

3.2 Abstracts of Technical Reports

GLOBAL RESEARCH

Pond Dynamics

POND SOIL CHARACTERISTICS AND DYNAMICS OF SOIL ORGANIC MATTER AND NUTRIENTS

Eighth Work Plan, Pond Dynamics Research 1 (PDR1)

Claude E. Boyd and Julio Queiroz
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, USA

C. Wesley Wood
Department of Agronomy and Soils
Auburn University
Auburn, USA

Abstract

The objective of this investigation was to further develop a system for classifying pond soils that will assist with aquaculture pond management. Soil cores were collected from ponds at the Asian Institute of Technology (AIT), Pathum Thani, Thailand; the El Carao National Fish Culture Center, Comayagua, Honduras; and the Granjas Marinas shrimp farm, San Bernardo, Honduras. Cores were separated into 2-cm long segments and subjected to physical and chemical analysis. Data on bulk density were used to separate core samples into the following horizons: surface, well-mixed layer with bulk density of 0.3 g cm⁻³ or less (S horizon); stable, mature sediment with bulk density between 0.31 and 0.7 g cm⁻³ (M horizon); transition layer with bulk density of 0.71 to 0.99 g cm⁻³; and original, undisturbed pond soil with bulk density of 1.00 g cm⁻³ and above. The S horizon was not more than 2 cm thick in any of the ponds, and only the upper 1 or 2 mm layer of the S horizon was oxidized (S_o subhorizon). Wet soil pH in almost all core segments was between 7 and 8. Dry soil pH was lower than wet soil pH. Concentrations of total carbon did not exceed 2.35% in any of the core segments, and the highest carbon concentrations were in S and M horizons. Total nitrogen ranged

from 0.04 to 0.29% and was highest in S and M horizons. The carbon:nitrogen ratios in the S and M horizons were between 7 and 15. Total sulfur concentrations ranged from 0.15 to 3.42%, and some core segments represented potential acid-sulfate soil material in ponds at AIT and El Carao. There was evidence of phosphorus and calcium accumulation in surface soil layers as a result of inputs of these elements through pond management. Magnesium, potassium, and sodium concentrations were higher in soils of brackish water ponds than in those of freshwater ponds because of inputs of these ions in brackish water. Iron, manganese, zinc, and copper concentrations in soils were not especially high at any of the locations.

Reproduction Control

ARTIFICIAL PROPAGATION OF NILE TILAPIA FOR CHROMOSOME MANIPULATION

Eighth Work Plan, Reproduction Control Research 1B (RCR1B)

William L. Shelton
Department of Zoology
University of Oklahoma
Norman, USA

Abstract

The objective of this study is to establish appropriate techniques for the androgenic production of YY male tilapia. This report discusses initial efforts in the collection of freshly ovulated eggs from Nile tilapia (*Oreochromis niloticus*) that are required in experiments to develop techniques for induction of androgenotes. Hormonally induced ovulation of tilapias has not been successful; however, under environmentally controlled conditions tilapias can be somewhat predictably spawned. Given suitable water temperature and a controlled photoperiod ovulation time for tilapia can be reasonably predicted. Aquarium spawning of the Nile tilapia was managed through photoperiod manipulation. Four to six females were stocked with one male in 550-l aquaria maintained at 26 ± 2°C. Fish ovulated

from 9.5 to 13.5 h after the controlled light-on cycle of a 20L:4D photoperiod. Ten females were stripped for artificial fertilization experiments, but only five progeny groups developed to hatching. Eggs were collected, milt was expressed over the eggs, and water was added to initiate activation. Fertilized eggs were placed in 1-l upwelling incubation units at a controlled temperature ($\pm 0.2^\circ\text{C}$) two to three minutes post activation. The temperature-related development rate was examined to develop a tau (t_0) curve to be used in chromosome manipulation. The mean mitotic interval during early synchronous cleavage was between 73.5 and 30 minutes at 20.6 and 27.5°C, respectively. The temperature-compensating index of development will be used to standardize the application of shock treatment.

STEROID IMMERSION FOR MASCULINIZATION OF TILAPIA

Eighth Work Plan, Reproduction Control Research 2 (RCR2) and 3 (RCR3)

Martin S. Fitzpatrick, Wilfrido M. Contreras-Sánchez, Ruth H. Milston, Michael Lucero, and Grant W. Feist
Department of Fisheries and Wildlife
Oregon State University
Corvallis, USA

Carl B. Schreck
Oregon Cooperative Fishery Research Unit
Oregon State University
Corvallis, USA

Abstract

The use of all-male populations increases the efficiency and feasibility of tilapia aquaculture. The objective of this study was to determine the efficacy of a short-term immersion procedure for masculinizing Nile tilapia (*Oreochromis niloticus*). Three experiments were conducted to test 1. the effects of 17 α -methyl-dihydrotestosterone (MDHT) immersions at different stocking densities (33, 67, 100, or 200 fish l⁻¹) 2. the effects of single immersions (33 fish l⁻¹) in 500 mg l⁻¹ MDHT at 280, 310, or 364 Celsius Temperature Units (CTU) and

3. the effects of 17 α -methyltestosterone (MT) fed treatments (60 mg MT kg⁻¹ of food for 28 days) versus immersion treatments of MT and another masculinizing androgen, trenbolone acetate (500 mg l⁻¹). A single immersion in 17 α -methyl-dihydrotestosterone at 364 CTU (day 13 post fertilization at 28°C) was as effective as two immersions at 280 and 364 CTU in producing 80% male populations. In a population of fish with a female-biased sex ratio that was not masculinized by four weeks of feeding with 17 α -methyltestosterone, two immersions in trenbolone acetate at 280 and 364 CTU produced over 90% males. These results suggest that immersion of tilapia in steroids is an effective alternative to dietary treatment with androgens for the purposes of sex inversion.

Marketing and Economic Analysis

ECONOMIC AND SOCIAL RETURNS TO TECHNOLOGY AND INVESTMENT

Eighth Work Plan, Marketing and Economic Analysis Research 1 (MEAR1)

Carole Engle and Pierre-Justin Kouka
University of Arkansas at Pine Bluff
Pine Bluff, USA

Abstract

The objective of this two-year study is to develop estimates of social and economic returns attributable to PD/A CRSP technologies. Year one involved data collection and year two will involve analysis. Impact and welfare analysis models have been developed. Supply and demand equations will be estimated to develop estimates of consumer and producer surplus before and after technology adoption. From these estimates the net change in social welfare will be estimated. Survey instruments were developed to collect data on adoption of CRSP-developed technologies from shrimp and tilapia growers in Honduras. Data collection should be completed by December 1997. The survey data will be used in the analysis.

RISK ANALYSIS OF POND MANAGEMENT STRATEGIES

Eighth Work Plan, Marketing and Economic Analysis Research 2 (MEAR2)

Carole Engle and Pierre-Justin Kouka
Department of Aquaculture and Fisheries
University of Arkansas at Pine Bluff
Pine Bluff, USA

Abstract

The primary objective of this study is to analyze the integration of pond fertilization schemes into farming systems including explicit treatment of risk factors, by use of a "safety-first" model. A farmer's decision to adopt a new technology will depend upon many factors that range from simple costs and returns to market factors and complex interactions between the new technology and the farming system practiced by the farmer. Survey instruments have been designed and are currently under review. They will be used to collect key production and price risk data on the variation in shrimp and tilapia production in Honduras. Data collection should be completed by December 1997.

Decision Support Systems

ADVANCES IN THE POND[®] SOFTWARE: WIZARD DEVELOPMENT AND MODEL REFINEMENTS

Eighth Work Plan, Decision Support Systems Research 1A, 1B, and 1D (DSSR1A, 1B, and 1D)

Shree S. Nath and John P. Bolte
Department of Bioresource Engineering
Oregon State University
Corvallis, USA

Abstract

To enable users to compare the production efficiency of pond culture systems receiving different levels of fertilization, alternate feed types (differing in moisture, protein, and energy contents), and various feeding levels, considerable refinements have been made to the POND[®] software in terms of its decision

support capabilities and systems models. To improve the user interface and provide better support for decision-making, a series of "wizards" has been implemented. The wizards assist users to set up ponds and lots, generate liming and fertilization guidelines, produce optimal feeding schedules, and simplify the steps required to perform simulations under different conditions. POND[®] software model refinements during the current reporting period also include methods that account for the effects of fertilization, high fish biomass, feed types, and feeding levels on fish growth. Simulation results of the refined fish bioenergetics model (POND[®] Version 4.0) for common carp (*Cyprinus carpio*) and the African catfish (*Clarias gariepinus*) and progress on the development of models for phosphorus flux and polyculture interactions in ponds are discussed. Additionally, descriptions of two research efforts that commenced in the area of macrolevel agroecological system analysis are provided: 1. the development of POND[®] software capabilities to simulate integrated farming systems and 2. the integration of POND[®] fish growth and water temperature models within a Geographical Information System (GIS) that will also include economic and production factors to assess aquaculture potential in Africa.

APPLICATION OF SYSTEMS MODELS FOR EVALUATION AND OPTIMIZATION OF POND MANAGEMENT PRACTICES

Eighth Work Plan, Decision Support Systems Research 1C (DSSR1C)

Shree S. Nath and John P. Bolte
Department of Bioresource Engineering
Oregon State University
Corvallis, USA

Abstract

A comparative analysis of the production efficiency of pond systems managed using different PD/A CRSP fertilization strategies at three locations (Honduras, the Philippines, and Thailand) was

undertaken. Fertilization rates recommended by PONDCLASS® (a responsive fertilization strategy) were three to seven times more efficient in terms of phosphorus (P) recovery in fish flesh compared to fixed input strategies that are typically used at these sites. Nitrogen (N) recovery was in general comparable to or somewhat higher than that obtained in fixed input strategies. Net fish yields for the fixed input treatments were in general higher than those for the PONDCLASS® treatments; however the cost efficiency (in terms of fertilization costs per unit of fish produced) for the PONDCLASS® treatment was 1.5 to 3 times higher than the fixed input strategy for experiments conducted in the Philippines and Thailand. In Honduras, cost efficiency was comparable for the fixed input and PONDCLASS® treatments. This analysis suggests that current fixed input rates particularly for P at CRSP sites can be reduced without compromising production efficiency. Drawbacks of responsive fertilization strategies, such as the need for water quality analysis and adjustment of fertilization rates for individual ponds, are discussed.

For semi-intensive pond aquaculture, feeds are often the dominant component of the variable cost of fish production. Therefore, developing optimal feeding schedules that minimize feed use is important. An adaptive, non-linear search strategy has been implemented in the POND® software that enables users to generate optimal feeding schedules for individual ponds. Example simulations indicate that although such schedules result in lower feed requirements, fish tend to be cultured for longer time periods compared to satiation feeding (100 d). The cost of holding fish for a longer period may need to be accounted for in order to generate feeding schedules that are economically optimal. This area will be explored in future work on the optimization of pond production techniques.

Aquaculture Systems Modeling

AQUACULTURE POND MODELING FOR THE ANALYSIS OF ENVIRONMENTAL IMPACTS AND INTEGRATION WITH AGRICULTURE: RELATIONSHIP BETWEEN CARBON INPUT AND SEDIMENT QUALITY IN AQUACULTURE PONDS

Eighth Work Plan, Aquaculture Systems Modeling Research 1A (ASMR1A)

Daniel Jamu and Raul H. Piedrahita
Biological and Agricultural Engineering Department
University of California
Davis, USA

Abstract

The objective of this study was to develop a computer model which can be used to analyze and predict nitrogen and organic matter flows in aquaculture ponds. Previous improvements made to the integrated aquaculture/agriculture model include:

1. consideration of organic matter and nitrogen transformations;
2. modification of the fish growth model to include the effects of low quality feed on fish growth;
3. inclusion of sediments in mass balance calculations; and
4. coupling of the agriculture component and the aquaculture pond ecosystem model.

Further improvements to the model focused on:

1. the incorporation of sediment mineral processes;
2. the calculation of the carbon to nitrogen ratio in the water column; and
3. the modeling of the light extinction coefficient in ponds with high non-algal turbidity.

The modeling of the agriculture component processes and the relationship between the soil-terrestrial crop submodels is also discussed. Simulation results for chlorophyll *a*, water column total ammonia nitrogen, sediment organic matter, and total nitrogen are presented. The refinements

made to the model suggest that accuracy in the simulation of organic matter and nitrogen improves with an increase in the level of detail of the water column and sediment process equations.

AQUACULTURE POND MODELING FOR THE ANALYSIS OF ENVIRONMENTAL IMPACTS AND INTEGRATION WITH AGRICULTURE: MODELING OF TEMPERATURE, DISSOLVED OXYGEN, AND FISH GROWTH RATE IN STRATIFIED PONDS USING STOCHASTIC INPUT VARIABLES

Eighth Work Plan, Aquaculture Systems Modeling Research 1B (ASMR1B)

Zhimin Lu and Raul H. Piedrahita
Biological and Agricultural Engineering Department
University of California
Davis, USA

Abstract

A model has been developed to predict water temperature, dissolved oxygen (DO), and fish growth in stratified fish ponds using stochastic weather variables. In the past year two model components were modified: phytoplankton respiration and organic matter decomposition, and two new components were added: the abilities to account for pond water exchange and multiple feed supplies. The model was tested using data from the PD/A CRSP Rwanda site. Simulation results are presented including water temperature, DO, individual fish weight, ammonia concentration, and chlorophyll *a* concentration.

Adoption/Diffusion

ASSESSING THE HUMAN CAPITAL IMPACTS OF THE PD/A CRSP: A CONCEPTUAL FRAMEWORK

Eighth Work Plan, Adoption and Diffusion Research 1 (ADR1)

Joseph J. Molnar
Department of Agricultural Economics and Rural Sociology
Auburn University
Auburn, USA

C. Kwei Lin
Agricultural and Aquatic Systems
Asian Institute of Technology
Pathum Thani, Thailand

Abstract

This qualitative study will assess the human capital impacts of the Global Experiment in terms of training, advancement, and the technology transfer of developing-country nationals affiliated with PD/A CRSP research sites. The PD/A CRSP seeks to promote aquaculture through research and extension services in certain countries. One aspect of this program is the support of students in aquaculture programs. This report summarizes some considerations related to the backgrounds of these students, their career paths after degree completion, and the connections of these experiences to subsequent involvement in the aquaculture sector.

REGIONAL RESEARCH

Central America

EFFECT OF DIET PROTEIN ON SEMI-INTENSIVE PRODUCTION OF *PENAEUS VANNAMEI* DURING THE RAINY SEASON

Interim Work Plan, Honduras Study 1 (Part Ia)

Bartholomew W. Green, David R. Teichert-Coddington, and Claude E. Boyd
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, USA

John Wigglesworth, Hector Corrales, and Rafael Zelaya
Grupo Granjas Marinas, S.A.
Choluteca, Honduras

Delia Martinez and Eneida Ramírez
Laboratorio de Calidad de Agua
La Lujosa, Choluteca, Honduras

Abstract

The objective of this study was to determine the effect of dietary protein on shrimp growth and yield. The effects of four commercially-produced feed protein levels (12, 16, 20 and 30%) were tested during the semi-intensive production of *Penaeus vannamei*. Shrimp were cultured in sixteen 2-ha earthen ponds during a 110-day study. Ponds were stocked at 25 post-larval shrimp m⁻². Shrimp survival did not differ significantly among treatments and overall was much lower than expected because of Taura Syndrome. Feed protein level did not significantly affect gross yield, mean shrimp weight, feed conversion ratio, or shrimp growth. Similar quantities of feed were offered in all treatments; however, total nitrogen added to ponds (in the form of feed) increased significantly with feed protein content. Mean material exchange was negative (i.e., net discharge) for total nitrogen, total phosphorus, soluble reactive phosphorus, and chlorophyll *a* and

BOD₂. Greater amounts of total ammonia-nitrogen and nitrate-nitrite-nitrogen were taken into ponds than were discharged. There were no significant differences in material exchange among treatments.

ESTUARINE WATER QUALITY MONITORING AND ESTUARINE CARRYING CAPACITY

Eighth Work Plan, Honduras Research 2 (HR2)

Bartholomew W. Green, David R. Teichert-Coddington, and Claude E. Boyd
Department of Fisheries and Allied Aquacultures
Auburn University, Auburn, USA

Delia Martinez and Eneida Ramírez
Laboratorio De Calidad de Agua
La Lujosa, Choluteca, Honduras

Abstract

Water quality was monitored in major estuaries of Honduras affected by shrimp farming. Data collected will be added to baseline data established in 1993 and will be used to detect the deterioration or improvement of water quality and formulate and validate numerical estuary models. Samples were collected from 29 sites comprising 12 estuaries and embayments of the Gulf of Fonseca and the Choluteca River at La Lujosa and water quality was determined every one to two weeks. These data were added to baseline data that was established in 1993 to monitor long-term effects of shrimp farming on inlet water quality. Water quality continued to vary seasonally in estuaries directly influenced by riverine discharge. Nutrients concentrate during the dry season when there is little freshwater input and are diluted with rainwater discharge during the wet season. Embayment water quality was less seasonally variable and considerably less nutrient-enriched than riverine estuaries. No trends of long-term nutrient enrichment were detected in estuaries or embayments during the period of 1993 to 1997. Riverine estuaries are flushed annually during the wet season and embayments experience sufficient water exchange with the Gulf of Fonseca to effectively eliminate nutrient buildup.

ON-FARM SHRIMP (*PENAEUS VANNAMEI*) PRODUCTION TRIALS DURING THE RAINY SEASON

Honduras Special Topics Research

Bartholomew W. Green, David R. Teichert-Coddington, and Claude E. Boyd
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, USA

John Wigglesworth, Hector Corrales, Rafael Zelaya,
Brian Boudreau, John Harvin, and Wayne Toyofuku
Grupo Granjas Marinas, S.A.
Choluteca, Honduras

Delia Martinez and Eneida Ramírez
Laboratorio de Calidad de Agua
La Lujosa, Choluteca, Honduras

Abstract

The effect of geographic variation on shrimp growth, yield, and survival in ponds all managed similarly was evaluated in 0.3- to 2.3-ha earthen ponds located on four different commercial farms in southern Honduras. Ponds were stocked with hatchery spawned post-larval *P. vannamei* at 250,000 PL ha⁻¹ (25 PL m⁻²) from the same production run. Shrimp were fed a 30% protein commercial ration. Ponds were harvested after 110 days. Shrimp survival did not differ significantly among treatments, but was much lower than expected because of Taura Syndrome. Gross shrimp yields were low and ranged from 120 to 325 kg ha⁻¹. Shrimp yield increased significantly with increased survival ($r^2 = 0.885$, $P < 0.001$), while average individual weight decreased significantly with increased survival ($r^2 = 0.263$, $P < 0.05$). Total nitrogen, total ammonia-nitrogen, total phosphorus, and soluble reactive phosphorus concentrations did not differ significantly between pond intake and discharge water on individual farms. Among farms, chlorophyll *a* and BOD₂ concentrations in pond water were independent of total ammonia-nitrogen concentration ($r^2 = 0.034$, $P = 0.509$ and $r^2 = 0.006$, $P = 0.789$, respectively) and soluble reactive phosphorus concentration ($r^2 = 0.005$, $P = 0.800$ and $r^2 = 0.010$, $P = 0.726$, respectively).

South America

DEVELOPMENT OF SUSTAINABLE POND AQUACULTURE PRACTICES FOR *PIARACTUS* *BRACHYPOMUS* IN THE PERUVIAN AMAZON

Eighth Work Plan, Peru Research 1 (PR1)

Christopher C. Kohler
Fisheries Research Laboratory
Southern Illinois University at Carbondale
Carbondale, USA

Susan T. Kohler
Economic and Regional Development Office
Southern Illinois University at Carbondale
Carbondale, USA

Fernando Alcantara
Instituto de Investigaciones de la Amazonia Peruana
Iquitos, Peru

Enrique Rios Isern
Universidad Nacional de la Amazonia Peruana
Iquitos, Peru

Abstract

To compare survival, growth, standing crop at harvest, condition, feed conversion, and cost of production fingerling paco (*Piaractus brachypomus*) are being reared at two densities (3,000 and 4,000 fish ha⁻¹) in six earthen ponds ranging from 1,015 to 5,320 m² in size in Iquitos, Peru. Fish are being fed 3% of their wet body weight daily using a locally-manufactured feed (approximately 30% crude protein). Production trials commenced 29 April 1997. Data are not yet sufficient for making treatment comparisons; however, data for water quality variables (hardness, dissolved oxygen, temperature, conductivity, ammonia-nitrogen, carbon dioxide, pH, alkalinity, nitrite-nitrogen, and nitrate-nitrogen) and production data are presented in this report. Pond soil and water samples have been collected and sent to Auburn University for detailed analyses. Pond construction and production data for Iquitos are being collected.

East Africa

NEW SITE DEVELOPMENT AND CHARACTERIZATION

Eighth Work Plan, Kenya Research 1 (KR1)

James Bowman and Christopher Langdon
Department of Fisheries and Wildlife
Oregon State University
Corvallis, USA

Karen Veverica and Thomas Popma
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, USA

Abstract

The resident researcher arrived at the Sagana Fish Culture Farm on 31 March 1997 and pond renovation was begun on 10 April. Four of the farm's one-acre ponds were split into twelve experimental ponds and five fingerling production ponds. Activities to complete renovation through July 1997 included drain pipe installation, inlet reinforcement, and planting grass on levees. Several of the renovated ponds still require some excavation to ensure that depths and bottom contours are uniform among all experimental ponds. Each of the new experimental ponds will have a surface area of 800 m² and minimum and maximum water depths of 60 and 100 cm, respectively. The ponds have sufficient freeboard so that water levels may be raised to achieve maximum depths of 120 cm and surface areas of 825 m². Part of the earthen main water supply canal was lined with concrete.

Four of the farm's quarter-acre ponds were put into production after an extended period of disuse. Site development and characterization activities to be completed through September and October 1997 include: upgrading the chemistry laboratory; obtaining laboratory, farm, and office supplies, a datalogger system, and a four-wheel-drive vehicle; and characterizing the site in terms of soil, water, and climatic attributes.

STRAIN VARIATIONS IN SEX RATIO INHERITANCE

Eighth Work Plan, Kenya Research 2 (KR2)

Karen Veverica and Thomas Popma
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, USA

James Bowman and Christopher Langdon
Department of Fisheries and Wildlife
Oregon State University
Corvallis, USA

Abstract

The sex ratio of individual spawns has been studied in only a limited number of strains of *Oreochromis niloticus*. Although *O. niloticus* females are thought to be homogametic and males heterogametic, progeny of single pair spawns have not conformed to the expected 50:50 sex ratio inheritance. The variance in *O. niloticus* sex ratio inheritance may be related to strain differences. Pair spawning and grow-out of the Turkana strain of Nile tilapia (*O. niloticus vulcani*) is being conducted at the Sagana Fish Culture Farm. This strain originated from a stock isolated in a crater lake on an island in Lake Turkana, Northern Kenya.

In the current study, the sex ratio of each set of progeny with a minimum of 100 fish will be determined through gonadal examination. Spawning hapas were constructed and stocked between three and five times between February and June, 1997. When water temperatures were less than 24 °C, females were often killed by males. Bird predation on brood fish also contributed to losses. Of the five spawns obtained, survival of fry was very low, due to predation from insects, and no spawns resulted in fry numbers greater than 30. More spawning hapas will be constructed and protection against predators will be enhanced to obtain improved spawning results. Sex ratio data from each spawn will be analyzed by Chi square to determine whether it differs from the expected 50:50 inheritance. This research is carried out in conjunction with the study "Monosex Tilapia Production Through Androgenesis." For further description of the study see the Global Research section of this report.

NUTRITIONAL CONTRIBUTION OF NATURAL AND SUPPLEMENTAL FOODS FOR NILE TILAPIA: STABLE CARBON ISOTOPE ANALYSIS (EFFECT OF PRESERVATION METHOD ON STABLE CARBON ISOTOPE RATIOS OF PLANKTON AND TILAPIA)

Eighth Work Plan, Kenya Research 3A (KR3A)

Rebecca Lochmann and Peter Perschbacher
University of Arkansas at Pine Bluff
Aquaculture/Fisheries Center
Pine Bluff, USA

Abstract

Stable carbon isotopic analysis will be used to obtain quantitative estimates of the contribution of natural and supplemental feeds to the nutrition of tilapia in ponds at the Sagana site, Kenya, Africa. This will be accomplished by tracking the carbon isotopic “signatures” of tilapia and their known and probable food sources. Prior to analysis of samples from the experiment in Kenya, a pilot study was conducted at the University of Arkansas at Pine Bluff to determine whether different methods of sample preservation (formalin and alcohol or lyophilization) would affect the carbon isotope ratios of fish and plankton differently. Fish (*Oreochromis niloticus*) and plankton samples were collected from ponds in Arkansas. Each sample was divided into two halves. One half of each sample was subjected to fixation in formalin, followed by storage in alcohol. The second half was freeze-dried. All preserved samples were sent to a commercial laboratory (Coastal Science Laboratories, Inc.) for stable carbon isotope analysis. The carbon isotopic ratio of plankton preserved by formalin and alcohol was significantly different from that of plankton preserved by freeze-drying. Results did not differ for tilapia tissue preserved in formalin and alcohol versus freeze-drying. From the standpoint of isotopic analysis, either method of preservation would be suitable for further use in this study because the magnitude of the preservation effect was small compared to the trophic enrichment (diet) effect expected over the experimental period. However, freeze-drying is preferred because noxious chemicals are not used, samples do not have to be

shipped in liquid (which reduces weight and shipping costs), and because the variability in isotope ratios of freeze-dried samples was slightly lower than that of formalin and alcohol-preserved samples.

Southeast Asia

A FINISHING SYSTEM FOR LARGE TILAPIA

Interim Work Plan, Thailand Activity 4

Yang Yi and C. Kwei Lin
Agricultural and Aquatic Systems
Asian Institute of Technology
Pathum Thani, Thailand

Abstract

This report presents the results of two experiments. A 90-day experiment was conducted to determine the appropriate biomass of caged tilapia cultured in earthen ponds that is required to support maximum production of small tilapia in open water while maintaining acceptable pond water quality. An 84-day experiment investigated the effects of aeration on the growth performance of both caged and open-pond tilapia and on water quality. Large tilapia (91 ± 5.2 to 103 ± 4.6 g) were stocked in 4-m^3 net cages at 50 fish m^{-3} . One, two, three or four cages were suspended in each earthen pond (three replicates per treatment). Tilapia fingerlings (13 ± 0.3 to 16 ± 1.3 g) were stocked at two fish m^{-3} in the open water of all ponds. Caged tilapia were fed commercial floating pellets; open-pond tilapia were solely dependent on the uneaten pelleted feed and natural foods derived from cage wastes. Water quality was analyzed biweekly. The biomass of caged tilapia had significant ($P < 0.05$) effects on the survival, growth, and feed conversion ratio of caged tilapia and also on the survival and growth of open-pond tilapia. Survival of caged tilapia decreased from $100 \pm 0.0\%$ to $76.8 \pm 15.9\%$ with an increase in their biomass (number of cages per pond); however, survival of open-pond tilapia was significantly lower in the one-cage treatment ($89.7 \pm 2.2\%$) than in the two- and three-cage treatments ($94.6\% \pm 2.4\%$ and $95.5 \pm 1.1\%$, respectively). The mean weight of

tilapia harvested from cages decreased significantly from 478 ± 34.6 g in the one-cage treatment to 280 ± 32.0 g in the three-cage treatment. However, the growth of open-pond tilapia, ranging from 0.72 ± 0.03 to 1.27 ± 0.07 g fish⁻¹ d⁻¹ increased significantly with the increased biomass of caged tilapia. The total net yield in this integrated culture system was highest (4.83 ± 0.03 t ha⁻¹ crop⁻¹) in the two-cage treatment which had an overall feed conversion ratio of 1.00 ± 0.03 . Nighttime aeration enhanced the growth performance of caged tilapia (net yield of 6.93 ± 1.03 t ha⁻¹ crop⁻¹ compared to 3.65 ± 0.30 t ha⁻¹ crop⁻¹) and increased the overall carrying capacity of the system. However, the growth of open-pond tilapia in aerated ponds was significantly lower than in non-aerated ponds.

MANAGEMENT TO MINIMIZE THE ENVIRONMENTAL IMPACTS OF POND DRAINING

Eighth Work Plan, Thailand Research 3 (TR3)

C. Kwei Lin, Madhav K. Shrestha and Dherendra P. Thakur
Agricultural and Aquatic Systems Program
Asian Institute of Technology
Pathum Thani, Thailand

James S. Diana
School of Natural Resources
University of Michigan
Ann Arbor, USA

Abstract

The objectives of this study were 1. to evaluate the amount of nitrogen, phosphorus, and solids discharged from aquaculture ponds during harvest draining; and 2. to assess fish harvest techniques that may reduce the loading of nutrients and solids in effluent water. Nile tilapia (*Oreochromis niloticus*) (initial size 103 ± 1 g) were cultured for 113 to 119 days in 15 earthen ponds of 200 m² size. Fish were supplementally fed with 30% crude protein feed at 50% satiation level in a fertilized pond system. Five pond harvest/drainage procedures were followed: fish were anesthetized with tea seed

cake (10 ppm) and the ponds seined three times—ponds were not drained (A); ponds were limed, completely drained and fish were collected from a harvesting pit (B); ponds were completely drained and fish were collected from a harvesting pit (C); ponds were drawn down to 50 cm, fish were harvested by two seinings, followed by complete draining and collection from a harvesting pit (D); and similar to D, but water was drained into the empty ponds of D (E). The mean fish size at harvest was 528 ± 8 g. The total harvest using procedure A was $97 \pm 1\%$ of the total fish in ponds; 76 ± 5 , 14 ± 4 , and $6 \pm 1\%$ were harvested in the first, second, and third seinings respectively. Water quality was measured in column samples taken from undrained ponds and compared with effluent water quality at depths of 100-50 cm, 50-25 cm, and 25-0 cm from drained ponds. The waste discharged into receiving water was calculated for treatments B, C, D, and E. With the exception of total nitrogen, the effluent parameters measured (BOD₅, settleable matter, total solids, total volatile solids, total suspended solids, volatile suspended solids, and total phosphorus) occurred at higher levels in pond effluent water than was recorded in the water column of undrained ponds. Effluent values tended to increase as the pump position in the water column was lowered. Harvesting fish by seining, mid-way through pond drainage, also tended to increase the waste content of effluent water drawn from ponds, after seining, when compared with effluents of ponds which were drained without seine netting. Alternative fish harvest methods that minimize environmental impacts of pond draining are discussed.

A BIOENERGETICS GROWTH MODEL FOR NILE TILAPIA (*Oreochromis niloticus*) BASED ON LIMITING NUTRIENTS AND FISH STANDING CROP IN FERTILIZED PONDS

Thailand Special Topics Research 1

Yang Yi
Agricultural and Aquatic Systems
Asian Institute of Technology
Pathum Thani, Thailand

Abstract

A bioenergetics growth model for Nile tilapia (*Oreochromis niloticus*) in fertilized ponds was developed, which linked Nile tilapia growth with limiting nutrients in pond water. The model incorporated five key variables affecting growth in fertilized ponds: body size, temperature, dissolved oxygen, unionized ammonia, and food availability. In the model, food availability was estimated by a relative feeding level parameter, which was a function of potential net primary productivity based on limiting nutrients and standing crop for Nile tilapia. The model was validated using growth data for Nile tilapia in 30 fertilized ponds and successfully detected growth variations among ponds receiving the same nitrogen and phosphorus inputs. The model described 89% of the variance in growth in these ponds. The relationship between predicted and observed growth rates had a slope of 1.02 and an intercept of -0.17, not significantly different from 1 and 0, respectively. The model indicated growth variations that were caused by carbon limiting primary production during 55 to 99% of the culture period. Sensitivity analysis indicated that the parameters related to net energy from feeding were more sensitive than those related to fasting catabolism. Growth was most sensitive to food availability when DO was above its critical limit (1.0 mg l^{-1}) and was most sensitive to DO when it was below the critical limit.

A BIOENERGETICS GROWTH MODEL FOR NILE TILAPIA (*Oreochromis niloticus*) IN A CAGE-CUM-POND INTEGRATED CULTURE SYSTEM

Thailand Special Topics Research 2

Yang Yi
Agricultural and Aquatic Systems
Asian Institute of Technology
Pathum Thani, Thailand

Abstract

A bioenergetics model was developed to simulate growth of both caged and open-pond Nile tilapia in a cage-cum-pond integrated culture system. Five key variables affecting Nile tilapia growth—body size, temperature, dissolved oxygen, unionized ammonia and food availability—were incorporated in the model. Caged tilapia were given artificial feed, while open-pond tilapia were dependent on uneaten feed left by caged tilapia and natural foods derived from cage wastes. In the model, availability of natural foods was estimated by a relative feeding level parameter, which was a function of potential net primary productivity based on fish standing crop and limiting nutrients in ponds. The model was validated using growth data of both caged and open-pond tilapia in 28 ponds. The model described 95% and 83% of the variance in growth of caged and open-pond tilapia, respectively. Statistical analyses indicated there were agreements between predicted and observed values for both caged and open-pond tilapia. The model showed that, when the total number of tilapia stocked in cages was not greater than $200 \text{ fish pond}^{-1}$, the growth of open-pond tilapia was limited by the amount of phosphorus available to primary production. When more than $200 \text{ fish pond}^{-1}$ were stocked, phosphorus was initially the limiting nutrient but this later shifted to nitrogen. Nitrogen limitation increased from 0 to 84.4% of the culture period with increases of artificial feed inputs. The model revealed that nitrogen from biological nitrogen fixation accounted for 44.2 to 74.8% of the total nitrogen available for primary production. Under the model assumptions, pelleted feed accounted for only 13.8 to 14.6% of the growth of

open-pond tilapia when dissolved oxygen was above the critical limit (1.2 mg l^{-1}) for caged tilapia during the entire experimental period; however, the percentages ranged from 19.0 to 51.0% when dissolved oxygen was below this critical limit. Sensitivity analysis showed that parameters for caged tilapia affected growth of open-pond tilapia but not the reverse. Poor water quality (low dissolved oxygen and high unionized ammonia) further reduced the growth of caged tilapia, but increased the growth of open-pond tilapia.

EVALUATION OF LOW COST SUPPLEMENTAL DIETS FOR CULTURE OF *OREOCHROMIS NILOTICUS* (L.) IN NORTH VIETNAM (PART I)—FORMULATION OF SUPPLEMENTAL DIETS

Thailand Special Topics Research 3

Cao Thang Binh, C. Kwei Lin, and Harvey Demaine
Agricultural and Aquatic Systems
Asian Institute of Technology
Pathum Thani, Thailand

Abstract

An experiment was conducted to determine the feasibility of nine low-cost, formulated diets for Nile tilapia culture in North Vietnam. The first seven diets (T1-T7) containing 20% crude protein were formulated from locally-available ingredients such as concentrated chicken feeds, fish meal, rice bran, corn meal, and cassava meal. The two additional baseline diets (T8 and T9) used only rice bran or corn meal. All male, sex-reversed tilapia fingerlings with a mean weight of 8.4 g and stocked at 25 fish m^{-3} were cultured in net cages suspended in a $1,000\text{-m}^2$ earthen pond. The pond was fertilized with urea and superphosphate at a rate of 28 kg N and $7 \text{ kg P ha}^{-1} \text{ wk}^{-1}$. At initial stocking fish were fed 15% body weight per day which was gradually reduced to 3% body weight per day in accordance with fish growth over a 90-day culture period. Results showed significant differences among the experimental diets in fish growth rate, fish production, and feed conversion ratio (FCR) ($P < 0.01$), but results were not significant for

survival rate and protein content of harvested fish carcasses. The 20% crude protein diet formulated from concentrated chicken feed (40% crude protein) and cassava meal (T3) resulted in the highest growth rate and yield. Daily weight gain for this treatment was 1.91 g fish^{-1} , production was 4.17 kg m^{-3} ; and FCR was 1.64. Economic comparison showed that this diet also resulted in the highest profit ($\text{US\$ } 0.34 \text{ kg}^{-1}$ fish produced), which is approximately 11 times higher than the profit from the diet consisting solely of rice bran. Total feed investment per unit of area cultured for the T3 diet was relatively high but the break even price for 1 kg of fish produced was lowest ($\text{US\$ } 0.76 \text{ kg}^{-1}$ fish) due to high fish production. The treatments with diets formulated from fish meal and cassava meal (T6), fish meal and corn meal (T5), and concentrated chicken feed and rice bran (T4) had intermediate fish growth and fish yields and relatively high net profits. These results suggest that these diets present alternatives for farmers who require a relatively high net profit, but at a lower feed investment cost per unit area cultured. The sole use of either rice bran or corn meal for tilapia feeding resulted not only in low fish production and low profit but also in low returns to investment and high break even prices.

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**DEVELOPMENT OF LOW COST SUPPLEMENTAL
FEEDS FOR TILAPIA IN POND AND CAGE CULTURE
IN THE PHILIPPINES**

Eighth Work Plan, Philippines Research 1 (PHR1)

Kevin Fitzsimmons
Environmental Research Laboratory
University of Arizona
Tucson, USA

Antonio Circa
Freshwater Aquaculture Center
Central Luzon State University
Muñoz, Philippines

Abstract

A two-phase study will examine the use of yeast and composted rice straw as potential ingredients of supplemental feeds for tilapia (*Oreochromis niloticus*) and assess the effectiveness of compression pelleting technology in comparison with feeds processed using meat grinding equipment. Phase one will test two experimental diets—a 60% rice, 15% yeast, 25% meat and bone meal diet and a 60% rice bran, 15% composted rice straw, 25% meat and bone meal diet—in 12,500-m² earthen ponds. Ponds were stocked at three fingerlings m⁻² and received weekly nutrient inputs (1.625 kg of ammonium phosphate [16-20-0] and 1.1 kg of urea ammonium phosphate [45-0-0]). Tilapia were fed the experimental diets at 5% BWD for the first two months of the experiment and 3% BWD for the final month until harvest. Fertilization of experimental ponds was discontinued at initiation of feeding. Preliminary water quality results of the phase one experiment are presented in this report. The phase two experiment will test rice straw compost- and yeast-based diets prepared with a pellet mill or a meat grinder in 20 units of 6-m³ cages using a two x two factorial design.