerican Agriculture School.

UNDP. 2000. Human Development Report 2000. New York: Oxford University Press.

UNDP. 2004. Human Development Report 2004. New York: United Nations Development Program. Retrieved May 31, 2005. (http://hdr.undp.org/reports/global/2004/).

Van den Ban, A.W., and H. S. Hawkins. 1996. Agricultural Extension. Second Edition. Oxford: Blackwell Science.

Vandergeest, Peter, M. Flaherty and P. Miller. 1999. "A Political Ecology of Shrimp Aquaculture in Thailand." *Rural Sociology* 64(4): 573-597.

Verma, Brahm P., E.W. Tollner, D.E. Meyer, and J.J. Molnar. 2002a. "Regionalizing Training and Technical Assistance for Nongovernmental Organizations." *Twentieth Annual Administrative Report.* Corvallis, Oregon: Aquaculture CRSP. Retrieved July 3, 2005. (http://pdacrsp.oregonstate.edu/pubs/admin/admin_20/20ar_toc.html).

Verma, Brahm P., E.W. Tollner, D.E. Meyer, and J.J. Molnar. 2002b. "Institutionalizing Web-based Information Systems for Tilapia Culture in Latin America." *Twentieth Annual Administrative Report.* Corvallis, Oregon: Aquaculture CRSP. Retrieved July 3, 2005. (http://pdacrsp.oregonstate.edu/pubs/admin/admin_20/20ar_toc.html).

Villacis D., Fausto. 2004. "Determinación de la Densidad Optima de Biomasa de Alevines de Tilapia (*Oreochromis niloticus*) para su Transporte en Bolsa Plástica." Tesis para obtener el grado de Ingeniero Agrónomo. Zamorano, Honduras: Panamerican Agriculture School.

Willson, Douglas C., M. Medard, C.K. Harris and D.S. Wiley. 1999. "The Implications for Participatory Fisheries Management of Intensified Commercialization on Lake Victoria." *Rural Sociology* 64(4):554-573.

Zimdahl, Robert L. 2003. "The Mission of Land Grant Colleges of Agriculture." *American Journal of Alternative Agriculture* 18(2):103-115.