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9. ABSTRACT

Summarizes the on-site investigations into the potential of tropical fish culture in the Santa Cruz and Alto Beni regions of Bolivia. Each region is described in detail as to climate and topography, fish culture potential, fish culture project proposal, recommended culture fish, ecological impact, Bolivian participation and training, and USAID participation. Recommendations for the San Julian colonization project are: (1) a limited stocking program utilizing Tilapia nilotica to test if this fish significantly increases roadside pond fish production and is utilized by the rural population; (2) contacts with the construction company building a new access road to inform them on the proper construction of roadside ponds within the economic limits of the present contract; (3) a full-time fish culture specialist be made available for 2-3 years, to orientate interested parties in proper fish culture techniques and research maximization of fish production in roadside ponds and consumer preferences; (4) provision for training selected people in net construction and usage; and (5) funding for practical training in pond construction and tilapia culture for selected Bolivian field technicians. Similar recommendations for the Alto Beni area included a request for funds for the construction of small family-sized fish ponds to demonstrate proper pond construction and tilapia culture techniques associated with farm animals.

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SURVEY OF THE FISH CULTURE POTENTIAL IN THE SAN JULIAN AND ALTO BENI COLONIZATION PROJECTS OF BOLIVIA

by

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1.0 INTRODUCTION

From October 15, 1977 to November 3, 1977, the author traveled in the Santa Cruz and Alto Beni regions of Bolivia investigating the potential of tropical fish culture in these areas at the request of USAID/Bolivia. Eight days were spent in the Santa Cruz region in East Central Bolivia. The principal area of interest was the San Julian colonization project located about 100 km from Santa Cruz in an area between the Rio Grande and Rio San Julian, both tributaries of the Amazon river.

Five days were spent in the Alto Beni region in West Central Bolivia, investigating fish culture potential in this colonization area located in the upper Amazon river basin. The rest of the author's time was spent in La Paz, talking with representatives of the National Institute of Colonization (INC) and USAID officials and writing preliminary recommendations for implantation of a proposed fish culture program.

This report is a summary of the author's impressions on the potential of tropical fish culture in the above mentioned areas within Bolivian colonization projects.

2.0 SANTA CRUZ AREA - SAN JULIAN COLONIZATION PROJECT

2.1 Description of Area and Climate

The San Julian colonization project is located about 100 km northeast of Santa Cruz in an area of 200,000 ha between the Rio Grande and Rio San Julian. The area is flat and drainage is poor. The soils are considered good for agriculture in most areas and appear to have sufficient clay content to be satisfactory for fish pond construction. The only surface water that the author observed were rivers and several low swampy areas. No gravity flow water sources were observed and water for fish culture would have to be pumped or captured from rain runoff. The rainy season extends from November to April but rarely does it not rain in all 12 months of the year. The average yearly rainfall is about 150 cm (60 in). The Santa Cruz area is considered to have a subtropical to temperate climate. The sixteen-year (1960-1975) average annual maximum, minimum, and average temperatures are 29.6°C., 18.8°C., and 24.2°C. respectively. Where the virgin tropical forest has been cut back in many areas modern agriculture is being employed, in fact, the Santa Cruz area is considered the bread basket of Bolivia. Agricultural wastes to be used as fish feeds are available on a limited scale at this time.

2.2 Description of the San Julian Colonization Project

The San Julian colonization project is located on 200,000 ha of land donated by the Bolivian government. The project is coordinated by the National Institute of Colonization (INC) located within the Ministry of Agriculture with economic and technical assistance given by USAID.

INC field headquarters are centrally located within the colonization project. Each native lowland or mountain family is relocated within the colonization project on 50 ha of virgin tropical forest. First year colonists are located on 2 ha of cleared land which serves as village or community center. This cleared land contains a communal well and two buildings for communal sleeping and one building which serves as the kitchen and dining hall. Salaried colonists with a number of years of colonization experience teach the new colonists the techniques of land clearing, tropical agriculture, gardening and house building. The Bolivian government provides new colonists with seeds, fruit trees, a total diet for the first four months, and a supplementary diet for five additional months. While older colonists usually have livestock around their houses, new colonists' principal source of animal protein is wild game. Chain saws for land clearing and seed planters are loaned to the colonists on need. Colonists, with the aid of their neighbors, are expected to build simple housing and sanitary facilities, clear and plant several hectares of their 50 hectare plots, and organize a community cooperative within the first months of relocation. Basic health services, nutritional and sanitary education, and orientation in starting of consumer cooperatives (food and clothing) is offered by low paid, young foreign and Bolivian workers that live amongst the colonists. Besides a communal vegetable garden, colonists plant corn, beans, rice, soybeans, peanuts, and fruits.

The first years of colonization are extremely difficult and rigorous for these people. Families often arrive at their new homes with

only what they can carry and enough money to buy only the barest necessities. Families from the mountain regions must confront a new climate, environment, agricultural and food habits, as well as new diseases. Yet, families willingly accept the uncertainty and rigors as they have a chance to make a better life for themselves. At this time, there are approximately 3,100 people composing 977 families settled in the colonization area.

2.3 Fish Culture Potential

Even though the San Julian colonization project is located near two large rivers, fish are not readily available to the people in the project. The commercially valuable fish caught from the rivers by commercial fishermen are transported to Santa Cruz and other large cities where the fish are quickly sold for 25 to 30 pesos[1/] a kilogram out of the economic range of most colonists. The colonists, themselves, have little fishing tradition and the author saw no nets or castnets in use. The people have little knowledge of the fabrication, repair, and use of nets to catch fish for home consumption. The little fishing done by the colonists is by hook and line. It appears that the colonists will eat fish if they are made available at reasonable prices or the people are taught to catch or raise fish for themselves.

Other than the rivers, the author saw no other manageable natural bodies of water. Several weed-choked swampy areas were visited but the utilization of these swamps for commercial fishing or fish culture was limited. Natural depressions or valleys are available for the construction

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[1/] Approximately 20 pesos equal $1.00 U.S.

of small reservoir ponds. However, this type of construction would entail the use of heavy equipment to clear the basin area of trees and vegetation and to build the dam. Given the conditions in the colonization project at the present, the use of heavy equipment for reservoir pond construction does not appear to be practical.

The best potential for fish culture within the colonization project is the many roadside ponds used for livestock and, in some cases, human water needs. A new, well constructed earthen road has recently been inaugurated within the project. This has made access to some areas of the colonization project much easier, especially during the rainy season. Earth fill to construct the road was taken from the road margin leaving large bar pits. These bar pits are filled by rain runoff and serve as livestock watering ponds. The construction firm contracted to build the road purposely built these roadside ponds so, that in most cases, the ponds are well constructed and can be used for fish culture. They are undrainable by gravity although pumps could be used for draining if needed. The author's visit to the area was at the end of a vary atypical dry season. There had been an unusual amount of rain during the dry season. All the ponds seen by the author still held water, and most of the ponds were close to full. As these ponds are at the most two years old, it is not known how the water level will fluctuate during a normal dry season. Most pond water was very turbid as a result of dirt washed into the ponds from the new road. It is felt that during a normal dry season and as the sides of the road become grassed, turbid water should become less prevalent except during the rainy season. The author observed, especially in the

older colonization areas, that domestic livestock, cattle, pigs, and ducks congregated around these ponds. The manures deposited by these animals were enriching the pond waters as evidenced by algal blooms and scums. Because of transport and economic problems, agricultural wastes would not be available initially for feeding fish. Feeds, if used, would be limited to the colonists' excess agricultural production.

The water quality in these ponds appears to be excellent for fish culture. PH readings taken by color comparison in the afternoon from a number of ponds ranged from 8.4 to 9.6. Ground water in the area is known for its high mineral content, mostly magnesium.

Most of the ponds appeared to be fishless and breeding only mosquitoes. The author observed only two old ladies fishing with hook and line during his three-day visit to the area. Their catch contained a predatory mud fish, Hoplias sp. and an unidentified catfish. Using a castnet the author was unable to catch any fish in a number of ponds except one. In this pond, the author caught about 20 small catfish, Callichthys sp. It was obvious from the ease that the author caught these catfish, that the pond was being under-utilized.

The author counted 148 ponds in a 40-kilometer stretch of road. The average pond size was estimated at 1,000 m^2 so that there are a calculated 14.8 ha of water that can be utilized at this time. USAID is also financing the construction of another 100-km access road for the area. Instructions have already been given the road building firm on the proper construction of roadside ponds so that they can be utilized for fish culture. By rough calculation, we can estimate about 4, 1,000 m^2 ponds

for every kilometer of road. This will result in about 40 ha of useable water along 100 km of road. This will give the Bolivian government over 50 ha of roadside ponds, that are being under-utilized at the present, to produce fish in an area where animal protein deficiency is high. The addition of fish to these ponds will also aid in the control of mosquito larve.

The natural productivity of these roadside ponds will vary depending on the water quality and domestic animal wastes deposited in and around the pond. From data collected at the Pentecoste fish culture research station using tilapia as a culture fish and having similar water quality conditions as the San Julian region, Table I below will give a rough estimate of potential fish production from the roadside ponds.

TABLE I

Estimated fish production from
roadside ponds in the San Julian region

	per ha/yr	per 50 ha/yr
Natural production (No manures or feeding)	200 kg - 400 kg	10 tons - 20 tons
Moderate manuring (uncontroled manuring by domestic animals)	1,000 kg - 2,000 kg	50 tons - 100 tons
Heavy manuring (control application of manures)	3,000 kg - 5,000 kg	150 tons - 250 tons
Moderate feeding	3,000 kg - 5,000 kg	150 tons - 250 tons
Heavy feeding	5,000 kg -10,000 kg	250 tons - 500 tons

A considerable amount of fish can be produced in these roadside ponds varying with the technic used. Even without feeds or manures, significant quantities of fish can be produced to help feed a protein hungry population.

2.4 Fish Culture Project Proposal

The author wants to make it understood that many problems will have to be solved before maximum utilization of roadside ponds can be realized. Also, initially, given the low economic standard of living of most of the colonists, the lack of government infra-structure and trained technicians in fish culture, that miracles should not be hoped for overnight. An aquatic resource exists that is under-utilized at the time and can be rationally exploited to produce fish for home consumption.

Research should be carried out not only to find methods to maximize fish production in roadside ponds, but to test consumer preference as to size of fish desired. A simple, but efficient government hatchery and distribution system will have to be organized to produce and stock fish in the roadside ponds. The ideal location for this hatchery would be at the INC headquarters where land, water and human resources are available. Colonists will have to be instructed in the fabrication, repair, and utilization of nets so that the ponds can be properly fished. Other problems that will have to be confronted and solved are the problems of pond ownership and the control of fishing so that the fish are allowed to grow and the ponds are not over-fished.

The rational use of roadside ponds has fish producing implications not only for the San Julian colonization project, but for all the tropical world where road building programs are in progress. The construction of roadside ponds is easily accomplished with proper planning without increasing road construction costs. Demonstrating the fish producing capacity of these bodies of water could be an aid to any developing tropical country to start a similar program.

2.41 Culture fish

The author suggests the use of Tilapia (Sarotherodon)[2/] nilotica as the fish to be cultured in the roadside ponds. The fish already exists in the Alto Beni region so Tilapia nilotica would not be a new introduction to Bolivia. The Nile tilapia is easy to reproduce and resistant to handling, disease, and poor water quality. The fish grows well using a wide range of animal manures and agricultural wastes as feeds. The flesh of the Nile tilapia is excellent with no intermuscular bones to lower the quality. The major drawback to the use of Tilapia nilotica is their uncontroled reproduction in culture ponds resulting in an overpopulation of stunted individuals.

2.411 Ecological impact

The introduction of any new plant or animal should always be done with care and study. The use of Tilapia nilotica in the San Julian region will mean introducing the fish to a new area. The author suggests that

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2/Tilapia nilotica has been recently reclassified Sarotherodon nilotica. For simplicity's sake, the author will continue using Tilapia nilotica.

Tilapia nilotica be introduced to a pond located at INC headquarters to reproduce and fingerlings then stocked into a few selected roadside ponds to see how the fish acclimates to its new environment. Cool winter water temperatures may have an effect on the growth and health of Tilapia nilotica. The acceptance of tilapia by the people should also be observed. If research performed by a USAID supported specialist demonstrates that Tilapia nilotica significantly increases the fish production of roadside ponds and that there is no resistance to the fish by the colonists, then widespread stocking of the fish can begin.

Another species of tilapia, Tilapia rendalli, has been present in the Amazon basin for over 15 years. This fish is known to be present in the Amazon basin of Brazil, Bolivia, Peru, Equador and Colombia. At this time, no case of environmental contamination is known to the author in the free flowing rivers of the Amazon basin. Tilapia rendalli does not appear to compete well with the Amazon fish fauna.

Tilapia nilotica has already been introduced to the Amazon basin in Brazil, Bolivia, and Equador. It is the author's opinion that Tilapia nilotica will cause little problem to the natural flowing waters of the Amazon river and its tributaries. The potential for raising fish and, thus, food production capacity of under-utilized waters through fish culture should far outweigh any negative influence on the environment.

At this time, in the majority of cases, aquaculture in South America is being done with fish exotic to the continent because of a lack of knowledge concerning the culture potential of South American fishes.

Thus, the only alternatives to using an introduced fish (tilapia) for culture in roadside ponds is to set up a more elaborate program to research Bolivian fish or forget about raising fish in roadside ponds until a native fish is found.

2.42 Research priorities

The initial stage in the use of the roadside ponds should be marked by the simplicity of the culture system. The goal should be to stock as many ponds as possible if research demonstrates the feasibility of the program, so that the natural productivity of these waters is used to produce useable animal protein. Expectations should not be too high as only about 200 kg to 400 kg per year can be produced by natural productivity alone. In the older colonization areas, use of wastes from domestic animals should be encouraged. This stage will include the training of Bolivian biologists and colonists in the art of fish culture and harvest.

The second stage will be initiated as the colonists and Bolivian biologists become more confident of their fish culture ability and the colonization region becomes more developed. This stage will entail the rational use of domestic animal wastes to increase the production of the roadside ponds. Small tilapias will still be cultured but more advanced and progressive colonists may begin to raise large fish for sale.

The third stage will be reached as raising economic standards modify the needs and wants of the colonists and permit them to turn from subsistance culture to commercial culture. This stage may never be reached if social, political and economic factors affecting the colonization project

do not provide the colonists with sufficient infrastructure, technical assistance, organization, or economic conditions to culture fish at this level. The third stage will be the culture of a large fish with intensive manuring and feeding for home or market consumption. Modern tilapia culture methods will be used to raise the production potential of the roadside ponds to their highest level. It may take 10 to 15 years to reach this stage. Research should be done with these future goals in mind. Research testing various levels of manuring and feeding should be carried out. Methods of controling tilapia reproduction should be tested to determine if it is feasible to raise a large fish. If fish culture in the area progresses to the advanced stage, then basic data will be available to orientate biologists and colonists.

2.421 Ponds that hold water year round or ponds that dry up

Depending on the water retention time of these roadside ponds determined from research studies, two systems of culture can be used.

If the ponds hold water year round, they can be stocked heavily initially and then moderately if needed in the future. Fishing would be prohibited allowing the tilapias time to grow and reproduce. After the tilapias are reproducing, controled fishing would be allowed so that a fixed yearly production, as determined from research, would be harvested. The idea is to have a reproducing population that yields a continual maximum yearly production through controled fishing so that continual stocking is not necessary. This system entails the training of the colonists in net and/or trap fabrication and use to harvest the fish. The colonists will have to be educated in the need for controled fishing and some type of enforcement may be needed.

If the ponds dry up during the dry season, a second culture system will have to be used. Ponds will have to be stocked on a yearly basis requiring a more sophisticated hatchery and transport system. Fishing will have to be prohibited in the ponds while the fish are growing. As the pond water recedes, colonists are allowed to fish by any means available. The harvest will be total as the pond dries up. The need to teach the colonists fishing technics with nets and traps will not be so great as the tilapias can be harvested by hand if necessary.

It is possible that both culture systems will have to be applied depending on the amount of rainfall during the year and the water holding capacity of each pond determined by pond depth and infiltration rates. Research concerning growth and production of Tilapia nilotica at various stocking rates will have to be performed. This research will be based on the water retention time of the roadside ponds.

2.422 Small fish or large fish

As the author mentioned previously, the principal disadvantage to using tilapia as a culture fish is their uncontroled reproduction in culture ponds. This results in many small fish with low market value. However, in this case, the fish are for home consumption where size may not be a vital factor. Research testing the size preference of fish to be consumed by the colonists will have to be performed. If the colonists will accept a small fish (20 g to 100 g) then the culture system to be used will be greatly simplified. Ponds can be stocked with pure Tilapia nilotica and the fish allowed to reproduce. By controled fishing, small

fish can be continually removed giving a constant source of fish. It is the author's impression and experience that small fish will be accepted by the new colonists as their standard of living is extremely low. As the colonists' economic standards increase, their needs will change and a larger fish may be needed. If a larger fish is needed, (100 g +), then the culture system will demand a higher level of technology. There will be a need to introduce a predatory fish to the pure tilapia culture or stock only male fish to reduce or eliminate tilapia reproduction allowing the stocked fish to grow to a larger size. This will require a more sophisticated hatchery system and a higher level of culture knowledge by Bolivian biologists and colonists. Research examining the potential of the monosex culture of male Tilapia nilotica and the culture of Nile tilapia with a local predator should also be performed.

It is the author's hope that a small fish will be accepted by the colonists at least initially allowing the Bolivians to see the fish producing potential of these roadside ponds. Fishery technicians and colonists will also have a chance to gain basic knowledge of fish culture before a more sophisticated culture system is employed.

2.423 Water quality

It is not known what effect flooding and the resulting muddy water and siltation will have on fish production. Research will have to be performed to test the effect of these physical factors on fish production.

2.43 Technical assistance

The use of roadside ponds for fish culture is a promising area of food production for all developing nations. Yet, very little is known of

the rational exploitation of this resource. To fully understand the potential and limitations of roadside ponds for fish production, there is a need for a planned series of experiments by a competent professional knowledgeable in the area of tropical fish culture. A fish culture research specialist should be contracted for a minimum of 2 years and preferably for 3 years to plan and carry out a research program. This foreign specialist will also be involved with the training of host country biologists connected with the project and aiding private individuals interested in raising fish in the Santa Cruz area. The contract specialist should live in Santa Cruz where he will be only a few hours from the San Julian colonization project. At the termination of the technical assistance contract, a scientific document will be written giving the results of the research performed and detailing strategy for the rational use of roadside ponds if feasible.

2.44 Bolivian participation and training

At this time, Bolivia has no facility available for training biologists in tropical fish culture and specifically, tilapia culture. Training will be needed for the Bolivian counterparts associated with the project. Training should be as practical as possible so that the Bolivian biologists will be able to perform the necessary functions needed to run the fish culture program after the termination of the technical assistance. Besides accompanying the foreign fish culturist on all research and fish culture activities, short-term training should be arranged in Brazil with the Centro de Pesquisas Ictiológicas administered by the Departamento Nacional de Obras Contra as Secas in Fortaleza.

2.5 Recommendations

I. Whereas, there now exists 150 useable roadside ponds totaling approximately 15 ha of water and an estimated 400 new ponds totaling 40 ha of water will be constructed within the next two years and the existing ponds are not being actively managed for fish production, it is recommended that:

a limited stocking program be initiated utilizing Tilapia nilotica to test if this fish significantly increases roadside pond fish production and if this fish is utilized by the rural population.

It is cautioned that no widespread stocking program with Tilapia nilotica be undertaken until the positive effects of stocking this fish can be proved.

II. Whereas, no Tilapia nilotica now exist in the San Julian area and a center for reproduction of this fish will be needed, it is recommended that:

one or two ponds be immediately constructed at the INC headquarters in San Julian so that Tilapia nilotica can be introduced as soon as possible to the area to allow them to reproduce.

III. Whereas, well constructed roadside ponds have a potential for increasing fish production in the San Julian colonization project, it is recommended that:

contacts with the construction company that is to build the new 100 km access road be immediately initiated and informed on the proper construction of roadside ponds within the economic limits of the present contract.

IV. Whereas, there is a lack of trained fish culture personnel in the Santa Cruz area, the proper management of roadside ponds to maximize fish production is unknown, the proper use of roadside ponds to produce fish has potential on world wide basis, and consumer preferences and marketing studies on fish have never been carried out, it is recommended that:

a full-time fish culture specialist be made available for a 2 or 3 year period in the Santa Cruz area to orientate interested parties and INC staff in proper fish culture techniques and carry out a research program on the maximization of fish production in roadside ponds and consumer preferences.

V. Whereas, the people in the Santa Cruz area have limited fishing tradition and knowledge in the fabrication and repair of nets and traps, and the harvest of permanent roadside ponds will be most easily accomplished with the use of nets and traps, it is recommended that:

a provision be made for training selected people in net construction and usage either by knowledgeable host country nationals or specialists from outside of Bolivia.

VI. Whereas, Bolivia has no training facilities in tilapia culture, it is recommended that:

funding be made available for sending selected Bolivian field technicians and colonists for short-term practical training in pond construction and tilapia culture at the Centro de Pesquisas Ictiológicas administered by the Brazilian federal agency, the Department of National Works against the Droughts (DNOCS) in Fortaleza, Brazil.

3.0 ALTO BENI AREA - ALTO BENI COLONIZATION PROJECT

3.1 Description of Area and Climate

The Alto Beni area is located about 350 km from La Paz. Terrestrial access is by a mountainous, dirt road that is difficult to transit during the rainy season. The part of the Alto Beni visited by the author would be considered foothills of the Andes, the terrain being very hilly. Year round water sources are common as many springs, streams, and rivers are found in the area.

The climate is tropical and the average yearly rainfall is about 1500 mm spread throughout the year.

The Alto Beni region is a colonization project administered by the National Institute of Colonization. USAID has no direct role in this project. Details of the colonization project are not well known by the author. However, this area has been open for colonization for many years and there are many established families in the area. Principal crops are cacao, tea, watermelon, rice, corn, fruits, and vegetables. Domestic animals for family use are common. Subsistance farming is the principal activity in the area.

There is no rural electricity and basic communal services such as education and health are minimal. The standard of living of the colonists is low.

3.2 Fish Culture Potential

Despite the presence of a large river, the Beni, fish for consumption are scarce. The people have little fishing tradition and the fabrication

and use of nets is not a common practice. Fishing is done mainly by dynamite and hook and line. When available, fish can be readily sold and the population appears to appreciate fish.

The Alto Beni region visited by the author has excellent potential for small, family ponds. The soils are heavy clay and many gravity water sources are available. The region is not good for larger commercial fish culture operations because of the hilly topography which does not permit the building of large pond complexes. Even reservoir ponds would be difficult to build because of the steep stream valleys.

The water quality is good for fish culture. Flowing water in the area had a pH of 7.6 - 7.8, hardness of 100 ppm and total alkalinity of 85 ppm as measured by a Hach water testing kit.

Very few agricultural wastes are available to be used as fish feeds. Animal manures on a commercial scale are also limited. However, manures from family domestic animals are available for fertilizing small family ponds.

Access to many colonized areas is very difficult. Except for those colonists living along the main road, access in outlying areas is by motorcycle and foot making frequent visits by biologists difficult.

The best potential in the area for the immediate future appears to be in subsistance fish culture on the family level.

3.3 Existing Fish Culture Project

The Methodist Church is involved in promoting fish culture in the Alto Beni region. A Methodist preacher has constructed 4, 500 m^2 earthen

ponds in the village of Sapacho to serve as a community hatchery. The ponds are well built but the water source is precarious in that it is being lifted about 10 m by gasoline pump from a near by stream. If the pump should break down, there will be no way to get water to the ponds. The Methodist preacher and his son spent 5 days with the author in Fortaleza studying tilapia culture. With the permission of the Bolivian government, Tilapia nilotica was carried from the Pentecoste research station and successfully introduced to the fish ponds in Sapacho in May of 1977.

Unfortunately, when the author visited the Sapacho hatchery, the minister and family were in the U.S. Net samples of the ponds showed that the tilapia were healthy and reproducing. The fish were being fed rice bran and animal manures by a local villager.

The author visited a number of areas where ponds were to be built, were in the process of being constructed, or were already constructed by area families. All the ponds to be constructed or already constructed were dug by hand and were small in area. Three of the ponds had already been stocked with tilapia.

Interest in fish culture is very high in the area. Attendance to a slide show and simple fish culture short course offered by the author on short notice was good. A large number of local villagers have attended a short course offered by the minister to stimulate and inform the villagers to raise fish.

Located across the Beni River at kilometer 73 on the main road to La Paz, is a vocational school financed by the Ministry of Education and administered by the Methodist Church. The school has no connection with

the fish culture project except to give material and logistic support when needed. There is a small agricultural and animal husbandry experimental station located at the school. Several of the school's teachers have received one-year agricultural training in the U.S. The school is an excellent location to establish a small scale tilapia culture project associated with domestic animals to be used for demonstration and teaching purposes.

Despite the high interest by colonists and the dedicated work by the Methodists to aid the colonists, the author fears that the Alto Beni fish culture project has a high chance of failing as have so many subsistance fish culture projects throughout the world. There is a critical lack of trained fish culture staff with understanding of tilapia culture. The tilapia is an excellent culture fish but an understanding is needed of its strengths and limitations. The author feels that the colonists have unrealistic hopes of raising a large tilapia in a small pond with no reproduction control and minimal feeding and manuring. The colonists have to be given realistic goals or their initial disappointment in a few small fish most likely will lead to abandonment of fish culture. Some type of study should be carried out to determine if the colonists will eat a small fish. If a small fish is accepted, then no type of population control is needed and the use of animal manures will greatly increase fish production. The colonists should realize that a small pond cannot produce many fish. A minimum pond area of at least 100 m^2 should be demanded from the colonists to make their efforts worthwhile in terms of fish production.

The author saw ponds being built in areas that were poorly selected increasing the chance of failure before the first harvest of fish. Ponds

were being built over a wide area making frequent visits by biologists difficult because of access and transport problems. Initially, frequent visits to the colonists' fish ponds will be needed to insure success. Unless more knowledgeable staff can be hired, initial fish culture projects should be limited to an area where frequent visits can be made.

There is no Bolivian government participation in this project. One local villager aiding at the fish hatchery is being paid by the minister. If the minister and his family should have to leave Bolivia for any reason, the fish culture project is doomed to failure for lack of government support. The colonists will be unable to continue the project both financially and technically for many years. There is a great need for Bolivian participation in the project.

3.4 USAID Participation

The author realizes that USAID has no direct participation in the Alto Beni area. Yet, fish culture is being initiated in the region and if properly carried out, can aid the colonists to improve their standard of living.

There is a need for a demonstration fish culture project in the area that can be visited by the colonists to see the proper way to raise tilapias. The ideal location for a demonstration project is at the vocational school at kilometer 73. However, the school will need financial assistance to build a few small ponds. USAID could give financial aid through its small project cash fund.

Technical assistance in fish culture is badly needed in the area. The same fish culture specialist involved with the San Julian project could make periodical visits to the Alto Beni area. The specialist could aid in the construction of the demonstration ponds, preparation of teaching materials, and give lectures to the students on fish culture technics. The fish culture specialist would also aid the Methodist Church in Sapacho reorganize and reformulate their goals so that a realistic family fish culture program can be extended to the colonists. Assistance can be given in the localization and construction of fish ponds and the culture of tilapia using domestic animals.

If the Methodist Church can convince the Bolivian government, most likely the INC, to participate in the fish culture program, USAID could provide financial assistance to give the Bolivian biologist short-term training in fish culture outside of Bolivia. Short-term training in tilapia culture can be obtained in Fortaleza, Brazil at the Centro de Pesquisas Ictiológicas.

3.5 Recommendations

I. Whereas, there now exists a good demonstration and teaching installation at Km 73 and interest in fish culture for family consumption is high in the area, it is recommended that:

funds be made available for the construction of small family-sized fish ponds to demonstrate proper pond construction and tilapia culture technics associated with farm animals.

II. Whereas, there is a limited number of trained fish culture personnel in the Alto Beni area, it is recommended that:

a trained fish culture specialist (can be the same specialist working in the Santa Cruz area) be made available for a 2 to 3-year period to orientate Bolivian field staff and colonists in proper pond construction and tilapia culture technics in the Sarracho and Km 73 areas. The fish culture specialist would also aid in the preparation of materials for distribution and presentation at the vocational school at Km 73.

III. Whereas, Bolivia has no training facilities in tilapia and rural fish culture, it is recommended that:

funding be made available for sending selected Bolivian field technicians for short-term practical training in pond construction and tilapia culture at the Centro de Pesquisas Ictiológicas administered by the Brazilian government in Fortaleza, Brazil.

IV. Whereas, the present American and Bolivian personnel have limited understanding of rural pond construction and fish culture technics, proper understanding of tilapia culture limitations and strengths, and consumer preference regarding fish for consumption, it is recommended that:

a) a meeting organized by the Methodist Church, Church World Service, Caritas Boliviana, INC, and/or USAID be held to reaccess the Sapacho fish culture project, reformulate goals, and make arrangements for permanent Bolivian staff to be present at the Sapacho fish reproduction center to oversee reproduction activities and orientate colonists.

b) the number of rural fish culture projects in the Alto Beni area be limited initially in number to those colonists that have the best conditions to raise fish and are easily accessable to the limited staff to allow them to work closely with these colonists to assure initial success.

c) that conditions be established and rigidly enforced that must be met by colonists before they receive fish to raise.

1. ponds are properly constructed and a minimum pond size limit be set
2. colonists have to demonstrate specific skills and understanding essential to tilapia culture
3. some farm animals must be raised in association with the tilapia to assure optimum production

d) efforts should be made to have a trained fish culture specialist knowledgeable in tilapia culture attend this meeting.

TABLE: Calculated Results of Tambaqui and Pirapitinga at 6 mos

Treatment[1/]	Tambaqui 10,000/ha	Tambaqui 5,000/ha	Tambaqui 5,000/ha + T. hybrid 5,000/ha	Pirapitinga 10,000/ha	Pirapitinga 5,000/ha	Pirapitinga 5,000/ha + T. hybrid 5,000/ha
Avg. initial wt.	23 g	25 g	25 g	28 g	30 g	32 g
Avg. initial wt. T. hybrid			18 g			20 g
Avg. wt. at 6 mos.	424 g	619 g	485 g	415 g	521 g	383 g
Avg. wt. at 6 mos. T. hybrid			245 g			261 g
Biomass/pond [2/]	148.4 kg	108.3 kg	84.9 kg	145.3 kg	91.2 kg	67.0 kg
Biomass/pond T. hybrid			42.9 kg			45.7 kg
Biomass total	148.4 kg	108.3 kg	127.8 kg	145.3 kg	91.2 kg	112.7 kg
Biomass total/ha	4,229 kg	3,087 kg	3,642 kg	4,141 kg	2,599 kg	3,212 kg
Conversion rate [3,4/]	1.39	1.41	1.59	1.48	1.43	1.69
Total conversion rate			1.1			1.0
Days of experiment	189	189	189	189	189	189
Growth/day	2.1 g	3.1 g	2.4 g	2.0 g	2.6 g	1.9 g

1/ All treatments are averages of 3 replicates

2/ 350 m^2 earthen ponds

3/ All treatments are fed 3% of the average biomass of tambaqui and pirapitinga

4/ Feed is a commercial, pelleted chicken ration with 18% protein