

**The Pond Dynamics/Aquaculture CRSP-Sponsored
Proceedings of the Third Conference
on the Culture of Tilapias at High
Elevations in Africa**

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For Anacllet, murdered in Rwanda, may we always remember your *joie de vivre*.

Proceedings of the Third Conference on the Culture of Tilapias at High Elevations in Africa

EXECUTIVE SUMMARY

This was the third conference of its kind to be held for Rwanda, Burundi and Kivu province in the east part of Zaire. High elevation was understood to be greater than 1,000 meters. During the conference, country reports were presented describing the extension service and providing technical data following a list of points included in the conference invitation. Technical papers on rice-fish culture and extension strategy were presented from Burundi. Papers on rabbit-fish culture, composting regimes, elevation-related tilapia production and tilapia-clarias polyculture were presented from Rwanda. Kivu province presented a paper on the Zaire Peace Corps fish culture sustainable extension service. Attendees included ministry personnel, university professors, FAO personnel, university students, Peace Corps volunteers, station managers, model farmers, extension and training specialists, and some trainees.

The organization and operation of the extension services in all three countries were compared. Fish culture extension has been assured mainly by Peace Corps volunteers in Zaire, with very few Zairian counterparts on hand. In Rwanda, although some Peace Corps volunteers have recently commenced activities in fish culture, Rwandese extension agents are responsible for all fish culture extension. Burundi is in the midst of re-vamping its fish culture extension

service. It previously relied on Peace Corps volunteers but now has funding to train its own extension agents. However, Burundi presently has a freeze on hiring for government jobs and has opted to use extension agents already working in other domains such as forestry. A very lively discussion of the advantages and disadvantages of each country's extension service took place. All three countries have active farmer training programs.

Fish culture techniques adapted to the climatic and social conditions of the high-elevation zones are: a longer growing cycle, use of larger fingerlings for stocking ponds, and smaller pond size. *Oreochromis niloticus* remains the fish of choice, given the lack of access to station-produced fingerlings and the low quality inputs available. Burundi reports higher yields from ponds below 1,300 meters, compared to those over 1,300 meters, but net yields do not seem to steadily decrease with elevation above 1300 m in any of the countries. However, "best production" is much greater in the lower elevation zones. Size of fish at harvest is somewhat greater, and amount of reproduction is less as elevation increases. Pond management and input levels still seem to be the most important factors to increasing pond productivity.

Recommendations made by the group of participants and a table of comparative data by country are presented.

EDITOR'S NOTE

KAREN L. VEVERICA

Although the conferences on high-elevation tilapia culture were initially held with the intention of consolidating technical information on production systems, participants at the third conference were more concerned with the constancy and sustainability of information systems for tilapia culture. At the time the conference was held, there were hints of what was to come but nobody would have suspected the scale of upheaval. Rwanda, after an extended war that began in 1990 and large-scale massacres of its population, is on very shaky grounds to recovery. Zaire has

encountered much internal unrest, triple-digit inflation rates and overall government dysfunction. Burundi has had several major changes in government and is teetering on all-out civil war. The Peace Corps programs were terminated in all countries; first in Zaire, then in Rwanda, followed by Burundi. The fisheries officers in Burundi and Rwanda have changed several times since 1991. Some of the people who attended this conference fell victim to the killings.

Currently, Rwasave Fish Culture Station is limping along, producing some fish and fingerlings. There are reports that farmers are still producing fish in Rwanda. It would be interesting to see the level of fish culture currently practiced by farmers in all three countries and how their under-

standing of tilapia production has fared in the absence of extension programs.

The initial intentions of this report were: (1) to initiate the publication of conference proceedings in the hope that future conferences will publish also; this report can provide the baseline of information upon which future conferences can build; (2) to contribute to the dissemination of information on techniques and expectations developed for tilapia culture at high elevations or in cooler environments and where inputs are severely limiting; and (3) to publish discussions on extension program strategies.

A more current reason for publishing this report is to maintain a record of fish culture activities and experiences in light of the loss of trained and experienced personnel. Therefore, even though much of the information on extension programs is no longer current, it may be the only existing record.

Many presentations were made in French, which I translated to English. Country reports are included in their entirety. Abstracts of the technical presentations and associated graphs and tables follow the country reports. Only one technical presentation abstract was not available (Rice-fish Culture by M. Todd Uhlir).

Secretaries Eugene Rurangwa and Carrie Henderson helped take notes on the discussions of extension strategies and conclusions. Venantie Mukasikubwabo and Analet Gatera assisted in organization. The labora-

tory staff of the Rwasave station managed the refreshments and set up the conference room. Nathanael Hishamunda helped with some of the translations. Robyn Hearn of Auburn and Danielle Clair of OSU assisted in editing. This publication was designed by Terry Rodriguez.

The third conference was financed in part by a special grant from the Pond Dynamics/Aquaculture CRSP for programs to enhance technology transfer. The UNR kindly provided housing and logistic support as well as allowing the Rwasave Fish Culture Station to host the conference.

Explanation of Terminology

An "are" is 100 square meters or 0.01 hectare. It is the usual measure for pond surface area, because most ponds are one to four ares. Extensionists realized that speaking of yields in terms of kilograms per hectare confused farmers into thinking they would get tons of fish from their small ponds. The term "productivity/production" is used for net annualized fish yield. It is measured in kilograms per are per year or kilograms per hectare per year. This usually includes any reproduction. Because a production cycle from stocking to draining is quite variable, ranging from four to 16 months, extensionists in these zones discuss yields extrapolated to one year as a basis for comparison.

Opening Remarks by the Rector of the National University of Rwanda

Mr. Vice-Rector, Mr. Dean of Agronomy, and delegates of the conference, it is a great honor and privilege to have been invited to open the third conference on tilapia culture at high altitudes. I take this occasion to thank you for having responded to our invitation and to welcome you and wish you a good stay with us at the Butare campus of the UNR, College of Agronomy, whose fish culture station of Rwasave is hosting the conference.

The Rwasave Fish Culture Station is a research center for aquaculture attached to the College of Agriculture of the UNR and was created in 1983 with the collaboration of an American university, Oregon State University. The objectives and mission assigned to this station are: first, carry out fundamental and applied research in aquaculture and particularly fish culture in collaboration with other institutions of learning or of research interested in this domain; second, facilitate teaching and training in aquaculture; third, extend appropriate fish culture techniques; fourth, produce fingerlings to meet the station's needs and to satisfy demands of the farmers; fifth, demonstrate the integration of fish culture with animal husbandry and agriculture extendible to the rural sector; sixth, produce fish for the market to satisfy the nutritional needs of the population in the Butare area. The results attained in meeting these objectives are encouraging.

Actually, some of the ponds at the station date back to 1950 and were used by the agriculture school of the Groupe Scolaire Officiel de Butare, formerly called the Groupe Scolaire of Astrida. At about 1980, the station was in a state of abandon. It was renovated in 1984 after having been ceded to the UNR and with the financial intervention of the European Economic Community (61,100,923 Rwanda francs) The station presently covers 20 hectares, 8.3 of which comprise 71 ponds containing Nile tilapia or *Clarias gariepinus*. To optimize economic returns, the station has integrated the raising of farm animals such as swine, chicken, goats, sheep and ducks with the raising of fish.

The station has had the privilege of receiving researchers from many American and European universities. It is honored today with the presence of researchers from the economic community of the Great Lakes countries.

It is my earnest wish that the discussions you will have and the experiences you will share, the ideas you develop, the recommendations and conclusions you reach, will contribute to the resolution of certain problems that our three countries have in the area of fish culture. And it is with this wish that I declare the work of the third conference on tilapia culture at high altitudes to be open.

THIRD CONFERENCE ON TILAPIA CULTURE AT HIGH ELEVATIONS IN AFRICA

Summary of First and Second Conferences

KAREN L. VEVERICA AND EUGENE RURANGWA

The first conference was organized with the intention of discussing the different techniques for raising tilapias at high elevations developed by the technicians, extension agents and farmers. The fingerling production problem was the most important, followed by the lack of information on the potential productivity in the high elevation zones.

The first conference was held at Gihindamuyaga, Rwanda, from Feb. 17-19, 1986, and was organized by the National Fish Culture Project under financing from USAID. The chief advisor for fisheries and fish culture from Burundi, Antoine Kiyuku and the coordinator for the Family Fish Culture project in Kivu, Citoyen Kivimpi, and Peace Corps volunteers working in Burundi and Kivu participated. Seventeen conclusions and recommendations were made at the end of the conference.

The second conference was held in Bujumbura from February 21-22, 1987. Much progress had been made during the year between conferences in the development of fish culture in Burundi and Rwanda and in the gathering of data in all three zones. The fingerling supply problem no longer seemed a major constraint. Some specific techniques for tilapia production at high elevations had been refined and some good net yields were observed in all three zones. However, there remained some areas in which information was lacking.

During the four years that have passed since the last conference, all countries have witnessed great changes in administration, personnel changes, the start of some projects and the end of others and second phases or extensions of some, and a continuing collection of pertinent technical data. The Rwasave fish culture station has sought to answer some of the questions posed during the first two conferences. This is our attempt to present some of the information we have and to exchange ideas on tilapia production and on extension.

DISCUSSION

Q: What were some of the recommendations made in Bujumbura?

A: There was nothing published from either of the two conferences. I have some notes from the first conference's conclusions but have nothing in my files from the second conference except an article from the CRSP Aquanews written by Boyd Hanson and Felicien Rwangano. As I recall, some time was taken by an FAO consultant trying to encourage *Macrobrachium* (fresh water shrimp) production trials. One very interesting recommendation was to establish a regional research center. Rwasave station was selected as the best site because it was already in operation as a research center.

Q: What has been the impact of the research center on fish culture, is the investment worth it and how can we get the funds? Will these proceedings be published and available for worldwide distribution?

A: It takes quite a while to get a research station going and to train the

laboratory and field staff. We hope the European Economic Community, the Belgian government and the USAID-funded Pond Dynamics CRSP will be able to make a significant contribution to this end. It will only be worth it if we can maintain contacts with the extension service and with the rural sector and collaborate with other countries. This conference is an attempt to continue the outreach efforts of Rwasave station. We have a small allotment set aside for publication of these proceedings.

CONCLUSIONS AND RECOMMENDATIONS MADE AT THE FIRST HIGH ELEVATION TILAPIA CONFERENCE, 1986

Conclusion: Due to the unique conditions of the three countries participating in this conference, record keeping should be standardized.

Recommendation: (1) Terminology should be compatible; (2) Participants should immediately begin using agreed upon standards for temperature, water chemistry and pond area measurements; (3) Efforts need to be increased to establish a solid data base for such items as biological and climatic data, length/weight to age relationships, and socio-economic effects.

Conclusion: *Tilapia nilotica* (*Oreochromis niloticus*) should be our fish of culture.

Recommendation: Organized studies should be directed towards gaining more information on: (1) Effect of fingerling size and age on production; (2) Effects of stocking density on production, harvest size and age at maturity; (3) Best reproduction system to maximize and/or minimize fingerling production; (4) Compost applications and quality as it affects production; and (5) Pond configuration as it affects production and reproduction.

Conclusion: Fertilization is our major management tool.

Recommendation: Find out the best kinds of compost.

Conclusion: Supplementary feeding is secondary due to limited availability of food.

Recommendation: (1) Examine available agricultural by-products, new products explored by farmers, and ways to make these products available; and (2) Efforts need to be made toward eliciting a feeding response from fish receiving low quality feeds.

Conclusion: Integration of aquaculture and other farm activities is important to maximize land and water use.

Recommendation: Elaborate on this idea as much as possible, considering land restraints.

Conclusion: Evidence is lacking that predation and disease are major problems.

Recommendation: Continued observations need to be made on the role of predation and disease in production.

Conclusion: When assessing the impact of fish culture, economic viability should take precedence over its dietary contribution.

Recommendation: Due to insufficient data, more work should be devoted to quantifying and qualifying the economics of fish culture.

Conclusion: As beneficiaries of fish culture, farmers need to attain a certain independent level of competence.

Recommendation: Continued efforts need to be made for farmer training.

Conclusion: Model ponds and/or demonstration centers are important tools for farmers to evaluate and improve their fish culture practices.

Recommendation: Efforts need to be implemented and/or maintained to mobilize farmers to visit such centers in an extension and seminar context.

Conclusion: A Regional Training Center could be beneficial.

Recommendation: Consideration should be given to make the existing Training Center at Kigembe into an African Regional Training Center.

Conclusion: Historically there have been difficulties with institutional and/or publicly owned ponds due to problems in division of responsibility and profits.

Recommendation: Government administrators of such endeavors should be well informed of the drawbacks of these projects, and the number of participants should conform to the anticipated harvest.

Conclusion: With present supply of fish falling below demand, pricing may be artificially low.

Recommendation: As supplies become available, prices

should be adjusted so that fish competes favorably with other animal protein sources.

Conclusion: Fingerlings should be sold, not given free by government stations.

Recommendation: (1) Fingerling sales can be partially subsidized to project farmers until fingerling supply meets demand; and (2) Attention needs to be given to fingerling sales from private ponds to insure the continued supply of quality fingerlings.

Conclusion: Not all farmers are ready to follow proposed techniques.

Recommendation: Those farmers who do should be recognized.

Conclusion: A common goal among the three participating countries is that the quality of results and depth of understanding of farmers take precedence over quantity of ponds.

Recommendation: Due to the tenuous status of fish culture, quality of results needs to be maintained and underscored.

Conclusion: This conference has functioned as an exchange of techniques and ideas.

Recommendation: (1) Another conference should be held in 1987 scheduled at a time when each country has accumulated enough data and/or information to contribute; and (2) A representative from each participating country should meet in the host country a few months beforehand to plan an agenda.

Burundi Country Report

INLAND FISHERIES PROJECT

ANTOINE KIYUKU

Fish culture was first introduced in Burundi by the Belgians with the construction of a 13.3-hectare fish station which went into operation in 1952. It operated until 1959, initially with good results. With time, both interest and production dropped, and the station was abandoned after independence. Between 1972 and 1974 renovations were initiated, but the project was never completed due to lack of funds. The Belgians attributed the failure of fish culture in Burundi to inadequate funding, a lack of training for fish farmers and failure to convince farmers of the benefits of raising fish.

Other ponds dating from the Belgian period include some impoundments of more than 20 acres and numerous diversion ponds of three to five acres. All have cement drainage structures. In general, these are deep (1.5 meters or more) with steep, eroded levees. Renovations have begun recently on some of these ponds.

The Burundi Government/Peace Corps Inland Fisheries Project began in 1985. The first group included six volunteers. One volunteer was placed in Isale to establish a national fingerling supply facility. This was necessary to supply the extension program with badly needed fish seed. The others worked as extension agents with private farmers.

It is unfortunate for Burundi and also the project that, with a

deteriorating political climate, the project was temporarily closed in 1987. This came at a particularly bad time because the first group of volunteers were just finishing their service and were about to see their first harvests and begin collecting important harvest data.

Fortunately, one year later in 1988, the Burundi government allowed the project back into the country. There are currently 18 Peace Corps volunteers, 17 working as extension agents and one supervising and managing the national fingerling station.

As farmers began to harvest their ponds and statistics were obtained, the feasibility of fish culture at each site was re-evaluated. As a result, certain posts were closed, while others were opened. It was decided that fish culture must be limited to areas where: (1) the altitude is lower, because a warmer climate leads to higher productivity and is therefore more profitable; in addition, reproductive rates at lower altitudes ensure fingerling availability for restocking; (2) the population density is lower, and there is less competition for land usage; and (3) there is an existing market for fish.

Present Activities

Extension Strategies

The process of extension is taking place at an intensive direct volunteer-to-farmer level. Dissemination of information and orga-

THIRD CONFERENCE ON TILAPIA CULTURE AT HIGH ELEVATIONS IN AFRICA

nization of local contacts is also being accomplished through local agronomists and administrators. Overall unity within the country is aided by the Department of Water, Fisheries, and Fish Culture, which falls under the jurisdiction of the Ministry of Development, Tourism, and Environment.

The number of farmers interested in fish culture far exceeds the number with which a volunteer can effectively work. For this reason, the focus of the project has been the transfer of quality fish pond construction and management skills to a select group of farmers who will serve as an example for their neighbors. With the Department of Water, Fisheries, and Fish Culture, the Peace Corps has established a list of criteria for project ponds, the intention of which is to maximize the quality of these examples.

The early emphasis of the project is to instill the ideas of modern techniques of fish culture, while using locally available materials to minimize costs. For simplicity, the species *Oreochromis niloticus* is used exclusively. The Inland Fisheries Project emphasizes the role of good management practices in increasing productivity. Fertilization through composting is recognized as the most important management tool. The project recommends that 10-15% of the ponds' surface area be occupied by enclosures for composting material, and that this material be augmented and mixed regularly to maintain an adequate plankton bloom. Feeding should be done twice daily at regular times, with available local materials such as various leaves, rice bran, brewery waste, termites, etc. Excessive "fishing out" should be avoided and the pond should be drained completely at least once each year. Throughout the process, thorough records are kept of each pond's history and harvest results. These records have been used to create a nationwide data base, which has allowed the evaluation of progress at each individual post.

The extension program for Peace Corps volunteers varies with the individual, but in general includes site visits to project farmers, as well as meetings and demonstrations. Volunteers have established a networking system of farmer-to-farmer exchange and regular communal meetings. Peace Corps/Burundi has developed a technical guide to fish culture and a fish cookbook. Both are written in Kirundi and French. The technical guide discusses all aspects of pond culture from site selection to harvesting and record-keeping, and it is used by many volunteers as a weekly lesson planning tool. The cookbook explains cleaning and preservation techniques such as drying, salting, smoking, and preparing fish meal, and it includes simple and economical recipes. It is used as a guide for fish cleaning and preparation demonstrations given after each harvest and also at communal meetings.

Pond Statistics

There are an estimated 4,000 fish ponds currently in Burundi. Unfortunately, the vast majority of these were built without any technical guidance, and so are poorly constructed and, if stocked, poorly managed. These are in general privately or cooperatively owned.

The project recognized that improvements in fish culture

would involve improvements in construction techniques. Ponds having an average area of two to four ares are encouraged (with areas ranging from one to 15 ares). Maximum water depth is one meter, but it is required that one region of the pond be significantly shallower (20-40 cm) to provide an area of warmer, solar-heated water to promote spawning. Dikes are constructed with an inside slope of 3:1, again to provide more area for spawning, and with a 2:1 slope for the outside levee. The site must have a reliable water source. The pond must be completely drainable and dryable.

The volunteers of the Inland Fisheries Project are currently working with a total of 276 model ponds around the country. These compose a total of 600 ares of surface area, giving the average pond a surface area of just under 2.2 ares. The vast majority are private, single-owner ponds, and there is a minimum requirement of at least one are of surface area per owner for group-owned ponds. Privately owned, multi-pond systems are encouraged. Communal and cooperative ponds have been discouraged due to the poor management practices which persist in such situations.

Volunteers have begun work with women and women's groups, and have insisted upon discussing pond management practices with the individual farmer as well as his wife in an effort to encourage participation of the entire family. This has been met with limited success because of the traditional roles in Burundi culture. Animal husbandry falls within the domain of the men, and the women are reluctant to move into this territory.

Production Systems

Production systems in effect in Burundi include a general model for grow-out ponds, as well as polyculture and integrated agriculture.

General Model — The Burundi Inland Fisheries Project chose *Oreochromis niloticus* (Egyptian Strain) as an appropriate culture fish because of the following characteristics: (1) High reproductive rate which ensures availability of fingerlings and a diminishing dependence on the fish station; (2) Omnivorous feeding habits — feeding on plankton and other materials which are non-competitive with human needs and are cost-effective; (3) Fast growth rate; (4) Disease resistance; and (5) Tolerance to low oxygen levels.

The project was started using a uniform stocking rate of one fingerling per square meter. After the first production cycle, volunteers assessed the harvest results and management skills of each farmer as well as availability of inputs (compost and feed materials). In certain cases the stocking rate was increased to 1.5 to two fingerlings per square meter.

The growth cycle varies with altitude and climate. Ponds in the plain at an altitude of less than 1,000 meters are harvested every six months, while those at altitudes of 1,800-1,900 meters are generally harvested after 10-12 months. The deciding factor is fingerling availability.

In Burundi, there is a wide variety of compost and feed material available. One of the criteria for each pond is an enclosure occupying 10-15% of the pond's surface area. This is to be filled

before the pond is stocked, and augmented regularly, to ensure an adequate level of plankton. Materials frequently used include cow, goat, sheep, chicken, and duck manure, dead frogs and rodents, slaughterhouse waste, kitchen waste, and a large variety of grasses and leaves. Feed should be given twice daily and at regular times. This commonly consists of various leaves (sweet potato, taro, peanut, papaya, cabbage, manioc), avocados, termites, rice and wheat bran, kitchen waste, cotton seed oil press cake, banana wastes, brewery wastes, and manioc and sorghum mill sweepings.

Polyculture — In regions of Burundi having an altitude of roughly less than 1,000 meters, where there is a common problem of over-reproduction and overpopulation in grow-out ponds and in cases where farmers have a firm grasp of fish culture techniques and pond management, polyculture systems involving *Oreochromis niloticus* and *Clarias* species have been introduced. The carnivorous *Clarias* species, a popular food fish, feeds on and keeps the *Oreochromis* population in check. At higher altitudes, where cooler temperatures decrease growth and reproduction rates, polyculture with *Clarias* is seen to deplete the *Oreochromis* population.

Integrated Agriculture — As the Inland Fisheries Project in Burundi has progressed, reliable fingerling sources have been established in each active province. The demand for fingerlings from the national facility at Isale has decreased, allowing for the development of the station as a demonstration and training center, and as a producer of food fish. During the past year, Isale has established integrated systems involving chickens, rabbits, and pigs with *Oreochromis niloticus*. In addition, plans are currently being formulated to develop a training center for agronomists and project farmers at the site.

Present Constraints

The number of farmers interested in fish culture continues to exceed the number with which a volunteer can effectively work. The project therefore focuses on a select group of farmers in each province. There are large numbers of farmers who have constructed ponds and receive no technical assistance. These ponds are, for the most part, unprofitable, and it is hoped that they will learn from the example of their more successful neighbors. In many cases, these non-project farmers abandon their fish culture endeavors.

Another constraint has been the lack of knowledge of fish preservation and preparation. A cookbook has recently been developed to address this problem, and volunteers now demonstrate the cleaning and cooking of fish after each harvest, as well as simple techniques for drying, salting, and smoking. Use of preservation techniques permits increased protein consumption for farmers and their families during periods between harvests.

Volunteers work directly with local farmers, and while skill transfer at this level has been successful, the establishment of formal counterparts and a government infrastructure of trained Burundian extension agents has yet to be realized. FAO has been

recently approved to begin implementation of an intensive training program to meet these needs. Two representatives of the Department of Water, Fisheries, and Fish Culture have completed a four month intensive training program at Auburn University, Alabama. FAO has also appointed a full-time technical advisor to the Burundi project. This advisor acts as coordinator and will be training a third department representative as his counterpart during the next two to three years. Regional training sites are being developed and sessions for agronomists will begin in 1991. Training for model farmers, selected by volunteers, will begin in spring of 1992. The most advanced farmers will be chosen for training as formal counterparts for volunteers in the field. Thus, the FAO project will establish the needed government infrastructure within the next three years.

Future Directions

Model farmers will continue to improve their management skills, resulting in higher productivity and increasing profits. Farmers are encouraged whenever possible to develop multi-pond systems, and more advanced aquaculturists will continue to experiment with polyculture and integrated systems.

The FAO Project will provide the necessary government infrastructure so that the Inland Fisheries Project in Burundi is self-sustaining. The project will also provide volunteers with formal counterparts at each site.

With the distribution of the cookbook and concurrent preparation demonstrations, the populace is learning simple methods of preparation and conservation techniques. Volunteers will begin working with rural health centers and dispensaries to promote fish as a health food.

FISH PRODUCTION IN RELATION TO ELEVATION IN BURUNDI AND OTHER PRODUCTION RESULTS

JOANNE LUND AND M.T. UHLIR

In our attempts to select sites with high potential for placing volunteers and to understand and predict production from fish ponds, we examined several factors in fish production. Figure 1 and Table 1 show how elevation influences yields from fish ponds. It is quite clear that net yields from the ponds at lowest elevations are generally higher than at the highest elevations. Figure 2 shows the average net yields by elevation zone dramatically decreases as we go above about 1,500 meters. Unfortunately, farmer interest seems to be greatest at higher elevation zones.

We also examined the length of the cycle and the number of fingerlings per acre produced at different elevations (Figure 3). We did not have much data from the lowest elevations. No clear relationships emerge.

Peace Corps volunteers use a rating system to assess the overall management of a fish pond. Water management, composting, feeding, and other variables are used to assign a number from one to

Table I. Pond Production Statistics by Altitude in Burundi

Altitude (meters)	850-1,060	1,270-1,480	1,480-1,690	1,690-1900	Country average
Net fish yield (kg/are/yr)	28.15	26.23	13.7	12.38	20.12
Fish size at harvest (grams)	93	104	89	100	94.3
Pct. fingerlings (by number)	73.7	82.9	67.2	76.4	75.5
Pct. fingerling (by weight)	29.5	34.1	21.9	27.8	25.7

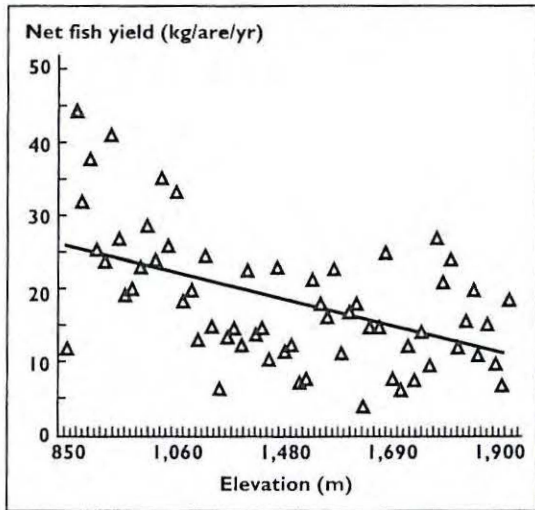


Figure 1. Relationship between net annualized fish yields and elevation from rural ponds in Burundi.

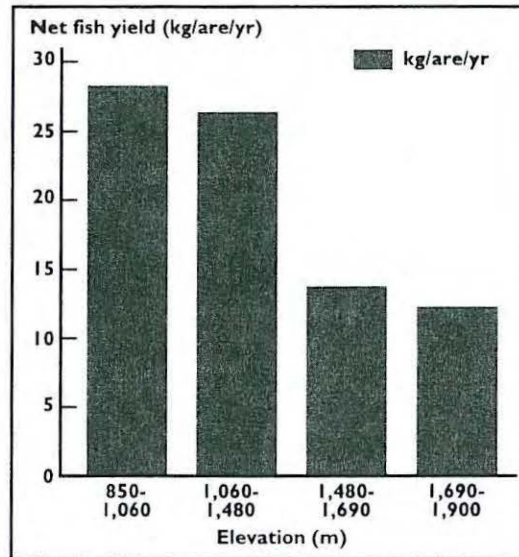


Figure 2. Average net annualized fish yields from rural ponds in Burundi by elevation zone.

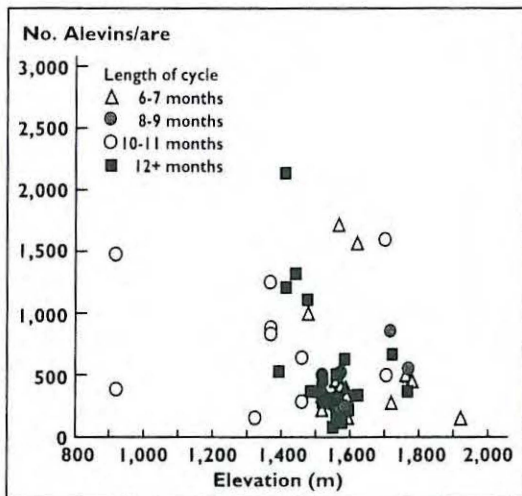


Figure 3. Relationship between fingerling production (alevins/are) and elevation (meters above sea level) for rural ponds in Burundi. Length of cycle denotes time from stocking to draining.

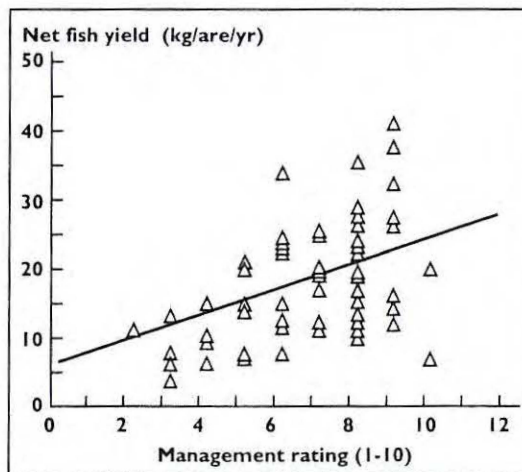


Figure 4. Correlation between farmer management practices as evaluated by Peace Corps volunteers and pond productivity for rural ponds in Burundi, all elevations combined.

10, with 10 being the best possible management. Although admittedly subjective, this is the best predictor we have found for fish yields (Figure 4).

Discussion

Q: How many ponds were used for your statistics represented in the graphs?

A: We used harvest data from 62, about one-quarter of the model fish ponds.

Comment by Mr. Kiyuku: With our new project starting, we plan to get many more statistics.

Q: In Rwanda, we see similar results by elevation, except that we do not have many ponds below 1,400 meters elevation. Do your net yield figures include fingerlings?

A: Yes.

Q: Why is the size at harvest and the percent fingerlings similar at all the elevations but the net yield so much lower at higher elevations?

A: Some of the fingerlings from the first reproduction of the cycle get big enough to be counted in with the market-size fish at the lower elevations.

Kivu (Zaire) Country Report

AN OVERVIEW OF THE NATIONAL FAMILY FISH CULTURE PROGRAM AND THE PROGRAM SPECIFICS FOR THE PROVINCE OF SOUTH KIVU

CAROLYN CANFIELD HENDERSON AND MICHELLE LYNN YOUNG

The people of Zaire have a long history of informal fisheries work. Long before formal pond fish culture was introduced by the Belgian colonists, Zairians used various techniques to maximize their yield from lakes and rivers. The colonial period brought many fish culture endeavors with varying degrees of success. Many large scale fish stations were built, but perhaps the most ubiquitous endeavor was the drive for every Zaire family to dig a fishpond. With no technical assistance, the result of the program was the creation of thousands of mismanaged and unmanaged "ponds," largely partially dammed river valleys with constant water flow. The fish raised were whatever happened to get caught in the pond. Slow growth and low reproduction discouraged the farmers and many ponds were abandoned over the years. Ponds which did not dry up were more successful at breeding mosquitoes than fish, and pond fish culture often got a bad name in rural areas. After independence in 1960 the Belgian fish stations were also abandoned and fish culture all but stopped in Zaire.

The idea of a family fish culture project in Zaire was born of a desire to reintroduce fish culture to Zaire. A grassroots approach was designed to aid a large rural population suffering a low standard of living, low protein intake, and in many areas poor soils unsuitable for crops other than cassava. In 1973, the British OXFAM studied the possibility of beginning a project to teach improved fish culture methods to rural farmers in Bandundu province. As a result, the first Peace Corps Zaire Fisheries volunteers were placed in Bandundu in 1974. It was thought that volunteers living in villages alongside farmers would be an effective means of introducing the new techniques and a new style of pond building to a large number of people. Bandundu's poor cropland and lack of animal protein sources assured the willingness of farmers to give fish culture another try.

Oreochromis niloticus was chosen as the standard fish to be raised at production stations and in all project ponds. This choice was based on the following characteristics: fast growth rate; high reproductive rate, which allows a short growing cycle; opportunistic feeding habits, including filter feeding; tolerance to low oxygen levels and high temperatures; and adaptability to intensive pond culture. This fish was well received, and the volunteers were soon unable to meet the demands of all interested project candidates.

Family Fish Culture Project

The success of the volunteers inspired the Government of Zaire (GOZ) to adopt the project and install government technicians to complement the work of the volunteers. In 1978, the Family Fish Culture Project (Projet Pisciculture Familiale [PPF]) was created within the Department of Rural Development. Co-funded by the GOZ and USAID, PPF's overall goal was to raise the level, availability, and quality of nutrition of the rural population through pond production of food fish. Regional coordination centers were established in the provinces of Bas Zaire, Bandundu, Kasai Occidental, Kasai Oriental, and Kivu. These five centers were staffed with technical experts and animators.

Fingerling production stations were built in each of these provinces to aid in the dissemination of quality seed to project farmers. Additionally, the station in Kasai Oriental province was equipped as a research facility and training center.

PPF matured as a government project as regional organization and technical skills improved. Through training by volunteers and PPF agents, a broad base of experienced fish farmers was created and PPF's spheres of activity in each province steadily increased. While day-to-day extension with individual farmers was the volunteers' job, the coordination staff was responsible for organizing periodic farmer training seminars and site technical visits as deemed necessary by the volunteers at each post. As the technical skill level of the fish farmers increased, two revisions were made in the services provided by PPF: first, each provincial production station was to serve as a training center and model pond system; and second, in two provinces a "mobile team" of technicians was organized to follow up work at posts which had become independent.

Current Project Status

In 1988, the project funding and organization were again revised. Now fully nationalized, PPF took its present name of the National Family Fish Culture Program (Programme National de Pisciculture Familiale [PNPF]). Thus, the 40 fisheries volunteers currently working in Zaire now serve as PNPF extension agents within the Zaire's Ministry of Agriculture, Rural Training, and Community Development. USAID still provides financial assistance, but funding has been reduced and PNPF is working towards full Zairian funding by 1994. Working together, approximately 325 volunteers and 60 PNPF agents have helped an estimated 10,000 fish farmers raise 250 tons of *O. niloticus* annually. The five production stations manage a total of 6.7 hectares of water and produce an additional 30.5 tons annually.

Extension Strategy: Structure

The success of PNPF as an extension agency can be largely attributed to its collaborative extension strategy. The provincial coordinators and volunteers fulfill distinct but complementary extension roles, in a unique system which has become the model for fisheries programs in many other African nations. The division of duties maximizes resource and personnel use and allows the most complete farmer training possible. While Peace Corps volunteers concentrate on rural, hands-on extension work, PNPF provides structure and organization at the national and regional levels. PNPF's five main activities are: identification of potential sites, planning, follow-up and support of regional activities; provision of information and training to PNPF technical agents; assistance to fish farmer training with site visits and training seminars; maintenance of training and support infrastructure including training centers and production stations; and evaluation of program activities via an extensive report system, visits to each province, and an annual nation-wide planning and budgeting conference.

At the regional level, collaboration is coordinated by a co-management team consisting of the provincial coordinator and the

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provincial Peace Corps Volunteer Leader(PCVL). This team creates an annual activity plan and budget, presented at the national conference, suited to meet the specific technical needs of the province. Each trimester, a calendar of events is established to fulfill the needs cited in the annual plan. The regional coordinator then oversees the work of the government agents, while the PCVL is responsible for technical and logistical support of the volunteers.

Extension Strategy: Methods

The most important extension tool for all volunteers is local language competence. As French is not spoken in rural areas, volunteers increase their effectiveness by gaining proficiency in the local language of their area at the training facility in Bukavu. Additional extension tools employed by volunteers include a colorful instructional flip chart and a comprehensive fish culture manual published in French and five local languages.

Volunteer posts are chosen by the PCVL and/or regional coordinator according to a recognized need or a request from the village. Once established, each post hosts a series of three volunteers for a six-year cycle of volunteer activity. The volunteers consider the fish farmers to be their counterparts, and work solely to improve the fish culture practices in their area. Each of the three volunteers may emphasize different aspects of project work, but with a common goal to bring the post to technical self-sufficiency at the end of the six year cycle.

The first volunteer locates areas of interest around the post and works with promising fish farmer candidates. The emphasis is on site selection and construction of improved model fishponds. The volunteer works with a small core of quality farmers to assure that the post follows the standards which will realize maximum production. Intensive management skills focus on the importance of daily feeding and composting to achieve a plankton bloom which will serve as the primary food source for the fish. The second volunteer expands the post and sharpens the skills of the existing farmers. Farmers are encouraged to construct second and third ponds, working towards the goal of a three-pond system. The main emphasis is on the development of management skills, assuring that each farmer understands the importance of program methods.

The third volunteer works to prepare the post for his/her own departure. This job demands that each farmer become independent and proficient in all aspects of fish culture: site selection and construction; management; harvesting; transport and stocking; and record-keeping. Ideally, the farmers should also be trained to pass these skills on to others. To assure the successful continuation of the post, the volunteer helps the farmers to establish a committee to carry out the functions performed by the volunteer. Regular meetings allow the farmers to gather to discuss issues of concern at the post and quarterly reports retain contact with the provincial coordination.

The goal behind the establishment of a farmers' committee is not only the maintenance of a post and upkeep of standards, but the continued expansion of a post in terms of numbers of ponds and numbers of farmers. A successful committee relies on members willing to donate their time to aid new farmers. Committees are aided by the PNPF agents, who continue to do site visits and plan farmer seminars at posts run by committees. Though typically production at a post does decrease after the volunteer leaves, this fall-off tends to stabilize at approximately 15% lower production. Success of committees has also been shown through the growing numbers of new fish farmers at inde-

pendent posts. Some of these farmers follow all program methods, becoming committee members. Others, called "secondary adoptors" incorporate some aspects of improved construction or management into their non-program ponds. This "second generation" of farmers is understandably most evident in the region of Bandundu, where the project and the "mobile team" have been most active for the longest time.

Program Standards

Nationwide standards assure the quality and consistency of work at all posts in all provinces. These standards govern both the construction of fishponds and their management. The current standards have been developed over the years as the characteristics which achieve maximum production and program continuity have been established. They are as follows:

Site Selection — (1) room for a minimum of six ares of pond surface area; and (2) slope allows gravity fed/ drained pond of minimum one meter depth;

Construction — (1) 1.75 to 3.5 ares surface area per pond; (2) no organic material in dikes; (3) 3:1 inside slopes, 2:1 minimum outer slopes; (4) one meter minimum depth at deep end; (5) 30 centimeters minimum freeboard; (6) screened inflow pipe; (7) screened overflow pipes, one per are; and (8) grass covering all dikes; and

Management — (1) fish fed twice per day; (2) compost corals 10% of surface area refilled weekly; (3) complete record of production information kept by farmer; (4) eventual construction of three-pond minimum system; (5) six-month production cycle; and (6) 1.1 fish per square meter stocking rate of three- to four-centimeter fingerlings.

South Kivu Specifics

The four rural Peace Corps volunteer extension agents currently located in Kivu work exclusively at the village level and consider the farmers themselves to be their counterparts. Support is provided by a Peace Corps Volunteer Leader. A government support staff theoretically holds frequent farmer seminars. Posts located in South Kivu are at higher elevations than those in other provinces in Zaire. These higher elevations and resulting lower water temperatures affect reproduction and production levels in the culture of *O. niloticus* thereby affecting certain changes in PNPF's standards and management strategies for this province.

A comparison between five posts in South Kivu was made to examine trends and differences associated with varying elevations (Table 2). These posts were selected on the basis of their elevations and on the reliability and accessibility of their data. The data were collected for routine quarterly reports by Peace Corps Volunteers serving as extension agents at each of these posts. The complete data encompasses a time span between 1988 to 1991; however, the data for any one post averages one year or four quarterly reports. All processed data can be found in the table though this discussion will be limited to those data relevant to elevations.

The five posts are Kabare, Walungu, Kalehe, Mwenga and Bunyakiri. Kabare and Walungu have the highest elevations, each at 1,700 meters. These are followed by Kalehe and Mwenga at 1,600 meters and 1,500 meters, respectively. Last is Bunyakiri located at 1,160 meters. Typical water temperatures of 17-20°C were reported for Kabare, Walungu and Kalehe. Mwenga was found to be hotter at 19-

22°C, and still yet higher temperatures of 20-23°C were reported in Bunyakiri.

Production Information

Locally available farm byproducts, such as manure, ash, leaves and kitchen wastes, are composted in corners of the ponds. Typical feed materials include cassava, sweet potato and taro leaves, termites and, occasionally, rice bran and brewery wastes. Farmers make little distinction between feeds and compost ingredients.

The standard length of production expected by PNPf is six months. The cycle in South Kivu is averaged at 7.6 months or a 1.5 month extension onto the PNPf standard. The average length of production apparently varies in accordance with elevation, as can be seen when individual posts are examined. Kabare and Walungu, the highest posts, also have the longest average cycles, 7.8 and 8.1 months respectively. Kalehe drops in elevation from these two posts by 100 meters and also has a shorter average cycle, 7.3 months. In Mwenga, another 100-meter drop from Kalehe, the average cycle decreases to seven months. No distinction was made to account for logistical delays in harvests versus required extensions due to delayed reproduction, and this may account for why Bunyakiri had an exceptionally high cycle recorded at 7.9 months.

Those posts with the highest elevations and the longest average cycles were also found to have the lowest percentages of fingerlings in total production. Again, both Kabare and Walungu had very similar values, 9% and 10% fingerlings of the total harvest. Kalehe increases to 14%, and this figure again increases in the still lower Mwenga post to 38%. Bunyakiri, although it also has a high percentage, 23%, remains an unexplainable anomaly by having a figure lower than Mwenga.

Oddly, no relationship or pattern could be determined in average yearly production from one post to another with respect to altitude. Overall, the average production for South Kivu was 21.5 kilograms per are annually, and none of the individual values varied far from this figure. However, when looking at the production of the best harvests from each quarterly report, a pattern can be seen. Here it appears that with the exception of Kalehe, whose best net yield was 25.4 kilograms per are, the posts with the higher elevations have lower production. Kabare and Walungu have very similar net yields of 29.2 and 28.4 kilograms per are, respectively. Mwenga, whose elevation is 200 meters lower than that of Kabare and Walungu, reports higher net yields of 31 kilograms per are, while production in Bunyakiri was even higher at 43 kilograms per are. These production values of the best harvests may more accurately demonstrate the potential of a post rather than the average production but are still inconclusive.

It is unfortunate that data for the possible size of harvest fish

is incomplete for the posts Kabare and Bunyakiri. The number for Kalehe is also only an estimate on the part of the extension agent. Due to insufficient data it is impossible to draw conclusions as to the effect of elevation on size of harvest fish. However, a cursory inspection reveals an apparent pattern that diminished returns from fingerlings may be compensated for by a larger harvest fish. Walungu had an average return size of 126 grams. This — when compared to the estimated value for Kalehe, 111 grams, and the value found for Mwenga, the lower of the two in elevation, 84.5 grams — shows that there is a good possibility for such an argument. Further study is required.

With these findings it can be seen that a different management strategy is required for high altitude fish culture of *O. niloticus* in the province of South Kivu. Due to a retarded reproductive cycle a delay in the production cycle must be anticipated. Harvests are therefore timed according to both the first sighting of fry and the size of the fingerlings at the proposed harvest date. Likewise, a larger size fingerling (four to six centimeters) is used to stock ponds, rather than the program's standard of three to four centimeters. This is done in the attempt to obtain an earlier reproduction. Also, due to steep valleys and land scarcity, both smaller ponds and pond systems will often be accepted where they would not otherwise be encouraged. Although it has been necessary to modify the PNPf standards due to the effects of higher elevations there is no evidence to suggest high altitude fish culture results in lower production rates as compared with other provinces.

Conclusion

In spite of its success — Peace Corps Zaire Fisheries is touted as the most successful project of its kind in Africa — the future of PNPf is unclear. Congressional aid cuts to Zaire in 1990 drastically reduced financial support of PNPf, four years before its scheduled self sufficiency target date. Cuts have meant decreased activity of PNPf agents at the provincial level. Fewer site visits and PNPf sponsored seminars have increased volunteer workloads and have diminished an important aspect of farmer training, that of Zairians teaching Zairians. Production stations have also suffered. Although all stations are working toward self financing, lack of funds for expansion, improvement, and pond management inputs makes it difficult to raise production to a level at which a station can be self-supporting. The current political situation in Zaire is such that government funds are frozen for many “non-essential” programs. It is hoped that these funds will resume flowing and that the provincial coordinators will resume normal operations.

Discussion

Q: Do the farmers really act as extension agents?

A: Yes, but getting the farmers to operate this way is the most difficult task of the third volunteer. I think there have been 360 volunteers working in fish culture in Zaire since 1974. Presently, about 250 tons of fish per year are produced from fish culture in all of Zaire. The average net yield for the country is about 25 kilograms per are per year.

Q: What about the farmers who started in 1974; and who no longer have a volunteer in the area?

A: We do not get much information

Table 2. Production Results by Post in South Kivu Province

Zone	Bunyakiri	Mwenga	Kalehe	Kabare	Walungu	Avg.
Altitude (±100 m)	1,160	1,500	1,600	1,700	1,700	1,532
Temp. °C	20-23	19-22	17-20	17-20	17-20	18-21
Total ponds	31	20	30	33	31	29
Active ponds	12	16	12	13	23	16
Area (ares)	18.1	33.7	24.3	17.1	39.9	26.6
Avg. production (kg/are/yr)	22.1	20.9	23.0	21.4	19.9	21.5
Avg. top 10% (kg/are/yr)	43.0	31.0	25.4	29.2	28.4	31.4
Cycle (months)	7.9	7.0	7.3	7.8	8.2	7.6
Fish size (grams)	—	83	111	139	126	115
Pct. fingerlings	23	38	14	9	10	19

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from those farmers but they are occasionally visited by the "equipe mobile" or mobile team we mentioned previously.

Q: Is there any large-scale commercial fish culture in Zaire?

A: Not in Kivu area, with which I am most familiar. The only big fish farms are the government stations.

Q: What do you count as "fingerling" in your production data?

A: The first fingerlings produced get to be food-size fish so are counted as marketable. It is mostly the second, third, etc. fingerling groups that make up this percent.

Comment: The duration of culture can be reduced to reduce the number of tilapia generations at draining.

A: Yes, but the farmers still remember when fingerling supply was a problem, and they still have good revenues from the sale of fingerlings so such a change will be difficult to make at this time.

Q: Do farmers do any kind of intermediate harvests?

A: We discourage it but it is done anyway.

Commentary: A discussion on the relative advantages and disadvantages followed. The point was made that pond harvest results will never be realistic if earlier partial harvests were done, and the record keeper/reporter was not aware or was afraid to report it. It is therefore not wise to outright forbid partial harvests. Also, there is little information from controlled experiments evaluating partial harvests available, and more work should be done to come up with recommendations regarding partial harvests.

Q: How do you get production data from farmers where there are no extensionists?

A: There is a farmers' committee set up, and the president of the committee keeps records of pond productions and pond numbers. It is not the best, but it works better than nothing. Our objective is to put in place a system that can work in the absence of Peace Corps and without any intervention of the Government of Zaire.

Q: Does it work in the posts already vacated by Peace Corps?

A: So far, it works much better than nothing.

Q: Are the five different posts because the temperatures are different, or who chose these posts?

A: The Ministry of Rural Development in Kinshasa and a Peace Corps representative based in Kinshasa get together to select the posts, using potential and farmer interest as main criteria.

Q: Are there other projects that work with fish culture in Kivu and how is the collaboration?

A: There are a few that started. For example, the French financed a station at 2,200 meters, but it was abandoned after two months. The station people there say that they find enough fingerlings in the ponds after nine months, but we have never verified this.

Q: Is there a minimum yield that the farmers find to be acceptable?

A: Yes, but it depends on the place. There are areas where nothing - including fish-grows well. Kivu is the most difficult province for extending fish farming because the population density is relatively high and agriculture is quite profitable.

Q: How is the fish market in the Kivu area?

A: It is the best nearest Lake Kivu. People know fish there, and the price of tilapia is quite high.

Rwanda Country Report

HISTORICAL PERSPECTIVE AND START OF THE NATIONAL FISH CULTURE SERVICE

PAUL MPAWENIMANA AND CHARLES KARAMAGA

Note: This article was taken from reports submitted by N. Hishamunda.

Fish culture was introduced in Rwanda during the 1950s with the construction of the fish culture station at Kigembe. At the end of this period, a little more than 200 rural ponds produced an average of four kilograms per are per year (400 kilograms per hectare). In spite of these discouraging results and contrary to what was observed in other African nations, fish culture was not completely abandoned by the farmers at the time of independence in 1962.

However, the 1960s was a period in which fish culture did not develop due mainly to the following: (1) a lack of desire or conviction on the part of the farmers resulting from fish culture having been imposed upon the farmers and not extended; (2) a lack of understanding of the basics of fish culture by the farmers; (3) a lack of trained technicians; and (4) fish culture was introduced at a time when fish consumption was little known.

In summary, in 1966 it was reported that 448 ponds had been constructed since 1950 but that none were truly operational. Since then, the government of Rwanda never ceased requesting aid from nations and friendly organizations to return the infrastructure to operation.

It was thus that from 1967-1970, the FAO furnished technical assistance, but since there did not exist any formal fisheries or fish culture service, very little was done in terms of extension and in 1970, only 300 ponds were counted. From 1972-1973, the FAO intervened for a second time; productivities of 10 kilograms per are per year were obtained. In 1975, the FAO intervened for a third time, with the principle objective of fisheries development, with fish culture playing a marginal role. After this intervention, it must be noted that fish culture was not at all developed and that various results, sometimes deplorable ones, were registered.

In 1978, under the project called ELADEP, lake stocking and fisheries development began and was supposed to continue through 1981. The project, financed by IDRC of Canada was supposed to assure the re-stocking of lakes in the country by aiding the fish culture stations to produce fingerlings. A very minimal effort was given to fish culture extension. (Editor's Note: Some fisheries officers were trained in fish culture, as well as fisheries, but they were largely illiterate prior to training and the three-month training program did little to change this.) Administrative problems caused the

project to be terminated a year early (1980) and without any tangible results.

In 1980, the FAO sent a team to examine the feasibility of a small-scale fish culture development project (Editor's Note: requested by the USAID). The team concluded that, in spite of the various interventions and the interest shown by the farmers, there had been a stagnation in the development of fish culture activities because of the absence of an extension service to transfer to the farmers an appropriate technology for fish culture in Rwanda.

Consequent to the recommendations of the FAO team, made in September 1981, a project financed by the USAID was signed by the governments of the USA and of Rwanda. This four-year project (Rwanda Fish Culture Project) began in 1983 and had the following objectives: (1) renovate the fish culture stations required to assure fingerling production; and (2) develop and consolidate an extension service capable of dispensing advice on construction of new ponds and renovation of previously abandoned ponds, and on pond management to increase production. At the end of the project in September 1987 some "spectacular" results were attained, according to James Miller, who made an evaluation of the project. Since that time, the Rwandese personnel trained under the project took over from the U.S. technical assistants, and the activities continue as such. However, it is no longer called the national fish culture project, but the National Fish Culture Service. The work methods and organization remain fundamentally the same as for the project.

ORGANIZATION OF THE NATIONAL FISH CULTURE SERVICE

The service is comprised of four sections. First is the *Administrative Section*, which includes the secretarial, accounting and overall coordinating responsibilities.

The *Training Section* identifies training needs, plans and organizes training programs and conducts training, all in collaboration with the administrative and extension sections. All levels of personnel receive training or refresher courses. Training programs are also held for farmers.

The *Research Section* examines prospective new species to cultivate, looks for solutions to problems identified by the extension section and tests new techniques for fish culture. This section operates in collaboration with the administrative, training and extension sections. Only applied research is carried out.

The *Extension Section* plans and assures operations of the extension personnel (Editor's Note: and services such as fingerling distribution) in the field and compiles their reports. At the central office level (located in Kigembe), the extension supervisor, the training supervisor and the director all work with the extension service. There are three other levels — the zonal level, the communal level and the farmer level.

At the zonal level, we have divided the country into eight zones based on location and fish culture activity and potential. Each of the zones is supposed to have an *agronome* (A-2 level) trained in fish culture assigned to it. The *agronome's* job is to supervise the extension agents who operate at the commune level, to collect and compile the extension agents' reports. The zonal supervisor also helps intervene with local authorities and with the Directorate of the Service. Presently, only two of the eight zones have *agronomes* and their utility is being questioned.

At the communal level are the extension agents or "*moniteurs piscicoles*." They have three years post-primary education and

have received a three-month intensive training in fish culture at Kigembe. They are the direct links with the farmers and are responsible for transmitting information and for demonstrating all techniques for fish culture including pond construction and renovation, pond management, harvest, preparation and preservation of fish and fingerling holding and transport. The *moniteur* must also collect data on pond stocking and harvests. They submit a quarterly report to the Directorate of the Fish Culture Service, with copies going to the Communal authorities.

Extension agents at the commune level are chosen based on the following criteria: (1) that they are native to the commune in which they will work; (2) that they have at least three years post-primary education; and (3) that they pass the entrance test for the training program. Not all prospective agents pass the training program. The communes to receive an agent are chosen based first on availability of budget to pay their salary, followed by the pond number (at least 25 ponds exist in the commune) and by the potential for the expansion of fish culture as demonstrated by interest and by availability of sites.

The next level is the farmer. They receive the messages transmitted by the *moniteur*, put it into action and produce the tangible results.

Note: the administrative, training, extension and research sections are coordinated by the Director of the National Fish Culture Service (Editor's Note: *Service Pisciculture Nationale* [SPN]), who answers directly to the Director General of Animal Husbandry in the Ministry of Agriculture, Animal Husbandry and Forests.

SPN'S RESOURCES

Human: The service employs four "A-0" staff: the SPN director, chief of the extension section and assistant to the director, chief of the training section, and chief of the research section. They all are based at Kigembe. Four "A2" *agronomes* supervise fish farming activities in Butare Sud, Gitarama, Kigali, and Gisenyi zones. Fifty-nine extension agents provide support to farmers in 62 communes located in the country's 10 prefectures. Beside this technical personnel, the service has a support staff at Kigembe. These include one accountant, one secretary-cashier, one typist and two drivers. Moreover, the service employs daily permanent workers at the stations of Kigembe (30), Runyinya (five) and Nkungu (five).

Infrastructure: We have at Kigembe one administrative hall, one classroom, one dormitory hall, and one apartment complex of seven rooms. The classroom has a capacity of 18 people, the dormitory 20, while the apartment complex has a capacity of 28 people. The Kigembe station also has 32 production ponds (nine hectares), 25 training ponds (approximately 25 ares), 21 holding ponds (approximately 0.5 are each), and nine experimental ponds (approximately one are each). More than half of the production ponds have infrastructures of integrated fish culture. Our goal is to extend the integrated systems to 90% of those ponds. We also have five holding tanks, a hatchery for carps and *Clarias* sp., and one large warehouse. At each of the two other stations (Runyinya and Nkungu) we have a small office, a small warehouse, two holding tanks, and ponds.

Finances: SPN is first of all an extension service where even fingerlings, the farmer's most important input required to operate his fish pond, are subsidized. Logically then, the government should entirely finance the service's activities. But this is not the case. Only four A-0, 2 A2, and 46 (of the 59) extension agents' salaries are paid for. Salaries of the remaining personnel, fees to purchase and maintain cars, insurance, gas, office supplies, animal and fish feed, and so forth

are provided by the service using revenues from sales at different stations and services rendered to other institutions such as agricultural projects and NGO's.

EXTENSION STRATEGY

Basic Principles

The SPN's extension strategy is based on four basic principles. First, before extending a fish species to a region, SPN determines whether it is suitable to the region, the standard being the yield and input availability.

SPN's extension strategy also requires its agents to work regularly with a group of farmers. When it is obvious that this group has mastered fish culture techniques, agents work with another group until the entire zone is reached.

Extension agents (*moniteurs piscicoles*) also must follow a rigid weekly program. This approach allows farmers to still remember the theme previously introduced.

In addition, agents first work in zones with higher fish culture potential. Agents do not necessarily follow administrative borders to establish the work zones.

Extension System

Our extension system is built in such a way that it encourages a close and regular contact between farmers and the first level extension agent: the *moniteur*. It is constructed around three elements which constitute its foundation: visits, training and follow-up-evaluation.

Visits: Every extension agent at any level visits farmers at the ponds. Hence, our first level extension agent (*moniteur*) is organized in a way that he visits all his farmers (ponds) weekly. This means that every eight days the *moniteur* re-visits each of his farmers. Visits are then regular and scheduled, and we insist on their non-changing characteristic if possible. Similarly, the A2 *agronome* visits each of his *moniteurs* at least three times a month. In that way he works out problems encountered by the *moniteur*. In addition, the SPN directorship makes, whenever means allow, either individual (especially) or group visits. Such visits are a means to stimulate farmers.

Training: In general, a retraining is organized every six months for the *moniteurs* and once a year for the *agronomes*, while the staff at the SPN headquarters occasionally get field trips in other countries. These field trips are not excluded for the *agronomes*, *moniteurs*, and even fish farmers.

Followup/Evaluation and Feedback: The follow up is provided by the *agronomes* to *moniteurs*, and by the directorship personnel to the *agronomes* and *moniteurs* while visiting them. The same is true for the evaluation.

An evaluation form is established by SPN directorship. When visiting the *moniteur*, the *agronome* completes the form in the presence of the *moniteur*. Thus, given that pond deficiencies are better detected when one is closer to the pond, completing the form will allow the *Agronome* to clearly notice the pond inadequacies which he will tell the *moniteur* and inform him how to fix them and help him do so. A copy of the form is sent to SPN headquarters. In turn, during their field visits, the personnel at SPN headquarters fill out the evaluation forms, making sure to evaluate one of the ponds previously evaluated by the *agronome* and at least another pond chosen at random. This is a quantitative evaluation. These field visits are a means of evaluating the overall quality of the extensionist's job; and through interviews to farmers, one can get an idea

of the level at which farmers comprehend fish culture techniques. Data collection (reports) is another tool that allows us to follow up and get feedback of the message extended to farmers. The report analysis allows the chief of extension to evaluate its author, the level of comprehension of the extended techniques, and hence, the fish culture development level in the commune/zone. Thus, our system of continuous follow-up and evaluation is not only a means of control but also a way of detecting and correcting deficiencies in the information extended to farmers in a timely manner.

Scheduling Extension Agents' Activities

Like visits, the followup is made easy and efficient by the *moniteur's* regular schedule. Every *moniteur* has to work with farmers five days a week. Such a schedule has been established based on the following: (1) number of ponds supervised by the *moniteur* and their relative distances; (2) farmers' work days in a given marais where ponds are located; and (3) transportation means available to the extension agent (bicycle).

According to our experience, an extension agent using a bicycle can work in a 15 kilometer radius distance. The *moniteur's* work zone being thus determined, the next step will be to divide the zone into five groups of ponds corresponding to five days of work per week. Fish ponds in one group must be located in the same direction. Following the extension agent's activities becomes easy because each day he visits the same group of ponds, the schedule remaining unchanged for the week, month, and year; moreover, copies of the schedule are available to the direct supervisor (A2 *agronome*), the SPN directorship at Kigembe, and to the commune's headquarters. Whoever wants to can get a copy of the schedule in order to check whether or not the *moniteur* is actually working where he should be at a given time. Hence, the extension service organizes unexpected visits and evaluations of *moniteurs*.

Extension Methods

Our extension methods are derived from the fundamental elements of the system. They are classified as individual methods, group methods and mass method.

Individual Methods: These are the most used by our service. They include pond visits, as previously defined. Individual methods also include informal contacts. Sometimes, actual or potential farmers stop by the office or unexpectedly stop us on our way to work and ask fish culture-related questions. We answer their questions and promise to visit them. Indirect contacts is a third individual method; we answer farmers' questions and address their needs by mail.

Group Methods: Group methods include group pond visits and methods and results demonstrations. From time to time, we gather farmers to inform them of new fish farming techniques. Such gatherings are followed by pond visits, in which farmers give their comments and criticism on the ponds visited. Also, despite problems associated with cooperative ponds, we try to work with them, whether they are all men, all women, or men-women ponds.

In a methods and results demonstration, we take advantage of good results achieved by farmers who followed our advice to teach other farmers. This approach allows us to better underline the importance of an extended technique.

Mass Method: We often organize awareness messages on radio. A fish culture manual (*Manuel de Pisciculture à l'Intention des Vulgarisateurs*), brochures and several articles on fish culture in Rwanda have been made available to the public.

FISH CULTURE STATUS IN RURAL AREAS

Technical Information

In Rwanda, ponds are located at elevations between 1,000 and 2,000 meters, but most of the ponds are situated at between 1,500 and 1,800 meters. The lowest elevation of the country is found in the Bugarama region (Cyangugu) and the highest elevated ponds are in the Gisenyi prefecture (Karago). The elevation determines the water temperature in the ponds, varying from 20°C at the high elevations to 25-26°C at the lower elevations.

From the data reported in SPN's 1990 annual report (not yet published), there are a total of 3,512 rural ponds with 11,269 ares total surface area, giving an average surface area of 3.2 ares. Of these, 2,897 ponds (82% of total) with total area of 9,288 ares are reached by the extension service and try to follow the methods extended by the service. We call them "active" ponds of the SPN (Figures 5 and 6).

These ponds have an average of 1,589 kilograms per hectare per year net fish yields (Figure 7). We estimate the top 10% of the ponds to have 2,500 kilogram per hectare annual net yields. The production cycle is about seven to nine months, the average being eight months. Overall, about 20% of the total harvest weight is fingerlings.

Composting in the pond is the method of fertilization. The extension service recommends that 10% of the pond surface area be occupied by compost enclosures in the corners. The service recommends that manure make up at least 20% of the compost ingredients, with the rest composed of fresh or dried grass and other materials.

Feeding depends on what is available to the farmer and is mostly fresh leaves of taro, sweet potato, cassava, galisonga, trip-sacum, etc. A few people feed sorghum or banana beer wastes. The lack of inputs for ponds is resolved in part by the integration of livestock with fish ponds, a technology which is being extended in the rural sector.

Socio-economic Information

The ponds are constructed in the "marais," which belongs to the state and comes under the authority of the Ministry of Agriculture but is also managed by the local authorities at the commune level. The farmers exploit the lands and ponds as tenants, even though they were the ones who constructed the ponds.

Ponds "belong" to individuals (32%); to groups of people, not exactly cooperatives (67%); and to institutions such as prisons and schools (1%). There are 978 individuals who "own" 1,152 ponds and 1,950 groups with a total of 12,933 members who "own" most of the rest of the ponds. The total number of people involved in rural fish culture is estimated to be 23,909, 25% of whom are women.

Fish prices vary by region and demography, but are generally in the range of 120 to 200 Frw per kilogram, averaging 150 Frw per kg. It must be noted that a price below 150 Frw per kilogram renders fish culture less competitive than other *marais* uses. A more reasonable price would be at least equal to the price of beef (180 Frw per kilogram). This problem of fish marketing will be addressed in a study to be undertaken by the National Fish Culture Service. This study is budgeted for this year in the Natural Resources Management project of USAID.

Table 3. Comparative Summary of Fish Culture Practices in 1991

	Burundi	Kivu ¹	Rwanda
Elevation (meters)	830-1,900	1,100 - 1,700	1,300 - 2,200
Typical pond water temperature (°C)			
am:	20-22	17	17-20
pm:	22-25	23	20-25
Total ponds	4,000	NA	>3,000
Active ponds	276	92	2,460
Area (ares)	600	160	1,130
Avg. net yield, including fingerlings (kg/are/yr)	20	22	17
Net yields of top 10% ponds (kg/are/yr)	35	30+	25
Production cycle length (months)	6-12	7-8	6-12
Avg. weight of fish at harvest (grams)	94	110-140	100-200
Pct. fingerlings (grams)	26	9-40	0-50 ²
Typical fertilizers used ³	compost over 10-15% surface	manure, leaves, ashes	grasses, leaves, manure, 5-10% of surface
Typical feeds used	rice bran, termites	termites, rice bran, beer wastes	sorghum, beer wastes, ashes
Pond ownership	private, one family, few groups	private, one family	groups: 67% private: 32% institutions: 1%
Ponds per owner:	1-2	1.75	est. 0.175
Pct. female owners	NA ⁴	0	25
Pct. female managers	NA	NA	est. 40
Pond bank price for fish (per kg) ⁵	\$1-2	est. \$1	\$1-2
Fish price at market	\$1-2	est. \$1	\$2+
No. extension agents ⁶	18	5	59

¹Kivu is a province of Zaire.

²15% average.

³All used the in-pond composting of fertilizers in corrals.

⁴NA = information not available.

⁵Converted to U.S. dollars. Given the enormous rate of inflation in Zaire, this is a very approximate number.

⁶Peace Corps fisheries volunteers located in Kivu province alone.

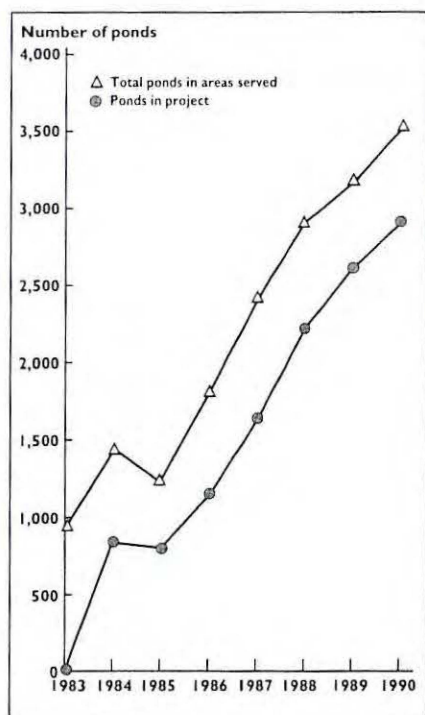


Figure 5. Growth in number of ponds served by the Rwanda National Fish Culture Service.

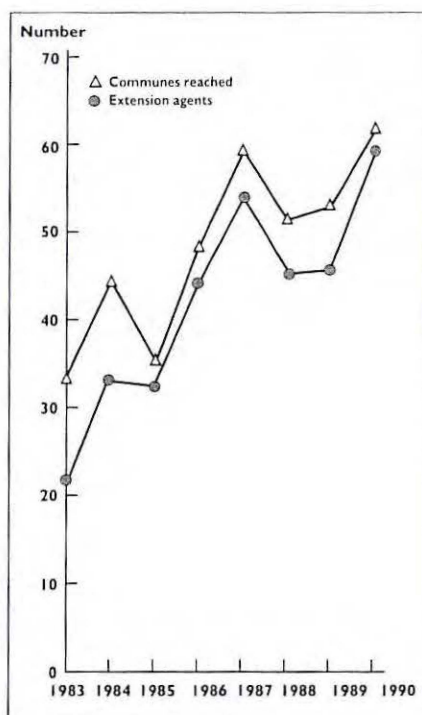


Figure 6. Expansion of the Rwanda National Fish Culture Extension Service.

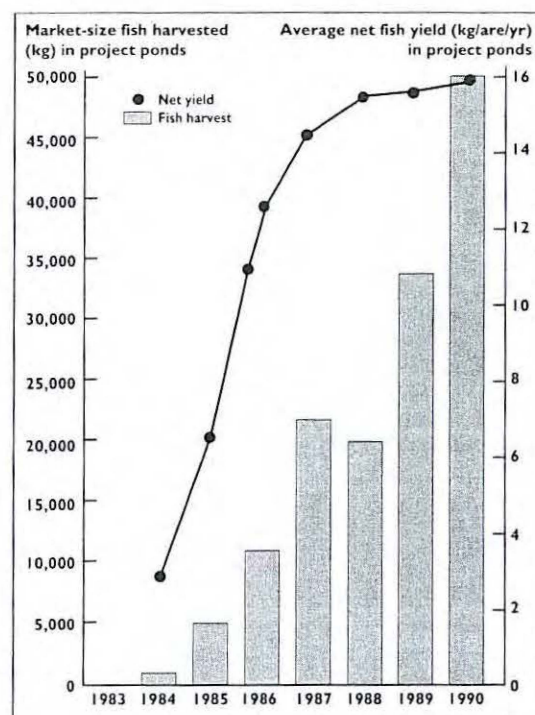


Figure 7. Recorded fish production from ponds served by the Rwanda National Fish Culture Service extensionists.

Expanded Abstracts of Technical Presentations

PRODUCTION OF *OREOCHROMIS NILOTICUS* IN FERTILIZED RURAL PONDS AT ELEVATIONS OF 1,370 TO 2,250 METERS

KAREN L. VEVERICA AND EUGENE RURANGWA

We located rural ponds and cooperative farmers in five different elevation zones for this study: zone 1, at 1,370±30 meters; zone 2, at 1,570±30 meters; zone 3, at 1,770±30 meters; zone 4, at 1,970±30 meters; and zone 5, at 2,180±30 meters. Rwasave station at 1,625 meters also conducted the study. Five ponds in each zone were chosen that satisfied criteria on pond construction, water quality and farmer capacity. Farmers in a "special zone" at 1,900 meters also participated, but only three ponds were found to satisfy criteria.

All ponds were stocked with *O. niloticus* fingerlings at one per square meter, averaging 22 to 28 grams and originating from the Rwasave fish culture station. Ponds were fertilized weekly with a fibrous grass (*Cyperus* sp.) common to all sites at five kilograms total solids per are per week and sufficient urea and triple super phosphate to bring total weekly nitrogen application to 160 grams per are and total weekly phosphorus application to 40 grams per are. Farmers made weekly measurements of secchi disk visibility and noted water color based on a standard-

ized chart. Monthly water samples were taken by station staff (except for October, due to war) and analyzed for total alkalinity, total hardness, chlorophyll *a* and phytoplankton species. Fish were sampled monthly and average weight for each sex measured. One pond per

Table 4. Average Pond Water Quality Characteristics (± SD) by Zone During the Experiment on Production of *Oreochromis niloticus* in Fertilized Rural Ponds at Elevations of 1,370 to 2,250 Meters¹

Zone	Avg. pond temp. (Jan)	Total alkalinity	Total hardness	Conductivity	Uncorr. chl. <i>a</i>	Secchi disk
	°C	mg/L CaCO ₃	mg/L CaCO ₃	µmhos/cm ²	mg/m ³	cm
Zone 1	23.8	65±26	195±33	732±41	58±33	28±7
Zone 2	23.6	54±11	34±6	128±16	100±34	24±5
Rwasave	23.8	41±4	40±3	143±6	340±207	20±5
Zone 3	NA	19±5	17±2	59±7	229±104	25±5
Special	NA	71±10	72±13	171±21	41±29	33±3
Zone 4	20.5	18±8	27±5	36±7	399±138	17±2
Zone 5	19.1	50±34	38±5	148±153 ²	192±47	24±2

¹Zone 1 is 1,370±30 meters above sea level; Zone 2, 1,570±30; Rwasave Fishculture Station, 1,625; Zone 3, 1,770±30; Special Zone, 1,900; Zone 4, 1,979±30; and Zone 5, 2,200±30.

²Caused by one pond with conductivity at 525 µmhos/cm.

Table 5. Average fish production statistics by zone on Production of *Oreochromis niloticus* in Fertilized Rural Ponds at Elevations of 1,370 to 2,250 Meters¹

Zone	Ponds harvested	Cycle length	Wt. gain males	Wt. gain females	Reproduction wt.	Pct. harv. as reprod.	Net fish yield w/o reprod.	Net fish yield w/ reprod.	Recovery rate
	no.	days	g/day	g/day	kg/are	pct.	kg/are/yr	kg/are/yr	pct.
Zone 2	6	185	0.76	0.36	3.31	27.9	11.51	18.04	64.0
Rwasave	5	185	0.71	0.29	1.85	13.7	16.45	20.12	88.9
Zone 3	4	236	0.47	0.24	3.40	31.4	7.03	12.48	67.9
Special	3	210	0.69	0.45	0.02	0.16	12.69	12.71	68.7
Zone 4	7	192	0.50	0.29	0	0	8.61	8.61	70.1
Zone 5	8	245	0.58	0.34	0	0	10.15	10.15	68.0

¹Ponds with less than 50% fish recovery rate are not included. Zone 1 ponds are not included as explained in text. See Table 4 for information on the elevation of each zone.

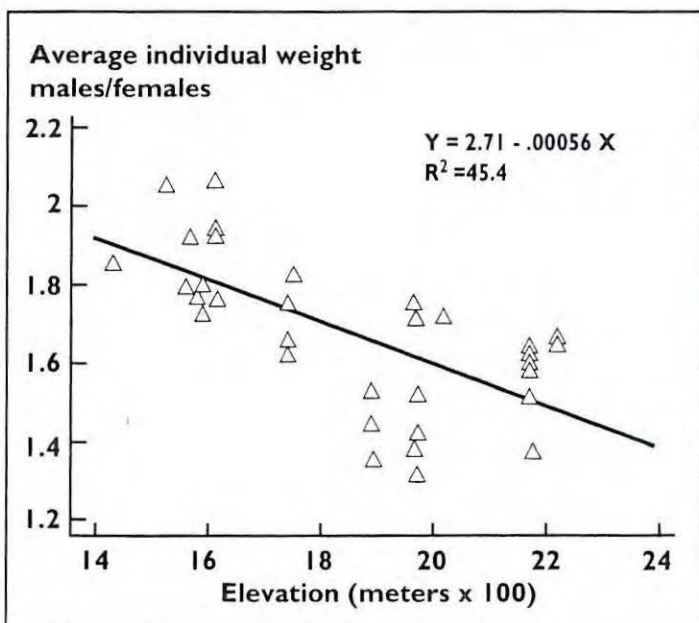


Figure 8. Relationship between the male:female weight ratio at harvest and elevation of ponds all receiving same inputs.

zone, except zone 3, had a recording thermometer placed at a depth of 15 centimeters. All ponds in a zone were drained when most of the ponds in that zone had male tilapia averaging at least 150 grams.

Table 4 presents water quality data from the various zones. Ponds in zone 1 all had very low production, probably because of a water quality characteristic (high manganese) that was not taken into account when sites were selected. Also farmers in zone 1 did not control water flow-through in the ponds as instructed. Thus, zone 1 was eliminated from further analyses. In the other zones, net yields diminished with elevation when reproduction was taken into account (Table 5). There was no reproduction in zones 4 and 5 over the seven months of culture. If only adult fish are counted, there was no difference in net yields with elevation. The ratio of male-to-female weight was significantly negatively correlated to elevation (Figure 8).

It seems that the quantity of natural food produced by this type of fertilization remains the most important limiting factor to growth of *O. niloticus*. A good choice of fingerlings and short production cycle seems to be the best technology to extend at lower ele-

vations. Fingerling availability will be a problem at the high elevations, but longer production cycles and possible higher stocking densities may alleviate the problem somewhat.

Discussion

Q: Why the special zone?

A: This zone had higher total alkalinity and hardness than both zone 3 and zone 4, but the elevation did not quite match our desired zones. The valley in which the ponds were located contained about 40 ponds; all of them but three were very leaky. So, we included the good ponds as a demonstration to the farmers of how well the tilapias could grow if construction and management were adequate.

Q: Was there a significant difference between zones for average weight of the male fish?

A: I thought there might be, but within-zone variation was so high that no significant difference even at 90% was detected. I would like to see what would happen if males only were stocked.

THE INFLUENCE OF COMPOSTING REGIMES AND STOCKING DENSITY ON MIXED-SEX TILAPIA PRODUCTION

ANACLET GATERA

Although it is generally accepted that the application rates of inorganic fertilizers should either increase or remain constant over a production cycle, the possible slow decomposition time of organic fertilizers such as composted grasses suggests that high initial application rates may be beneficial to fish production. This benefit may be especially great in mixed-sex tilapia culture, where an early high growth rate of fish is to be encouraged to compensate for later low growth rates of females due to reproduction.

The first objective of this experiment was to assess the growth and production of male and female *Oreochromis niloticus* (Nile tilapia) fingerlings stocked at different densities. A second objective was to test two organic fertilizer application regimes: a large amount applied at the beginning of the production cycle, followed by smaller weekly applications of 10% of the initial amount (HI); and a constant weekly application (CONST). The HI approach is currently recommended by the Rwanda Fish Culture Extension Service.

Materials and Methods

Each of nine seven-are (0.07 hectare) ponds was filled and fertilized with 3,448 kilograms per hectare (dry weight) of a 4:1 mix-

THIRD CONFERENCE ON TILAPIA CULTURE AT HIGH ELEVATIONS IN AFRICA

ture of freshly cut grasses from pond levees and chicken litter between October 10-13, 1989. About 10% of this amount was added to each pond weekly thereafter (composting regime HI). Nine other seven-are ponds each received the same grass/chicken litter mix (4:1 ratio) at a constant rate of 500 kilograms per hectare per week (dry weight) (composting regime CONST). Dry weights of the inputs were measured each week to adjust the input quantities for the next application. A total of about 700 kilograms (dry weight) was added per pond for all treatments (10 tons per hectare over 20 weeks). Each fertilizer regime was tested at stocking densities of 0.5, one and two fish per square meter, using mixed-sex, advanced juvenile *O. niloticus* averaging 45 grams.

Fish were sampled monthly, separated by sex, counted, and weighed. Morning and afternoon dissolved oxygen levels were measured daily for three weeks following the first fertilizer application and weekly thereafter. Uncorrected chlorophyll *a* was measured every two weeks; all other parameters were measured as directed in the Pond Dynamics/Aquaculture CRSP Fourth Work Plan.

Results

Ponds receiving the high initial application of compost had significantly lower morning dissolved oxygen levels during the first three weeks of the experiment (average 1.7 milligrams per liter) than did ponds receiving the constant compost application (average 3.8 milligrams per liter). Significant differences in chlorophyll *a* levels were observed among the three stocking rates but not between the two composting regimes. Ponds with stocking rates of one and two fish per square meters had the highest levels (57.7 and 51.3 milligrams per cubic meter, respectively), followed by ponds stocked at the 0.5 fish square meter rate, which had a significantly lower average chlorophyll *a* level (38 milligrams per cubic meter). The tilapias were frequently observed chewing on compost in the enclosures, so there may have been slightly better compost degradation at the higher stocking densities, which may explain the higher chlorophyll *a* levels.

There was little difference between the growth rates of fish of either sex in the two compost application regimes during the first two months. However, after the second month, the growth rate of fish stocked at two per square meter was notably lower in ponds receiving the high initial compost input rate than in ponds receiving the constant rate. The growth of males decreased with stocking density at a rate greater than that of females (Figure 9). The slopes of these lines differed by a factor of two. At the highest densities, many of the adult females were about the same size as the larger fingerlings produced.

Fingerling production was highest (9.8 per female) at the low fish stocking density, probably because of the higher average weight of the females at this low density. The total number of fingerlings produced averaged 1,541, 1,837, and 1,411 fingerlings per pond for the 0.5-, one-, and two-fish per square meter densities, respectively. However, no ponds yielded enough large fingerlings (larger than five grams) to allow for restocking at the same density. Average net production, including the weight of fingerlings, was highest for the stocking density of one fish per square meter, followed by two fish and 0.5 fish per square meter. The production difference between the one-fish and two-fish densities was mostly due to differences in reproduction (Figure 10).

Overall stocking densities, the average weight of males and of females at harvest was significantly less in ponds receiving the high initial dose of fertilizers (Table 6 and 7), probably as a result of reduced nutrient inputs towards the end of the experiment. Under both fertilizer regimes, the average weight of males from ponds stocked at two fish per square meter was unacceptable for the typical Rwandese market.

Discussion

Q: If less fish production results, why does the extension service then recommend this high initial dose of fertilizer at the beginning?

A: It was thought that farmers could be coerced into fertilizing their

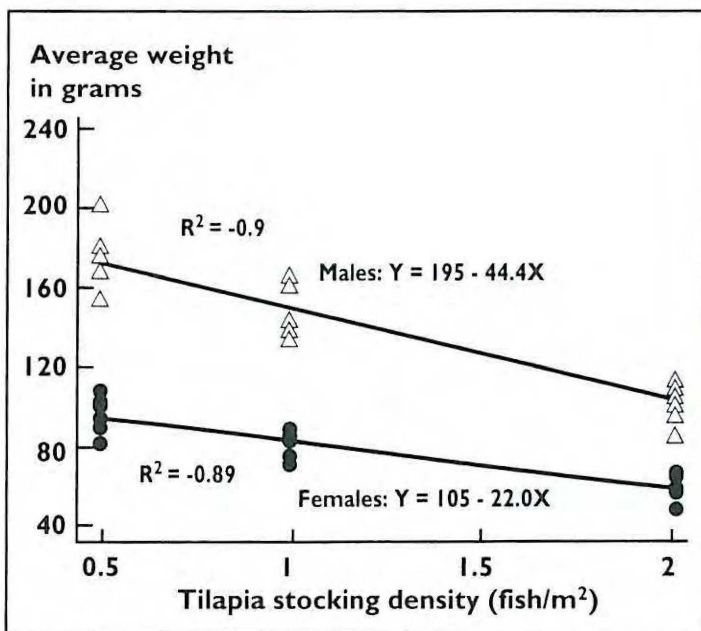


Figure 9. Mean weight of male and female tilapia (*Oreochromis niloticus*) at harvest in relation to stocking density at both composting application regimes.

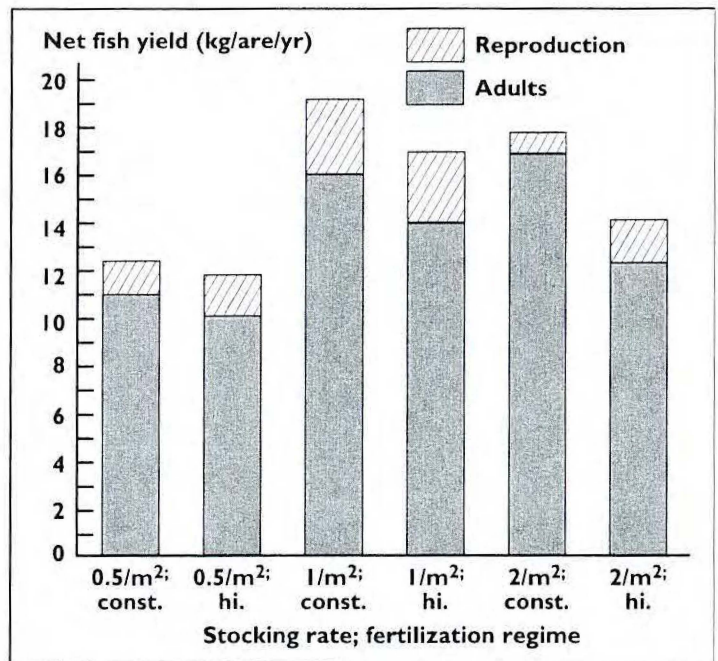


Figure 10. Production of adult and fingerling tilapia (*Oreochromis niloticus*) under two pond fertilization regimes—high initial (HI) and constant (CONST)—and at three stocking densities.

Table 6. Mean Weight of Males at Harvest in Study of Influence of Composting Regimes and Stocking Density on Mixed-Sex Tilapia Production¹

Compost regime	Stocking rate (fish/m ²)			Mean
	0.5	1	2	
	g	g	g	g
HI	161	150	100	137 ^a
CONST	183	155	112	150 ^b
Mean	172 ^b	152 ^a	106 ^a	

¹Superscript letters in a column or in a row denote means with significant differences at 95%.

Table 7. Mean Weight of Females at Harvest in Study of Influence of Composting Regimes and Stocking Density on Mixed-Sex Tilapia Production¹

Compost regime	Stocking rate (fish/m ²)			Mean
	0.5	1	2	
	g	g	g	g
HI	89	79	58	75 ^a
CONST	103	84	67	85 ^b
Mean	96 ^b	82 ^b	62 ^a	

¹Superscript letters in a column or in a row denote means with significant differences at 95%.

ponds only if the fingerlings were withheld until sufficient compost was added to the pond. Unfortunately, fingerlings were usually delivered within one to two weeks after the farmer qualified to get them, that is, after they paid their money and had their compost enclosures filled up. This experiment shows that fingerlings were delivered when the morning dissolved oxygen levels were at their lowest.

EFFECT OF OREOCHROMIS NILOTICUS-CLARIAS GARIOPIINUS POLY-CULTURE ON PRODUCTION

EUGENE RURANGWA

Oreochromis niloticus has for many years been the only species popularly cultured by Rwandese fish farmers. *Clarias gariepinus*, a species widely distributed in much of Africa has received much attention for culture, especially for its potential as a polyculture species with *O. niloticus* to benefit from an unexploited ecological niche in the pond and to reduce the overpopulation of tilapias.

The production of these two species in polyculture was studied in two different experiments. The first was conducted in six ponds, of seven ares each, over 175 days. All ponds were stocked with finger-

lings of *O. niloticus* averaging 25 grams at one per square meter. Two months later, *C. gariepinus* fingerlings averaging 3.6 grams were added to three of the ponds at one per three square meters (treatment ON-CG). The other three ponds were left as they were (treatment ON).

The second experiment was conducted as the first, the only difference being the ponds used (3.3 ares each), the duration (210 days), the initial weight of the *O. niloticus* (51.2 grams) and the *C. gariepinus* (3.43 grams). All ponds in both experiments were fertilized with a mixture of freshly cut grasses and chicken litter added weekly to compost enclosures in the pond. Fish were fed rice bran at 10% body weight per day, up to a maximum of five grams per fish per day.

In each of the two experiments, no significant differences were observed in net annualized fish yields between the two treatments: (Experiment 1) 3,231 kilograms per hectare per year for ON-CG, and 3,432 kilograms per hectare per year for ON; and (Experiment 2) 4,127 kilograms per hectare per year for ON-CG, and 3,360 kilograms per hectare per year for ON.

However, the yield of marketable fish was significantly greater in the ON-CG treatment than in the ON treatment in each of the experiments: (Experiment 1) 2,899 kilograms per hectare per year for ON-CG, vs. 2,130 kilograms per hectare per year for ON; (Experiment 2) 3,610 kilograms per hectare per year for ON-CG, vs. 2,033 kilograms per hectare per year for ON.

A simple economic analysis based on the value of the fingerlings used and the sale of market-size fish (all other factors being equal) demonstrated that the comparative benefit of polyculture was 25% greater than monoculture in the first experiment and 61% greater than monoculture in the second experiment.

If considering the sales of excess fingerlings four grams and over, after providing for re-stocking the ponds at the same rate, the comparative benefit of polyculture over monoculture falls to a -16.5% in Experiment 1 and to +16% in Experiment 2. The negative benefit in Experiment 1 could come from excessive predation on the young tilapias.

It is concluded that polyculture is preferable in zones where production of food-size fish is more important than production of fingerlings, for example at lower elevations where excessive fingerling production predominates.

RAISING RABBITS OVER FISH PONDS

JAMES VAN VLEET

Raising rabbits over fish ponds is a recent practice at the National Fish Culture Center of Rwanda, located at Kigembe. The first rabbit barns with 142 cages over a 0.5-hectare pond were constructed in 1988. Over the next three years, a 30-cage rabbit barn was built over a 0.2-hectare pond, and a 48-cage barn was just completed over another 0.5-hectare pond.

Table 8. Mean Yield Data for Study on Effect of *Oreochromis Niloticus-Clarias Gariepinus* Polyculture on Production¹

Experiment	Treatment	Cycle	Net yield-adults	Net yield-ON	Net yield-CG	Yield - market-size fish	Yield-ON fingerlings	Pct. of yield as reprod.
		days	kg/are	kg/are	kg/are	kg/are	kg/are	
1	ON-CG	175	32.3	10.2	3.7	13.9 ^a	4.2	23 ^a
1	ON	175	34.3	10.2	0.0	10.2 ^b	8.7	46 ^b
2	ON-CG	210	41.3	15.0	5.5	20.5 ^a	8.0	28 ^a
2	ON	210	33.6	11.7	0.0	11.7 ^b	12.6	51 ^b

¹For each experiment, superscript letters denote significant differences at the 95% confidence level. ON is *Oreochromis niloticus* and CG is *Clarias gariepinus*.

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The fish used in integration with the rabbits at Kigembe have been mainly *Oreochromis niloticus*. In the past year some clarias have been added but only experiences with *O. niloticus* will be discussed here. *Oreochromis niloticus* (mixed sex) stocked in integrated ponds are about 50 grams in weight and are stocked at two per square meter. Average individual weight gain is over one gram per day during the four-month cycle. A complete harvest is done and the pond is restocked a few days later. The net yield is about 6.1 tons per hectare per year of *Oreochromis niloticus* with the market fish averaging 180-220 grams. Reproduction accounts for about 10-15% of the total yield.

In comparison with chickens, pigs, and ducks, fish production with rabbits is slightly less than with chickens but well ahead that of pigs and ducks (Table 9). One possible reason that the rabbit- and chicken- integrated systems continually derive better results than the pigs and ducks is that the rabbits and chickens are housed over the respective ponds instead of beside the ponds like the pigs and ducks. This results in any spilled feed by the rabbits or chickens being directly consumed by the fish.

Table 9. Annual Net Fish Yield from Integrated Fish-animal Systems at Kigembe

Animal system	1988	1989	1990
	kg/ha	kg/ha	kg/ha
Chickens	6,200	6,500	--
Rabbits	--	6,000	6,100
Pigs	4,955	5,000	5,100
Ducks	4,500	4,500	4,500

Loading Rates

Rabbits at the Kigembe Station have varied in size from 10 grams to 6.5 kilograms. Loading rates were therefore based on weight rather than number. However, rapid growth of rabbits and varying litter size complicated this approach. The breeding program at Kigembe allows for each brood doe to produce young four times per year and raise their offspring (average eight young per litter) to two kilograms apiece within two months. The recommended rate for a pond using breeding adult rabbits of the medium size breeds (average weight about four kilograms), having breeding does producing four litters per year of six to 10 babies per litter and raising them to 1.5 to two kilograms within two months is six kilograms of breeding does per are (1.5 breeding doe of four kilograms average weight). This formula will supply another three to five kilograms of young rabbits per are, and the total of nine to 11 kilograms per are should supply sufficient manure for an excellent pond bloom.

If non-breeding or semi-intensive breeding does are used, the recommended loading rate is eight to 12 kilograms of rabbits per are (two four-kilogram semi-intensive brood or three to four non-producing does or bucks with average weight of three to four kilograms). The main point to observe is that the total weight of rabbit stocked will be reduced the more intensively they will be bred and/or the better producers they are.

Even though only about 20% of the weight of rabbit manure is urine, the urine contains about 50% of the nitrogen, 6% of the phosphoric acid, and 60% of the

potassium of the total manure. Also, the nutrients in the urine are more readily available to the pond phytoplankton than the nutrients in the solid excrement. These factors are important in looking at the value of placing rabbits over fish ponds because if the rabbits were placed on land, most of the N from the urine would be lost.

Using six kilograms of breeding does per are will supply about 120 kilograms of manure per are from the does and their offspring in one year. This 120 kilograms of manure will provide almost 2.88 kilograms of nitrogen, 1.68 kilograms of phosphoric acid and 0.72 kilograms of potassium. To supply the same amount of N + P, one would need almost twice as much chicken manure or over four times more pig manure (Table 10).

Housing for Rabbits over Fish Ponds

A breeding doe should have at least one square meter of cage floor area for her and offspring. Young does or bucks should have at least half of a square meter of cage floor space per individual. If a person can afford it, it is advisable to increase these recommendations by another 50%. Rabbits in larger cages seem to maintain better health.

At Kigembe, only wire floors have been used until now, so that is what will be discussed here. The wire found in Rwanda that has worked best for cage flooring has been half-inch square welded wire. Two years ago it cost about 3,000 Frw per square meter of floor space to build these cages along with the barn that housed them or the supports and walkways that held them. At present it will cost about 7,000-8,000 Frw per square meter of floor space. The biggest expense is the wire needed for long-lasting, well-ventilated, easy-to-clean cages. With the expense being so high for these cages it becomes important for the farmer to use them to their full potential.

There are several important factors in cage construction. First, one should allow at least 180-200 centimeters between the cage bottom and the water surface. This distance will permit proper moist air disbursement from the pond and not cause respiratory problems in

Table 10. Manure Output and Nutrient Content of Some Domestic Animals Used in Integrated Fish-animal Systems at Kigembe

Animal	Tons of manure ¹	Pct. nitrogen	Pct. P ₂ O ₅	Pct. potash
Rabbit	9.24	2.40	1.40	0.60
Chicken	9.90	1.10	0.80	0.39
Sheep or goat	13.20	1.44	0.50	1.21
Swine	35.20	0.49	0.34	0.47
Dairy Cow	26.40	0.57	0.23	0.62
Duck		0.60	1.40	0.50

¹Tons of manure per 1,000 pounds of liveweight.

Table 11. Summary Recommendations to Start a Four-are Pond with Fish-rabbit System¹

- (1) Build 12 cages over the pond, allowing six square meters of floor space for 60 kilograms of rabbits.
- (2) Buy 60 young rabbits — one kilogram each — and put them into cages as family groups, if possible.
- (3) Stock the pond with 880 *Oreochromis niloticus* of about 20-50 grams (two per square meter plus a 10% loss factor).
- (4) Weigh rabbits weekly and identify future breeders.
- (5) As the young rabbits near two kilograms, start selling off the smaller ones.
- (6) As the rabbits near three kilograms, separate males from females and choose the best male for the herd buck. Sell the rest.

¹Editor's note: The pond can be harvested after four months.

the rabbits. The cage should also be wide and shallow, rather than narrow and deep. This will permit easy access as rabbits will invariably go to the back of a cage when the front door is opened. It was found that an 80 centimeter front-to-back measurement for cages was about the maximum distance. Also, even though wire is very expensive, it should be used to supply good air circulation inside the cage. See Table 11 for a summary of recommendations to start a four-acre pond using the fish-rabbit system.

Feeding Rabbits over Fish Ponds at Kigembe

The feeding program started with local feedstuffs (sorghum, maize and soybeans), rice bran and free choice plants. Different problems arose with this program, mainly periodic unavailability of some ingredients, resulting in incomplete feed mixture (usually much lower in protein than required), low conception rates, small litters, slow gains, and overall poor health. Another major problem was that the cost of locally grown ingredients actually became greater than premixed chicken feed from a local distributor. Table 12 demonstrates how the price differences for feed stuffs evolved in a feed mixture using local ingredients as 50% of the mixture and rice bran or wheat bran as the other 50%.

Table 13 shows the cost of chicken feed as 50% of a feed formula using rice bran or wheat bran to satisfy the other 50%. By comparing the bottom lines of Tables 12 and 13, one can then see how it not only becomes more economical to use chicken feed in the formula, but also it provides a higher protein for the rabbits than the locally grown feed.

The 50% chicken feed/50% wheat bran mixture being fed at Kigembe provides about a 16-18% protein feed, which falls well within the 15-20% protein feed recommended for rabbits depending on what stage of growth or condition they are in. I prefer to use wheat bran instead of rice bran as a diet component for the following reasons: (1) wheat bran is more expensive, but the final cost of the diet is cheaper — this is because the amount of costly chicken feed can be reduced due to the higher protein content of the wheat bran; (2) rabbits seem to prefer the wheat bran mixes more; (3) the rabbits gain weight faster on wheat bran mixtures; (4) rice bran has a higher fat content and tends to spoil more quickly than wheat bran; (5) because of the much higher fat content of rice bran, processed rabbits have shown a higher body fat content than those fed on wheat bran formulas; and (6) rabbits fed wheat bran formulas have better overall health.

With fresh plants and fresh water also given daily, this formula seems to be supplying all stages of rabbit production with sufficient protein and other feed requirements needed for excellent growth and maintenance. Plants are important in the feeding program as they supply many vitamins and minerals not otherwise available and also give the rabbits something to chew on other than their cage.

The amount of feed needed for a brood doe with 10 babies until the babies are of market size is about 40 kilograms. In the first month, a gestating doe will eat three kilograms of the feed mixture.

Table 12. Comparative Costs of Rabbit Feeds Used in the Integrated Fish-animal Systems at Kigembe Before and After Devaluation in November 1990

Ingredient	Pct. protein	Before Nov. 1990			After Nov. 1990		
		Unit cost	Pct. of ration	Cost	Unit cost	Pct. of ration	Cost
Sorghum	11.1	22	29	6.38	55	29	14.15
Maize	9.5	35	10	3.5	55	10	5.5
Ground soybeans	37.9	43	9.5	4.1	63	9.5	6.0
Fish meal	60.0	300	1.0	3.0	450	1.0	4.5
Salt	0.0	35	0.5	0.18	60	.5	0.3
Half total above	16.74	34.3	50	17.15	—	50	30.45
Rice bran	13.5	7	50	3.5	10	50	5
Mixture w/ rice bran	15.12	—	100	20.65	—	100	35.45
Wheat bran	16.0	10	50	5.0	12.5	50	5.25
Mixture w/ wheat bran	16.37	—	100	22.15	—	100	36.70

Table 13. Cost of Feed Ration Composed of Chicken Feed and Either Rice Bran or Wheat Bran Used in the Integrated Fish-animal Systems at Kigembe Before and After Devaluation in November 1990

	Before Nov. 1990	After Nov. 1990
Chicken feed (20% protein)	38 Frw/kg x 50% = 19 Frw	43 Frw/kg x 50% = 21.5 Frw
Rice bran (13.5% protein)	7 Frw/kg x 50% = 3.5 Frw	10 Frw/kg x 50% = 5 Frw
Total mix (16.75% protein)	22.5 Frw/kg	26.5 Frw/kg
Chicken feed (20% protein)	38 Frw/kg x 50% = 19 Frw	43 Frw/kg x 50% = 21.5 Frw
Wheat bran (16.0% protein)	10 Frw/kg x 50% = 5 Frw	12.5 Frw/kg x 50.0% = 6.25 Frw
Total mix (18% protein)	24 Frw	27.75 Frw

During the second month, a doe and 10 babies will eat 4.5 kilograms; babies should each weigh half a kilogram by the end of the month. In the third month, the rabbits will consume 19.5 kilograms; babies should weigh 1.5 kilograms each by the end of the month. The doe should be removed from the cage and bred again at this point. Ten weaned babies will consume 13 kilograms during the fourth month; each baby should weigh 1.8 kilograms and should be marketed by the end of the third week of the fourth month. At 28 Frw per kilogram, the 40 kilograms of feed would cost 1,128 Frw.

The previous numbers only refer to the 50/50 mixture of chicken feed and wheat bran and do not include the plants that also need to be fed. The plants being fed may not enter into the feed figures as nutrients, but they do become important when calculating the costs of feeding the rabbits. Labor to collect one to two kilograms of wild plants per day over a 110-day period is estimated to cost 370 Frw. Thus, total feed costs would equal approximately 1,500 Frw to produce 10 baby rabbits.

Marketing Rabbits

At market price of 250 Frw each, 10 baby rabbits sold after 11-12 weeks, would earn the farmer 2,500 Frw. Taking into account the total feed costs, the net profit for one doe producing 10 babies for three months would equal 1,000 Frw. Net profit per doe per year would equal 4,000 Frw; this figure does not include the cost of housing.

In reality, rabbits at Kigembe are sold for 150 Frw per kilogram of live weight or 260 Frw per kilogram dressed weight. But, distance from major urban centers has made it necessary to develop markets in Butare and Kigali. Only 10% of the rabbits produced at the station are kept for breeding purposes. The remaining 90% are marketed,

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80% in Butare and 10% in Kigali. In 1990, 660 rabbits were sold for 180,000 Frw, equivalent to 270 Frw per rabbit sold. This year's (1991) sales have almost doubled with anticipated results being 1,000 rabbits sold at 360 Frw per rabbit. This increase in price per rabbit is due to higher selling weights of the rabbits and some higher paying markets in Kigali.

STUDIES ON THE ECOLOGICAL IMPACT OF FISH CULTURE

WILLIAM G. DEUTSCH

From Aug. 6-17, 1990, an environmental assessment was conducted at 10 potential sites (in seven prefectures) for cooperatively managed, integrated aquaculture farms in the marais (wetland valleys) of Rwanda. Sites were evaluated for existing pond construction and management practices, and recommendations were made to minimize the risk of waterborne disease and other negative environmental impacts.

Snail hosts for schistosomiasis and sheep and cattle liver fluke occurred at more than half of the 10 ponds sampled. Mosquito larvae were less common, and anopheline mosquitoes (vectors of malaria) were found at only one site. Most snails and mosquitoes occurred at poorly built and managed ponds. The presence of a well-

trained extension agent at a site was a critical factor to ensure well-managed ponds and thus reduce risk of waterborne disease.

Two supply canals and three discharge canals were sampled for macroinvertebrates to determine possible downstream impacts of fish ponds. Benthic communities were characterized by low biodiversity and high tolerance to organic enrichment, probably because of frequent dredging of canals, intermittent water flows and organic runoff from human and livestock activity. No negative environmental impact directly attributable to fish culture activity was detected.

At the scale and management intensity of the proposed aquaculture centers, fish ponds would have relatively low volume and infrequent discharges that should not cause undue environmental degradation downstream.

Four streams with a wide range of organic pollution were sampled for macroinvertebrates to evaluate methods for a biomonitoring program. Use of a biotic index proved appropriate and practical for assessing stream water quality in Rwanda. Protocols with field methods, data interpretation tables, and a cumulative list of macroinvertebrate taxa in Rwanda are provided in the final report.

Risks of indiscriminate introduction of non-native species to Rwanda are discussed, and a review and decision model for evaluating proposed exotic fish introductions is presented in the final report.

Summary of Workshop Subjects

THE IMPORTANCE OF DISTINGUISHING BETWEEN STUNTED ADULTS AND FINGERLINGS WHEN RESTOCKING RURAL PONDS

KAREN L. VEVERICA

Problem: the first production cycle is often quite encouraging for new farmers. If the stocking density is low enough to allow good growth given the inputs used (usually one fish per square meter or even two fish per three square meters), the fish are large enough for market before they have produced very many fingerlings. This is the basis of the stocking rate-production cycle recommendations; we want fish to reach market size before they produce so many fingerlings that overcrowding occurs and inhibits growth.

However, the farmers often think that instead of say, 400 large fish, they can get 800 large fish out of their pond just by putting in more fingerlings and not increasing the inputs. Extension agents often explain that this is not how it works but the farmers agree with them so they will go away and then the farmer adds fingerlings to the pond. Another problem is that ponds may not drain and dry totally, leaving many fry in the pond, or the farmers do not want to kill the poor little fish left on the pond bottom and they close up the levee before the pond bottom has had the chance to dry. Thus, even if the farmers restock at a low rate, the remaining fry result in a much higher stocking density. The second production cycle will therefore result in very many fish, some of which are large and others which are quite small.

It is at this point or possibly in the third cycle that things really start to go awry. The fingerlings used to re-stock the ponds are often much older than they should be. If, for example, you want a 10 gram fingerling, you may choose an old fish, usually female that hasn't

grown. We have gotten females that are two years old and are only 10 to 12 grams. They do spawn, almost immediately. This causes an almost immediate over-population in ponds and the old problem of tilapia culture appears even here at the higher elevations where we have the advantage of low reproduction rates. Farmers who select their own fingerlings or uninformed extension agents who help them often choose these small females as fingerlings. One way to overcome this is through monosex culture but it looks like farmers are not quite ready for that. As the next step, we must teach the farmers to either sex their fish or to at least cull out small, mature females. To identify fish to cull, here's what to look for:

Large Head to Body Ratio: It seems that the head and especially the eyes of fish continue to grow even though the rest of the fish has ceased growing. Some farmers have remarked that small old females have big eyes.

Spawning Colors: For the mature females here, we see a darkening of the body which can be picked out if the water color is right (not too muddy) and if the fish are not held in a shiny new bucket.

Easy to Sex: We usually have trouble hand-sexing fish of 15 grams or less, but if there are small old females, they can be quite readily distinguished. Eggs may even pop out of their vent under slight pressure.

Even though it may be beyond our present capability to supply monosex fingerlings, we must show farmers how to cull out these

old females. We have encountered several situations in which the fish would not grow and upon sampling the pond, we found it to be stocked with almost 100% small females. Once the farmers are shown how to distinguish these fish, they can readily identify them. It is quite realistic to think that farmers can, through hand-sexing, get an almost all-male tilapia culture going. The few females the farmers may put in by mistake should give them enough fingerlings for re-stocking.

Editor's note: the following year, we did some on-farm trials with monosex tilapias selected by hand sexing. During the samplings, we noticed a few female fish in the ponds that were supposed to have all males. Our hand sexing was about 98% correct, but those 2% females gave enough fingerlings to restock the pond at two to three fish per square meter. Some farmers became very good at sexing tilapia, but it is hard to predict who will be good at it without checking them. Some of the farmer experts were old, others very young; some women and some men. Even some of the young children became good at sexing tilapia.

PONDCLASS PROGRAM

This computer program was developed as an expert system meaning that if there is no expert around, this should do. If there are experts, the program can still help them in areas where they lack information. But a good expert can probably do as good or better than the program as it stands now. Please try out the program and fill in the evaluations.

There are three options for increasing production of fish in ponds: (1) polyculture of two or more non-competitive species to more efficiently utilize the pond's natural food; (2) chemical or organic fertilizers to enhance primary production; and (3) feeds.

The present Pondclass program focuses on the second option. Some basic assumptions are made: (1) increasing primary production will increase fish yields (often the case with tilapia but not always); (2) external factors limiting primary production are solar radiation and temperature; we can't do much about these and they are taken as "uncontrollable" for the location; and (3) internal factors are nutrients — therefore, the object is to estimate the concentrations of nutrients that permit the maximum or optimum primary production; and (4) ratios of 40C:7N:1P are used as ideal, even though this has been disputed — the carbon comes from the alkalinity system.

The users found the lists of fertilizer types and their corresponding nutrient concentrations to be of value. Also the climate data from nearby reporting stations was impressive. Many conference participants noted that the extension services in their country is far from being able to use such tools. Not only are computers very rare but many extension agents have trouble using a calculator, not to speak of a computer. However, as a teaching aid in university classes and as an aid in research, the program was perceived as quite interesting.

Editor's note: Pondclass has been superseded by a much improved version called POND. It is available from John Bolte or Shree Nath of the Department of Bioresource Engineering, 104 Gilmore Hall, Oregon State University, Corvallis, OR 97331, USA.

POND COLOR AND ASSOCIATED PHYTOPLANKTON BLOOMS AT RWASAVE STATION

We have continually followed phytoplankton composition in production ponds and in experimental ponds for several years, now at Rwasave. Based on these observations, we can predict phytoplankton composition based on pond color in some instances.

Bright Red Color at Surface: If the color turns green at dusk or in the shade and back to bright red/rust, it is a type of euglena, *Euglena sanguinensis*. It does not seem to pose any immediate problem to the fish, and we have observed them feeding on it. Since it stays on the surface, though, it can inhibit sunlight penetration that would, in turn, increase primary production if nutrients were available. If you think this is a problem, you can wait for the wind to blow it in a corner and take it off with baskets. This bloom is associated with muddy ponds that are a little bit fertile. That's because the only place where the phytoplankton can get light is at the surface. We always get some type of euglenid as a surface bloom immediately following pond filling, again because the water is a little muddy as it rushes in to the pond and mixes up the bottom and also because resting stages of euglena can survive in the mud of a drained pond. This usually is replaced by other types of phytoplankton as the clay turbidity decreases.

Reddish-brown, Very Light Film: Usually *Trachelomonas* spp., another euglenid and actively fed upon by tilapia.

Very Thick Pea-green Bloom at the Surface, Floating in Gobs Sometimes: This is almost always some type of *Microcystis*, a blue-green algae. We never had thick blooms of this until we started using urea and TSP. It had not been a problem on the station and was even associated with good tilapia growth until recently, when some very thick blooms caused oxygen depletion in all but the last few centimeters of surface water. We often have one pond per treatment develop a nuisance bloom of *Microcystis* that is very thick and in which more than 50% fish mortality occurs and very low growth rates are observed.

Bright Green, Almost Chartreuse: This color is associated with small green algae, often the type with indigestible mucilaginous sheaths (*Scenedesmus* sp., for example). Ponds with this color often look great, have a secchi disk reading of about 20 centimeters, nice green color and decent water quality. However, the fish don't grow. We have had this problem in one pond on the station (F6). The only thing we can do is try to change the bloom by fertilizing with another type of manure. We can also feed the fish more or try to perturb the bloom by seining.

Azolla

Azolla (the water fern) was pointed out to those participants who have never seen it before. The experiences of the Rwasave Fish Culture Station with azolla have been mixed. It was first brought on the station by researchers in about 1986, after they heard what remarkable nitrogen fixing and phosphorus concentrating qualities it had. However, it became apparent that these qualities were due to the symbiotic blue-green algae of the Genus *Anabaena*. This same genus appears free-living in the ponds and indeed its presence is always a sign of good tilapia growth. On the other hand, when *Anabaena* is present in the form of azolla, it is more difficult to obtain its advantages. Azolla is not consumed by young tilapias nor by clarias. It is consumed ("bothered" is a better word) by tilapias over 50 grams, but it can quickly get out of hand in understocked ponds or in fry grow-out ponds.

There have been thick blooms of Azolla in station ponds, which have led to cooling of the water by more than 2°C and oxygen depletions due to the complete shading of the pond. If the tilapia are large enough, the azolla can be pushed back to a corner with long bamboo rods and penned up. This allows the under-layers to die back and provides an open spot on the pond for the normal type of phytoplankton bloom to develop. The larger tilapias can then usually take care of

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the escapee azolla and sometimes crop back the corralled azolla. There is some information on the different species of azolla and it is known that certain species are more palatable to tilapias than other species of azolla. Also, some of the more herbivorous tilapias may more readily consume azolla than *O. niloticus*. However, I have witnessed ponds stocked with grass carp (*Ctenopharyngodon idella*) get so full of azolla that oxygen depletion occurred and killed all of the fish.

At this point the participants from the National Fish Culture Center in Kigembe began to detail their bad experiences with azolla in grass carp ponds.

Azolla in Animal Feed: The N content of dried azolla is relatively high (almost 5%). However, it must be removed from the pond in wet state. Azolla is more than 90% water. It therefore takes much labor to remove a few kilograms of nitrogen. At Rwasave, when fresh azolla was given to pigs at levels of 10% or more, they quickly developed diarrhea. Chicken do consume small amounts of azolla, and we often will try to put some in with their feed. However, we hesitate to do this for ponds with chickens in pens above the water because we then risk spreading it all over the station again.

Azolla in agriculture: Since we needed to remove the azolla from certain ponds, and we hated to waste all of the nitrogen and phosphorus it contained, we began using it as a soil amendment. It seems to work quite well to improve soil texture and fertility. We are now able to grow a nice crop of carrots in some previously unproductive heavy clay soil. As an amendment, it works about as well as compost taken from the ponds after draining. But we have done no real research on the qualities of azolla as soil amendment.

The recommendation we can give to farmers is: (1) if you have azolla completely covering your fish pond, you should try to

remove it with baskets or corral it; (2) removed azolla should be applied to nearby garden plots and turned into the soil but beware, large amounts of pure azolla will get very hot when decomposing; (3) do not allow your animals to eat only azolla; (4) If you are growing only clarias or only tilapia fry, azolla can cause big problems — it will have to be removed every few days.

Analyses made at Rwasave station found that 100 kilograms of fresh weight azolla has the following proximate composition: 93 kilograms of water; seven kilograms of dry matter; 2.3 kilograms of ash, or total minerals (33% of dry matter weight); 336 grams of nitrogen (4.8% of dry matter, which means it is about 30% protein when dry); 28 grams phosphorus (0.4% of dry matter); and 28 grams of calcium (0.4% of dry matter)

At higher elevations, we observe more duckweed than azolla in ponds but it can be treated in pretty much the same way.

Editor's note: This discussion was initiated by K.L. Veverica, with contributions from conference attendees. Much of this workshop was conducted during the pond tour.

VISUAL AIDS USED BY EXTENSIONISTS

Conference participants brought examples of their extension manuals and posters. Burundi has the best collection of instructional posters. Some pages of the books are reproduced in Figure 11. The page on composting is also enlarged to make a poster. J.P. Marquet showed some "fiches techniques" from Congo, for feeding fish. The extension agent training manual for Rwanda is much more technical in nature than the manuals used for farmer training in Burundi and Zaire.

Zaire volunteers showed how they describe the pond to farmers using ideas they know. The "restaurant," or feeding/compost area; the "bed-room," or banks of the pond where the fish nest; and the living area. The extension project in Zaire has produced a flipchart to aid in explaining fish culture.

The aim of the visual aids is best summarized by the justification for the posters produced in Burundi: they are reminders of what the farmers have seen and done during demonstrations conducted by a well-trained individual. The posters are especially effective because the farmers like to hang them in their homes. Nothing can substitute for a live demonstration.

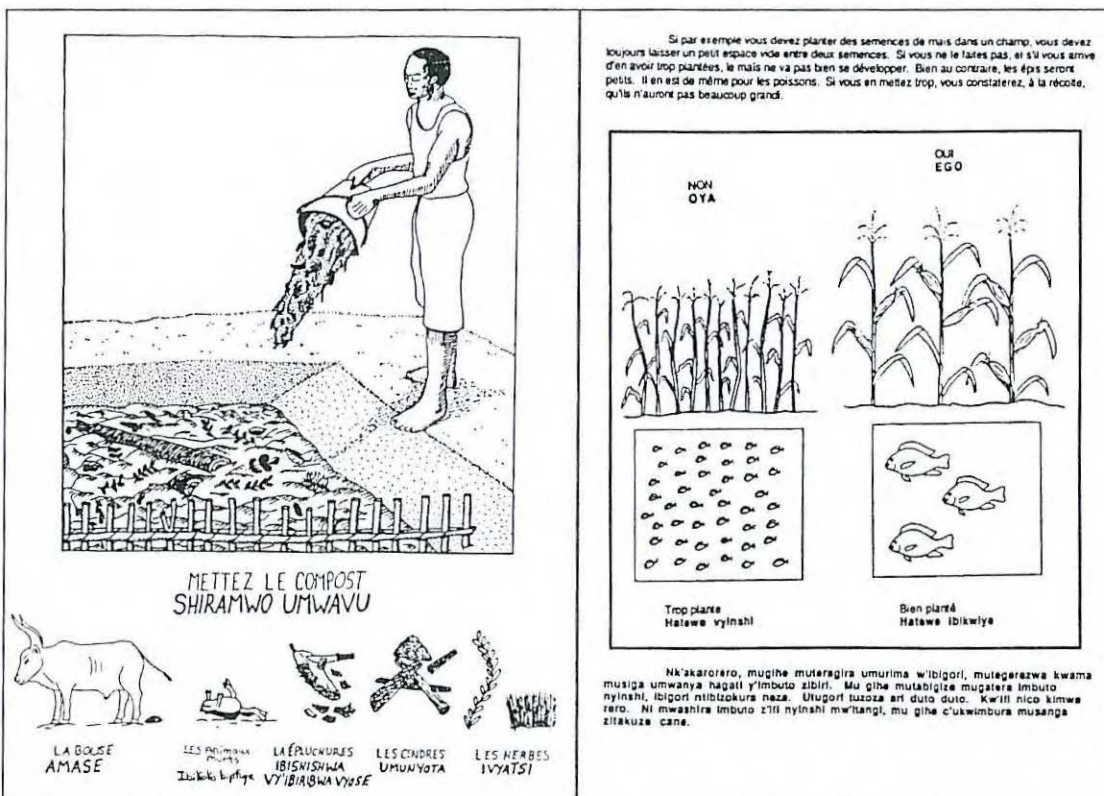


Figure 11. Selected pages in the bilingual (Kirundi and French) Burundi fish culture booklet demonstrating composting and stocking density vs. growth.

Discussions on Extension Service Organization and Critiques

ZAIRE'S EXTENSION PROGRAM

C. HENDERSON

The objective of the Peace Corps is to get the farmers to understand all they can about fish farming so they can be self sufficient. This is because the Zaire government rarely pays their personnel and cannot be relied upon to provide any services. The technical assistants and *animateurs* do not work often with the volunteers, usually because they are spending most of their time trying to locate their monthly salary. The Peace Corps volunteers (traveling by motorcycle usually but sometime on foot) work with the farmers directly. The regional coordinators have a vehicle at their disposal. Note that the PCVL and technical assistants are counterparts. They co-sign cheques and perform other responsibilities cooperatively. Training is provided to the technical assistants and the *animateurs* every year.

All Zairian extension personnel stay at the regional capital. The PCVs are assigned to villages; they work within a 40-kilometer radius. Their Zairian counterparts therefore have to travel greater distances to visit farmers.

Discussion

Remark: There are very few Zairian counterparts and this is not sustainable.

Answer: For Zaire, anything that relies on a functional government is not sustainable. This is the best that we can think of to do with the situation as it is. Also, communication problems are common: PCVs speak poor French but communicate mostly in local languages. The Technical Assistants are usually out of their native region also and must learn the local language. The PCVs view the farmers as their real counterpart. When PC closes down a post, they hope to have a committee of farmers formed who can help others to get started and pass on information. The farmers even send in reports on production.

BURUNDI'S EXTENSION SERVICE

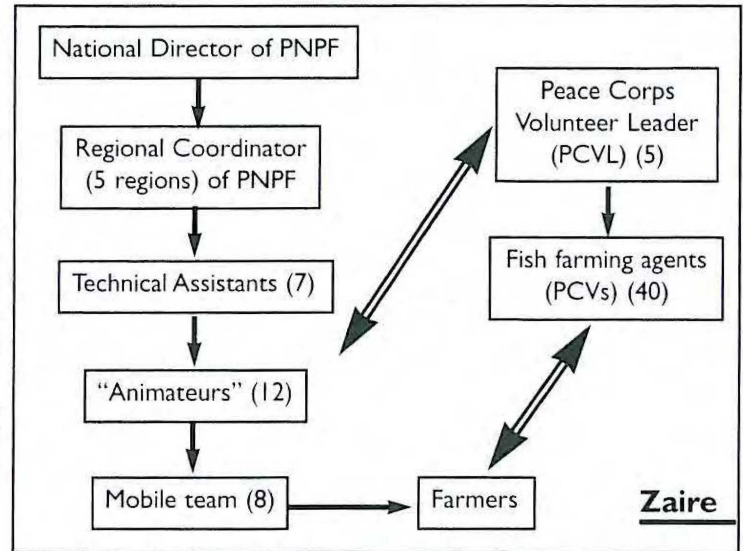
A. KIYUKU

There are two main constraints to this system. First is the lack of trained personnel. Provincial agronomes say they do not have enough time to spend on fish culture and they are not trained. Therefore there is a lack of counterpart personnel for the PCV's. The fish culture program started after a large-scale reforestation program was begun.

Also, there is a hiring freeze at all government agencies except for health and education, so no new extension personnel can be hired. We are therefore forced to try to use the people currently on hand, even though they work under a different ministry and are not evaluated on their efforts to help fish culture. We do not think the Peace Corps can make a long-term contribution unless they leave behind trained counterparts.

Discussion

Rwanda is best organized in terms of governmental assistance. There are several donor agencies who help out, but the majority of the personnel working in fish culture has been paid (reliably) by the government. Fish culture extension in Zaire has developed in



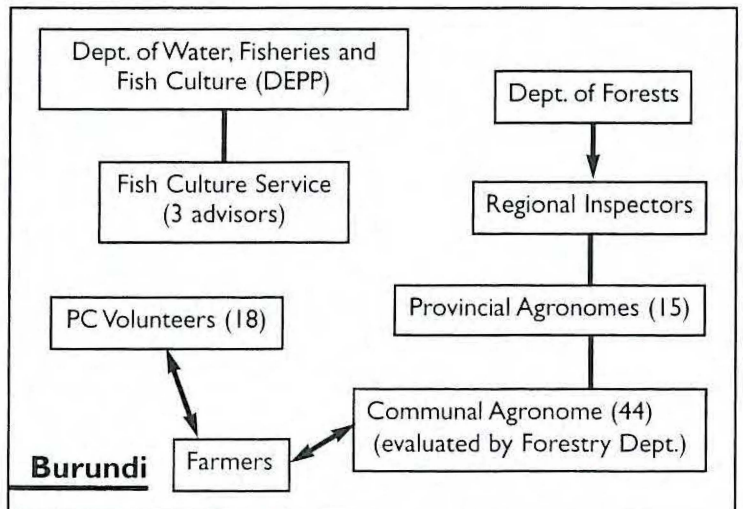
a way to be autonomous of the government.

Burundi is somewhere in-between. The DEPP would like to have a program like Rwanda's, but there are no funds available. Even donor agencies will not pay extensionists unless the government agrees to hire them on. The partnership of the Ministry of Agriculture and their rural development programs that cover fish culture and the Ministry of the Environment is an uncomfortable one. The only reason fish culture has developed so far is due to the Peace Corps volunteers.

In terms of government organization and intervention, the countries are ranked in this order: Rwanda>Burundi>Zaire. However, the quality of fish culture that is practiced (management, etc.) goes in the reverse direction.

Q: Can we propose a short-term strategy to get people trained?

Comment: It is impossible to train everyone well. Especially in pond



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construction. We need to have some very well-trained people in this. It is a bit easier to train many people well in pond management.

Q: Can we think of short-term development differently from long-term development? Perhaps propose an intensive project to train people and farmers, after which the extension program is organized to give less instruction but just a small amount of follow-up?

Comment: In Burundi, if a person is trained and then leaves the service, they take their knowledge with them.

Comment: There can also be a problem in terminating positions. People think that to have a government job means it is for life.

Comment: In Rwanda, I think we will have to come to that. The farmers are getting to know as much or more than the extension agents now, especially where the extension agent has been good enough to transfer everything they know about fish culture to the farmers. The farmers now know how to seek out information on their own. But it seems unfair to lay off an extension agent because they have done such a good job, and it is not possible to transfer them out of their home commune to start in a new area; they would not be accepted by the farmers if they are from a different commune.

Comment: Rwanda has decided on a long-term training programs funded by USAID and other projects. (Editor's note: These government agents use the phrase "long-term" to refer to higher education, MS and PhD.)

Comment: Zaire does not receive enough aid in this area.

Comment: However, Rwanda is paying 90% of its extension agents. Other projects pay for their training, though.

Comment: In Burundi, the Peace Corps program was interrupted in 1987, and we used the agronomes. They still do some fish culture extension work. Presently, the volunteers consider themselves to be a project separate from the agronomes.

Comment: The agronomes say that they do not have the time to work with us.

Comment: There is a lack of planning to get the working relationships going. The government must include fish culture extension into an agent's responsibilities if they are expected to do this work.

Comment: Fish culture in Burundi is not so well developed as in Rwanda because the government authorities do not accord it sufficient importance. We are in the process of making them aware of fish culture. Also, people who are untrained in a domain are very hesitant to go out into the field and demonstrate their lack of knowledge.

Comment: We had such problems in Rwanda before.

Comment: In Burundi's case, we have limited means and we must learn to live within them.

Comment: Yes, but then you should not expect the same results as a country with more means.

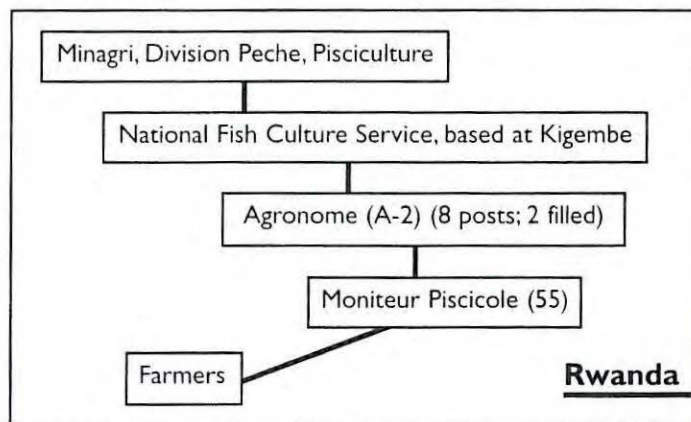
Comment: What we should strive for is reaching as many farmers as they do in Rwanda and getting the quality of production as is done in Zaire.

RWANDA'S EXTENSION SERVICE

PAUL MPAWENIMANA

There are eight zones, each supervised by an *agronome*. The field agent is the *moniteur piscicole*, acting at the commune level. They travel by bicycle and are supposed to: (1) make the population aware of fish culture; (2) help in pond construction and renovation; (3) verify if ponds are ready to be stocked; (4) write to the SPN to request fingerlings; (5) help in stocking and pond management; and (6) help in harvesting and record keeping.

All but a few extension agents are paid by the Ministry of Agriculture. Two are paid by UNR through Rwasave Station, and one



is paid by a development project. All of them report to the SPN in Kigembe, though. The *moniteurs* also send reports to the *agronome*, who consolidates them into a report for the zone, which is sent to SPN. But there are very few *agronomes* and the ones we have are not very active. We really only have two, so *moniteur* reports are collated mostly at the SPN. These *agronomes* are a major constraint to our program. They are the A-2 level, with special training in fish culture from Bouake, Ivory Coast. They do not want to go into the field and help the *moniteur*. They are always looking around to be posted as a Project Manager somewhere. We would prefer the A-0 level.

Discussion

Q: Is there no A-1 level?

A: Not yet, but there was a special training institute set up recently. The lack of activity of the A-2 means that we have a problem supervising the *moniteurs*. Their supervision is left to us at the SPN but we are somewhat outside the normal structures of the government and we have problems coordinating with communal authorities and other projects. (Editor's note: A-2 level is educated at a secondary school for agriculture; A-1 is further training; somewhat like a bachelor's level but not as broad in content. A-0 is somewhat between bachelor's and master's-level university training.)

Comment: Another major constraint is the lack of a policy on the use of the "marais."

Comment: In Rwanda there are too many farmers per acre.

A: But they say they are happy. However, we do require they have one acre pond area per member.

A: This rule is not followed and we cannot obligate people to follow it; we can only make the recommendation.

Comment: But this is ridiculous — 50 people on eight acres. Why not have them construct more ponds?

A: They always say they will but they can rarely get more land allocated to them because of local jealousies, etc. We have policies and recommendations but there are severe land constraints in Rwanda. We know that privately managed ponds produce more than group-managed ponds, and that institutional ponds are the worst. We do not promote the construction of ponds which are constructed by forced labor and managed by forced labor only to have the proceeds go to some government official or school supervisor. However, this still happens.

More discussions followed, and a general consensus was reached to concentrate efforts on the farmers who are most serious and who want to produce large quantities of fish. These farmers would be the most open to learning good pond management techniques. This does not always work as envisaged, though because there will always be imitator farmers who do not merit the efforts of a selective extension service and who dig holes in the ground and call them fish ponds.

COUNTRY CONSTRAINTS AND RECOMMENDATIONS OF CONFERENCE PARTICIPANTS

Constraints as Described by Representatives of Each Country

Rwanda: (1) higher level personnel (A-0 and A1) trained in fish culture and fisheries are assigned elsewhere; (2) supervision by prefectural coordinators is lacking; (3) NGOs intervening in fish culture are not coordinated and depend on other administrative structures; (4) lack of a land use and management strategy — current policy inhibits development of fish culture; and (5) only informal collaboration between extension and research services, no formalized links.

Burundi: (1) lack of trained personnel; (2) administrative structure unfavorable to fish culture (fish culture extension covered by General Direction of Waters and Forests and the personnel and funds required receive last priority) — specialists in fish culture assigned to a different ministry; and (3) government policy for re-structuring has stopped all recruitment in sectors judged to be non-priority (fish culture falls into this category.)

Zaire: (1) lack of administrative structure to manage fish culture extension; (2) insufficient or total lack of collaboration between Peace Corps volunteers, other foreign technical assistants, and the fish culture agents; (3) few Zairian counterparts available to interact directly with fish farmers; (4) logistical problems in extension work given the long distances to travel; (5) lack of data (pond statistics); and (6) lack of training for Zairian personnel. (Zaire was represented at this conference only by Peace Corps volunteers, the Regional Coordinator having been called to Kinshasa.)

Recommendations of Conference Participants

(1) Maintain a program in fish culture training at all levels, including primary and secondary schools.

(2) Encourage development of land use and land tenure policies for each country.

(3) Maintain concentration on *O. niloticus*. The next most interesting species is *Clarias gariepinus*.

(4) Base stocking rates on the management intensity. Use stocking rate of about one fish per square meter when ponds are fertilized well and fed some. Use two fish per three square meters if ponds are only fertilized or if the farmer just started. For fish production integrated with animal husbandry, stock up to two or 2.5 fish per square meter.

(5) Do not give free equipment such as wheelbarrows. It attracts less serious individuals.

(6) Promote self-sufficiency of farmers in fingerling production. This can cause problems for fingerling quality but there is no guarantee that government stations have high quality fingerlings either. Try to get some type of fingerling certification program going.

(7) Pursue research on new species.

(8) Encourage the exchange of stocks of fish between the countries.

(9) Try to conduct more trials with farmers, with parallel trials at stations if possible.

(10) Standardize collection of data and readily exchange data.

(11) Try to get a section for fish culture in the Economic Community of the Great Lakes Countries, much like the fisheries section that is already there. This can be the organizing vehicle for future conferences.

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