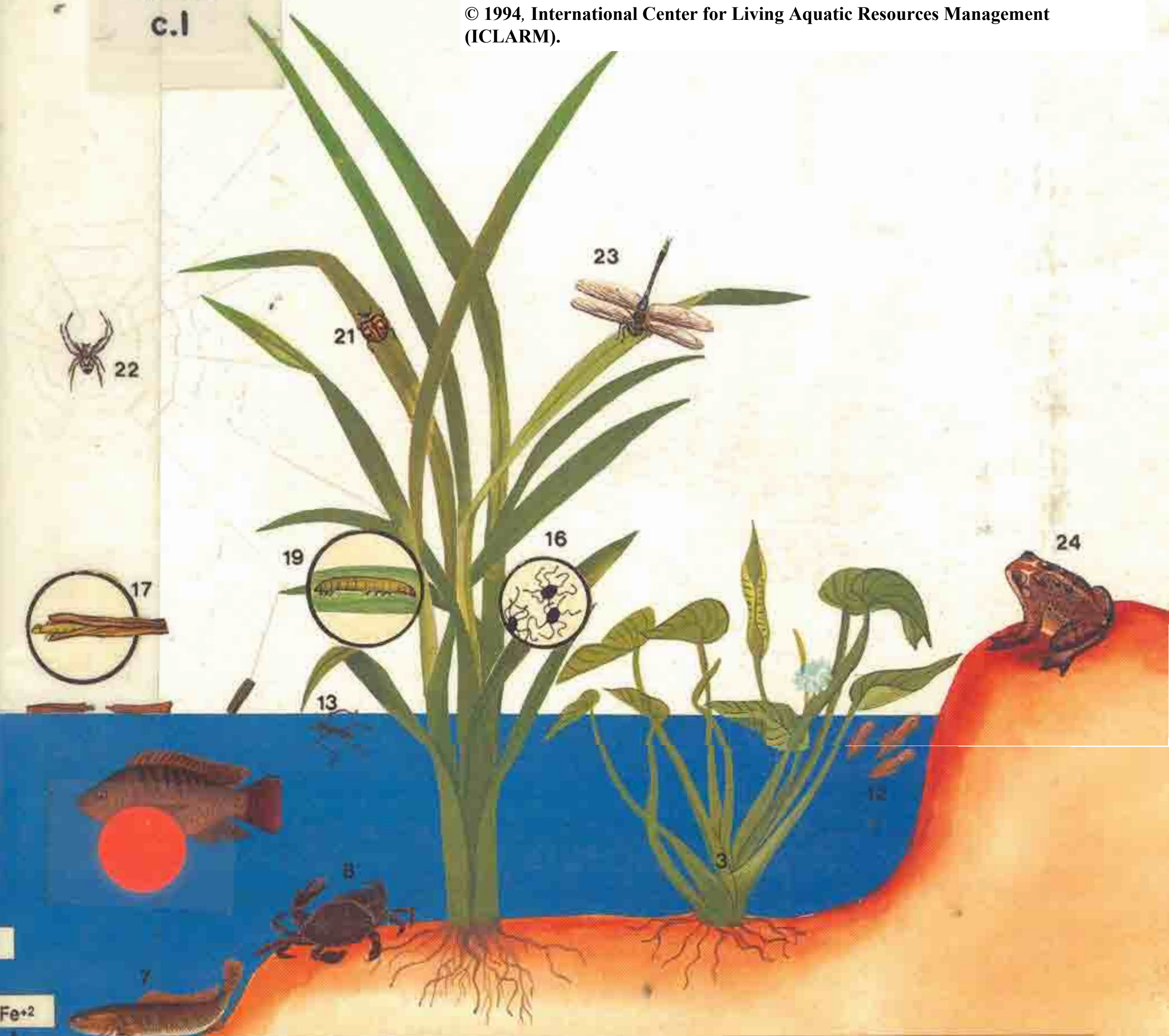
Role of Fish in Enhancing Ricefield Ecology and in Integrated Pest Management

Edited by Catalino R. dela Cruz



Central Research Institute for Food Crops-
Agency for Agricultural Research and Development

International Center for Living Aquatic
Resources Management

Role of Fish in Enhancing Ricefield Ecology and in Integrated Pest Management

Summary Report of the Third Asian Regional Rice-Fish Farming Research and Development Workshop
Sukamandi Research Institute for Food Crops
Sukamandi, Subang, West Java, Indonesia
6-11 June 1993

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CATALINO R. DELA CRUZ

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The workshop organizers express their great appreciation to the participants for their valuable contributions and cooperations in the workshop. Thanks are due to the efforts of ICLARM's Information Division, particularly Casilda I. Guevara for assisting in editing this proceedings.

Contents

INTRODUCTION

Dr. C.R. dela Cruz

Two regional workshops on rice-fish farming research and development were held in Ubon, Thailand, and at the Central Luzon State University, Philippines, in 1988 and 1989, respectively. In the 1989 workshop, the participants identified ricefield ecology and integrated pest management (IPM) as common research areas. For the following three years (1990-92), ICLARM, IRRI and CLSU collaborated in conducting research in ricefield ecology and IPM. As new knowledge has been generated from this research and in the region as well, a need arose to review and share the information. This is particularly true for the role of fish in rehabilitating ricefield ecology and IPM. Methodologies to expand the application of rice-fish in the region also needed discussion. Hence, the Third Asian Regional Rice-Fish Farming Research and Development Workshop was convened jointly by the International Center for Living Aquatic Resources Management (ICLARM) and the Central Research Institute for Food Crops (CRIFC) of the Indonesian Agency for Agricultural Research and Development (AARD), at the Sukamandi Research Institute for Food Crops (SURIF), Subang, West Java, Indonesia, on 6-11 June 1993.

The participants were from Bangladesh, Indonesia, Malaysia, the Philippines, Thailand, Vietnam, IDRC, ICLARM and IRRI. They included NGO staff active in rice-fish development; researchers and trainers involved in IPM and human disease vector control; researchers involved in the nutrient dynamics of ricefields; and researchers involved in the socioeconomic analysis of farmers' perception and adoption.

This volume reports the results from this regional workshop, as a series of extended Abstracts, Working Group Reports, and Recommendations. Focusing on the role of fish in enhancing ricefield ecology and in Integrated Pest Management (IPM) as its theme, the workshop reviewed the state of knowledge on the ecology of integrated rice-fish systems and the role of fish in Integrated Pest Management (IPM); drew up further research plans; and elaborated methodologies for evaluating the role of fish in ricefield ecology and IPM.

A simple ceremony opened the conference. The participants were welcomed and assured of ICLARM's continued presence and commitment on collaborative research work in the region by the workshop coordinator (Dr. C.R. dela Cruz). IDRC representative/consultant Dr. K.T. MacKay talked on IDRC's sustained support to rice-fish farming research and development in Southeast Asia (i.e., beginning in Thailand in 1984, the support has spread to Indonesia, the Philippines and Vietnam). IRRI Coordinator of Asian Rice Farming Systems Network (ARFSN) Dr. V. R. Carangal, discussed the role and activities of ARFSN in relation to rice-fish research and development. SURIF Director Dr. A. Fagi in welcoming the participants, reported that rice-fish farming has expanded and is now a national program in Indonesia. The rice-fish farms have increased to 150,000 ha, of which 65,000 ha occur in West Java.

Papers presented and group discussions provided new information and led to the identification of further research areas. Data presented indicated that the common species stocked in ricefields are common carp (*Cyprinus carpio*), Nile tilapia (*Oreochromis niloticus*) and silver barb (*Puntius gonionotus*) and that these increase rice yields, although variability is wide. The increased yields were attributed to changes in nutrient availability and pest abundance and farmers' perceptions and management. Evidence was also shown that fish are important in controlling malarial mosquitoes in Central Java.

New information was also presented on: the impact of agricultural practices on the aquatic invertebrates that contribute to the food supply of fish in ricefields, and on the feeding ecology of fish in ricefields; the application of an ecological modeling tool ECOPATH II to irrigated rice-fish ecosystems; the concept of Aquatic Life Management (ALM) in ricefields to signify the usefulness of frogs, indigenous fish and other aquatic organisms; and the complementarities among rice-fish farming, ALM and IPM.

It appears that fish may be an important entry point for the adoption of IPM. Alternatively, the adoption of IPM may be a necessary condition for the adoption of fish in rice. An FAO Intercountry Programme is now including rice-fish culture in its farmer training programs for IPM in Bangladesh and Vietnam.

A broader approach to fish culture in ricefields and IPM is now developing; i.e., to include Integrated Vector Management (IVM), to ALM and IPM in ecosystem management (EM) or ALM+IPM+IVM = EM.

The areas needing further research in ricefield ecology and IPM in relation to fish are as follows:

Ricefield ecology

- Characterization of rice-fish ecosystems (irrigated, rainfed, deepwater and tidal).
- Enhancement of rice-fish production systems (nutrient dynamics and management techniques, environmental protection of rice-fish ecosystems, comparative ecological modeling, feeding ecology of fishes and its relationship to ricefield management techniques, and the role of indigenous species in ricefields).
- Socioeconomics and adaptive research - that is, knowing farmers' needs, resources and problems (constraints to rice-fish culture, extension strategies and economics).

IPM

- Documentation and quantification of the effects of fish on rice ecosystems (rice yield and pest management).
- Monitoring, evaluation and adoption (constraints to adoption; entry points and sustaining adoption; quantify farm and systems level effects).
- Effects of pesticides and pesticide residues on fishes and aquatic organisms.

Details of the above research areas are in the Working Groups' reports and recommendations which follow.

Cognizant of the need to sustain the momentum gained in rice-fish farming research, the participants wrote a resolution acknowledging the progress achieved and outlining the importance of continued support for rice-fish culture research. The resolution is presented on p. 18.

WORKING GROUP REPORTS AND RECOMMENDATIONS

I. Fish and Ricefield Ecology

Convened by Mr. G. Chapman and Dr. A. Ali

The group drew plans for further research and elaborated methodologies for research on the role of fishes in ricefield ecology.

Research Priorities and Methodological Comments

The following is based on the premise that rice-fish culture is beneficial both for the rice crop and for fish production. Hence, the mechanisms that generate these benefits now deserve further study. The broad areas of research identified are ricefield ecosystem characterization, ecosystem enhancement in rice-fish production systems, and socioeconomics and adaptive research.

Ricefield Ecosystem Characterization

It was recognized unanimously that research priorities should be ecosystem-specific. Therefore, ecosystem characterization is needed as a first step in deciding what research and development should follow.

Four major ecosystems were listed: irrigated, rainfed, deepwater and tidal. Working Group II also recognized the need to classify rice ecosystems. Their categories were intensive lowland, rainfed lowland, tidal wetland and upland. It was pointed out that irrigated ricefields include both intensive and non-/semi-intensive rice cultivation.

The existing knowledge on the physical, chemical, biological, agronomic and climatological ecology of each type of ecosystem needs thorough review and publication in a synopsis. Any gaps should be filled through surveys (Participatory Rapid Appraisal, etc.) and appropriate direct measurement. Specific parameters (e.g., soil structure, pH, nitrogen) should be recorded and kept as baseline information through which the effects of fish culture could subsequently be evaluated. The parameters of interest need further elaboration.

Research priorities could be arranged in a matrix with ecosystem type along one axis and research area along the other.

Ecosystem Enhancement in Rice-Fish Production Systems

Five major research areas were identified: 1) nutrient dynamics and appropriate management techniques; 2) environment protection of rice-fish ecosystems; 3) feeding ecology of fishes and its relationship to ricefield management techniques; 4) comparative ecological modeling; and 5) other special considerations. These are discussed after the following general comments.

- Immediate answers should not be expected from this kind of research. Donors should expect satisfactory pictures to emerge after three to five years of work, and should be ready to provide support accordingly.
- Some of the topics covered can be addressed only in controlled on-station experiments. Others can be addressed with validity only on-farm. Researchers should keep this in mind when planning and preparing their work.
- Conventional statistics should be used with caution, and should not be the only criterion in evaluating the relevance of findings. Particularly in on-farm research, non-significance of results proves little or nothing, since real differences are usually confounded by many uncontrollable factors which cannot be always measured. Any positive result which entails minimal risk should be communicated.
- Multivariate statistics can be very helpful in exploring relationships in existing and in newly generated data sets. They should be put to greater use.
- Not all of the research listed below can be done everywhere. The number of centers capable of doing some of the basic research is particularly limited. Management options can be tested at the national/local level.
- Prioritization of research should be at the national and provincial levels, and should include feedback from the end-users.
- Continuous contact with the end-users of the research is necessary in order to assure that the research remains relevant, in content and approach, to their needs and problems.
- Many of the topics that follow are good thesis materials for graduate students. Scientists will often be overly burdened with administrative tasks, and may not be able to give some of these questions the detailed attention they require.

Nutrient Dynamics and Appropriate Management Techniques

The mechanisms by which rice-fish culture affects rice yields are of particular interest, but a number of other phenomena also call for this type of work. Among the parameters which should be measured are the rate of nitrogen uptake by rice plants at different stages in their life cycle, and levels of dissolved orthophosphate at different times throughout the season. The parameters crucial to the sustainability of ricefield ecosystems need further identification.

The topics identified under this area were: 1) identification of limiting nutrients; 2) effects of fish on nutrients cycles; and 3) role of fertilizer and water management in nutrient dynamics.

The availabilities of macronutrients and potentially limiting micronutrients should be assessed. A toxic excess of a nutrient can limit production as effectively as a deficiency. The effects of limiting nutrients on the entire biological ricefield community should be identified.

The synchrony of nutrient supply and demand is important, and deserves more emphasis than has been the case to date. Ideally, nutrients should be sufficiently available when needed and not wasted when demand for them is low. How does the presence of fish affect the availability and the timing of various nutrients?

The interrelationships between rice-fish culture and the primary and secondary productivities of ricefield ecosystems are also of interest. The effects of cultured fish on other ecosystem components such as forage bases should not be neglected.

Fertilizers (organic and inorganic) should be added as and when needed in the interests of maximal ecosystem efficiency and minimal waste. The effects of water regimes on nutrient dynamics should be addressed.

Environmental Protection of Rice-Fish Ecosystems

Three subtopics identified were: 1) effects of rice-fish culture on greenhouse gas emissions; 2) role of refuge ponds and other ricefield management strategies in maintaining biodiversity; and 3) effects of pesticides on ricefield ecosystems.

Ricefields have been identified as a major source of methane, which is suspected to have positive influences on both global warming and on degradation of the ozone layer. Does incorporation of fish into ricefield ecosystems increase methane emissions through increased, deeper perturbation of the soil? Or does this soil perturbation reduce methane production through increased penetration of oxygen into the soil? The questions are important.

The physico-chemical processes affecting emission of greenhouse gases require further study. Parameters to be measured include soil redox potential, soil pH, soil temperature, and levels of methane emission.

The effects of different water management regimes (such as intermittent and rotational irrigation) and of different fertilizer management strategies (especially use of organic fertilizers) on greenhouse gas emissions also merit serious study.

Wetlands preservation has been identified as crucial to preserving aquatic biodiversity and consequently, ecosystem stability. In this regard, the effect of refuge ponds on aquatic biodiversity needs study. Abundance and diversity of both fishes and their forage bases should be included. This work may be especially pertinent in areas where such ponds are being excavated or filled in (as in northern Malaysia).

Similar studies on the effects of different water and fertilizer management strategies on fish and on forage biodiversity and abundance deserve investigation. Possible beneficial and deleterious effects of organic and inorganic fertilizers are of particular interest.

The methodological points are:

- Identification of some organisms to the family level will be sufficient in many cases.
- The use of indicator organisms for relatively pristine, polluted, and otherwise disturbed areas can be very helpful in such studies.
- Existing data are scanty, and methodologies require further elaboration.

Studies on the effects of pesticides on fish and forage biodiversity, abundance, and production are needed. Pesticide is understood to include all biocides, but insecticides are mostly the focus of interest. All forms of pest suppression, however, may be included as appropriate. Three research thrusts were identified:

- Short-term toxicity, which can be addressed through bioassays to determine short-term lethal levels. Plenty of data exist on older pesticides, but new pesticides are being developed. Also of particular interest are pesticide mixtures, which appear to be more toxic than any single component of the mixture, and botanical pesticides. The Canadian University Services Overseas (CUSO) has recently produced a list of botanical pesticides.
- Long-term toxicity, and its effects on growth, fecundity, and production of aquatic organisms are of interest. Such studies are more relevant for persistent pesticides.
- Residue analysis of persistent pesticides in soil, water, and fish tissues are needed, as are studies on the biomagnification of these pesticides in the food web. The long-term implications for ecosystem and human health can be very serious.

Sensitive equipment (to the 1 ppb, not 1 ppm level) is needed for such testing. Such equipment and appropriate techniques are already available.

Feeding Ecology of Fishes and Its Relationship to Ricefield Management Techniques

Different methods should be used concurrently to achieve a thorough understanding of the feeding ecology of fishes. These include: 1) gut content analysis; 2) behavioral studies; 3) electivity indices; and 4) isotope ratio analysis.

On gut content analysis, emphasis should be on weight or volume, rather than frequency of particular components. It is important to know what fish eat, and their relative potential importance towards contributing to fish biomass. Frequency does not achieve this, and cannot be used for such items as plant tissue.

Direct field observation of fish behavior should be done. This can be coded, and frequencies and scores subsequently calculated.

Electivity indices indicate feeding preferences under differing environmental circumstances (notably availabilities of forage organisms) and differing stages in the life cycle of the fish species in question.

In the case of isotope ratio (notably delta-C) analysis, the ratio of Carbon-12 to Carbon-14 is unique to each species in the ecosystem. This ratio in the tissue of a particular fish species reflects the ratio in the forage material or species which are predominantly assimilated. Hence, in combination with other studies, this technique can indicate which forage species and materials contribute most significantly to the biomass of each fish species.

Also of interest is the effect of different management techniques on forage bases and on the feeding ecology of fishes (cultured and indigenous species). Under what circumstances do fishes prefer certain feeds? How do refuge ponds and other water management strategies affect feeding ecologies? Inclusion of a few fingerlings with fry during stocking is thought to increase feed availability through increased soil perturbation - the hypothesis deserves testing. Other management strategies can be found.

Comparative Ecological Modeling

Models serve to increase understanding of ecosystem dynamics and are helpful predictors of direction, if not magnitude, of change. Participants agreed that such models require further development and testing. Perfecting a model is probably not possible, but improving such models to the level where they can be useful appears worthwhile.

Three priority topics identified were: 1) refinement and testing of steady state models (such as Ecopath II); 2) development and testing of dynamic models; and 3) use of multivariate statistics in model development.

Initial approximations in a steady state model using Ecopath II software have mixed the use of primary data with that of secondary data from many sources. It was felt that exclusive use of primary data from one system could improve the model greatly. This should be followed by testing on other, more diverse rice ecosystems.

Little work has been done in dynamic models. Available models have been developed for pond ecosystems, but their present applicability to ricefield systems is doubtful and probably very tenuous.

It was felt that multivariate statistics should play a key role in model development. Multivariate methods can be very helpful in prioritizing the variables which should be included in the subsequent model. Some important related points were made:

- Models should always be used cautiously, since the predictions may not fit reality.

- Who will develop these models?
- Once satisfactory models have been developed, NARS scientists should be trained in their use.

Other Special Considerations

The role of indigenous fishes in ricefield ecosystems may be implicit in some of the above topics, but has not yet received the attention it deserves. Their biomass in some systems indicates that they are a very important component of these ecosystems. In most of the countries represented at this workshop, various wild or indigenous species are preferred to cultured species, given comparative market prices. Therefore, indigenous fishes are given special emphasis. It is further recognized that this identified ecological concern is not complete, and that priorities will change through time.

The priority topics identified were: 1) role of indigenous fishes on ricefield ecology; 2) interrelationships between indigenous and cultured fishes; and 3) effects of multiple harvesting and polyculture on production and nutrient cycling.

The effects of indigenous species on nutrient cycling and on other components of the ricefield ecosystem are poorly understood. The population dynamics of various species also need more thorough study. Detailed catch monitoring of indigenous species is needed to assess their economic as well as ecological importance.

The additional stocking of fish (introduction of already indigenous species such as broodstock or species exotic to the ecosystem) into a ricefield ecosystem could affect the dynamics of fish populations indigenous to the ricefield. Questions regarding predation, enhancement and competition for feed or living space should be addressed. Effects on biodiversity, production, and abundance are of interest. To date, data on these are very scanty and inconsistent.

In parts of southern Vietnam, continuous stocking and harvesting are possible. The effects of this management strategy on other ecosystem components are of interest.

The effects of polyculture on production and nutrient cycling could be studied in a way similar to investigations on the effects of multiple stocking and harvesting on rice ecosystems. Similar studies on other fish culture management strategies are worth conducting.

Socioeconomics and Adaptive Research

The importance and relevance of the proposed ecological studies were appreciated by the participants. While necessary to valid research planning, ecosystem-specificity is not sufficient. Socioeconomic group specificity is also needed. Target beneficiaries, then, must be defined and their circumstances appreciated so that subsequent research and development efforts can respond to their needs and circumstances.

Research content and approach, then, should be site-specific. Particularly in countries and regions where rice-fish culture has not yet been widely adopted, socioeconomic questions addressing the viability of the practice and verification of technological details must take priority. Related findings from neighboring countries or regions cannot be applied with confidence in a "new" area. Target groups should benefit from a "new" technology as quickly as possible, once the benefits and risks are adequately understood. Policymakers, then, require prompt feedback on these questions; other studies can follow this step, as soon as they can be accommodated.

Bangladesh is a case in point. The technology appears to be attracting increased interest in some parts of the country, due partly to extension efforts, but also to rapidly decreasing availability (and rising prices) of fish. Much of what follows, then, comes from the perspective of the three participants from Bangladesh, but will apply elsewhere, particularly in regions or countries new to any technology.

Many of these questions will remain important in countries and regions where the practice is already well-established. Circumstances change; so do technologies appropriate to the circumstances.

On-farm verification of research findings is a continuing requirement for all the investigations listed above. Not only does this test the applicability of the on-station results, but it also assures continued contact with the end-users, thereby maintaining responsiveness to the needs of these groups and society as a whole.

Three major areas of interest were identified: 1) surveys to determine needs, resources and problems; 2) extension strategies; and 3) economic studies.

Surveys of Farmers to Determine Needs, Resources and Problems

Such a survey should be interdisciplinary since farming is an integrated activity, and include ecological, as well as economic questions. As such, it could contribute to ecological characterization of the systems in question. Socioeconomic, demographic and marketing constraints are also of interest.

Rapid Rural Appraisal and Participatory Rural Appraisal techniques could be applied. In particular, it will usually not be possible to anticipate every relevant question prior to going to the field, so the people conducting the survey should be prepared to include "unplanned" information which appears relevant, and to collect such information systematically, once they are aware of its importance.

Surveys should be repeated periodically (say, every three to five years) to get a systematic picture of the target group and their feedback on research and development efforts. Any feedback received through less formal channels should also be incorporated into ongoing plans.

Extension Strategies

This was translated into several components: 1) training of extension workers; 2) farmer-to-farmer extension; 3) feedback to researchers; 4) follow-up and monitoring; and 5) assessment of extension approaches. The usefulness of components 1 and 2 is well documented and need not be discussed.

Feedback to researchers can be important in assuring the continued applicability of the research to the circumstances of the intended beneficiaries, and indicate directions which the research should follow.

Frequent follow-up or consultative visits are especially important if the technology is unfamiliar in the location, or risky. Aversion of and rapid response to problems are crucial at this stage. It can coincide with field data collection.

As a part of any extension effort, adoption rates should be assessed, factors affecting adoption (and non-adoption) quantified as frequencies, and results reported to appropriate research agencies. Such research can indicate appropriate modifications for both technologies and extension approaches.

Economics

The economics of a technology need to be thoroughly assessed before policymakers can support its dissemination. Methodological considerations are as follows:

- Studies must be carried out on-farm and under farmer management, to have credible applicability. On-station trials cannot reflect reality; neither, sufficiently, do researcher-managed on-farm trials.
- Studies should include nutritional and sociocultural costs and benefits, as well as strictly financial ones. The emphasis should be on livelihood, rather than on income alone. With a little relevant field investigation, such costs and benefits can be converted to units of time or money, if needed.
- Since there is no typical year, it is desirable for the study to cover the same group of farmers for three complete years. Sample size of farmers should be as large and diverse as is manageable.
- Intervals for field monitoring of inputs and outputs should be at least weekly. Such work can coincide with the monitoring needed for extension work.
- The inclusion of risk analysis in such studies is important, especially given the circumstance of the intended beneficiaries.

Institutions Involved in Rice-Fish Culture

Time was not enough to discuss this very important topic, but a few important points arose:

- Research content and approach must be institution-specific, as well as ecosystem- and socioeconomic group-specific. Different institutions are suited to different initiatives by virtue of their mandates, resources, and experiences.
- No institution is equipped to address all the questions raised in these deliberations. Inter-institutional linkages then, become important in addressing fully these needs. This can be particularly fruitful among institutions with complementary resources. Such linkages are also needed to address strategic research questions and common problems throughout the region. The involvement of concerned non-government organizations is normally advisable.
- Key people in respective institutions must feel the need for such linkages, if they are to be viable.

Some Suggested Strategies

- It was widely felt that the state of knowledge on ricefield ecology should be reviewed and published. Two books should be produced: one to review the current state of knowledge of ricefield ecology in different ecosystems, and another to review methodologies found valid in addressing the different research topics. These reviews should also indicate future directions for such research, in terms of content and methodology.

  The review on ricefield ecology could consist primarily of a collection of country reviews. This should include valuable information in unpublished data and reports in various countries. For published information, a 1993 Bibliography of References to Ricefield Aquatic Fauna, their Ecology and Rice-Fish Culture by C.H. Fernando, University of Waterloo, could be used.

  The inclusion of an annotated bibliography with the review of methodologies would be very helpful.
- Networking among concerned international and national centers/scientists would allow sharing of results and methodologies, resulting in complementation and mutual support, and help avoid duplication. As a first step, a mailing list should be produced (one exists on the program for this workshop), and a liaison with the Asian Rice Farming Systems Network or its successor developed.
- This could also lead to collaboration among agencies with complementary mandates and resources.
- Once methodologies and models have been perfected or developed to a satisfactory degree, training for NARS researchers in these tools should be provided.
- Interested donor agencies should be identified and contacted.

II. Fish and Integrated Pest Management

Convened by Drs. K. MacKay and S. Setboonsarng

The group drew plans for further research and elaborated methodologies for research on the role of fish in IPM. The group determined the priority areas *en banc*, and then broke into two sub-groups and discussed further the effects of fish on pest management in ricefield ecosystems, the issues on monitoring, evaluation and adoption, and the economics of rice-fish systems.

Research Priorities and Methodologies

The focus of the research efforts should be on the high production rice environments including the irrigated and the favorable rainfed environments. This is the area where pesticide use is high and IPM projects are targeted.

The following areas require further research and knowledge:

- Documenting and quantifying the effect of fish on rice ecosystems, particularly on rice yield (components due to improved nutrient management, pest management and farmer management) and pest management; documenting the role and mechanism for fish control of pest and disease and in the management of golden snail, brown planthopper (BPH), stemborer soil-borne diseases, leaf diseases, human disease vectors, and natural enemies of rice and human disease vectors.
- Monitoring, evaluating and adopting culture systems; investigating constraints to adoption; identifying the entry points and strategies in sustaining adoption; and quantifying farm and systems level effects regarding economics ($), environmental, health (malaria and nutrition), social, sustainability (need to be defined) and increase on farm recycling (productivity factor).
- Effect of pesticides and pesticide residues on fishes and aquatic organisms.

Fish Effects on Pest Management

Steps on the documentation and quantification of the effects of fish on pest management in the ricefield ecosystem were emphasized. The first step is a review of the papers presented at: 1) previous workshops; 2) this workshop; and 3) other literature especially the vector control literature.

The second step is a series of collaborative and concerted research projects on the target pests to be done in the countries where pests are a major problem (Table 1). These experiments would combine controlled greenhouse/screenhouse experiments with on-station and on-farm experiments. The new component in these experiments is to explore the mechanism of fish-target organism interaction.

Table 1. Target rice pests and organisms in evaluating the effects of fish, by country.

Target Organism	Country							Ranking
	Indonesia	Vietnam	Philippines	Malaysia	Bangladesh	Thailand	(China)	
Stemborer	✘	✘	✘	✘	✘			1
Hoppers	✘	✘	✘	✘	✘			1
Golden apple snail	✘	✘	✘	✘				1
Weeds	✘	✘	✘	✘	✘			1
Soil borne pathogens	✘	✘	✘	✘				2
Mosquitoes	✘	✘						3
Bacterial diseases	✘		✘					3
Rats	✘	✘						4
Thrips								5
Natural enemies	✘	✘	✘	✘	✘	✘	✘	!

Backed up by knowledge on rice ecosystems, a review, update and inputting a new structure on the following should be done:

- Pest management; focus work more on how fish affect natural enemies. Previous works done were on pest, not natural enemies.
- New information desired and suggested place of work:

  Hoppers : Dispersal of larvae (greenhouse);
  : disappearing larvae (on-farm).

  Golden snail : Preference of prey (greenhouse);
  : direct feeding by fish by observation and counting (on-farm): 1) no artificial infestation - check on initial snail population density before fish stocking; and 2) eliminate all snails, then do artificial infestation.

  Weeds : Fish preference studies and consumption ability (greenhouse); increase perturbation and proofing (on-farm). Differentiate between direct and indirect effects.

There will be a need for some coordinating mechanism to follow up research in the future. There was some suggestion this might be done via the existing IRRI IPM network or its successor.

Monitoring, Evaluation and Adoption

The group initially suggested the need for a framework. The framework should: 1) define the systems - these would be the lowlands (including both irrigated and favorable rainfed areas), rainfed uplands, tidal lowlands, and highlands; 2) define and characterize the practices within each system; and 3) develop criteria for evaluation of adoption and sustainability.

A framework for evaluating adoption and sustainability which takes into account the scale of the analysis and combines economic, environmental, health, nutritional and equity concerns is presented in Table 2. Research and development initiatives carried out to date in each country could be pigeonholed into appropriate cells in the matrix. This would help NARS and their partners in international organizations identify gaps which need to be addressed in future work. It is further recognized that the deliberations of this workshop may not have adequately addressed the needs of all countries in the region. Use of the matrix may make research planning more comprehensive and complete.

The group recommended that the existing research should be reviewed and restructured, use this framework, and gaps in the current research be identified.

Table 2. Structure for evaluation of rice-fish culture research.

Scale	Criteria				
	Profit	Environment	Nutrition	Health	Equity
Field (plot)					
Farm					
Community					
Society					

Economics of Rice-Fish Systems

The available data on economics of rice-fish culture should be summarized in the manner that is understandable for economists and others. Comprehensive economic studies and analysis of rice-fish systems should include the following:

- Collection of labor data for fish and IPM; the two systems are different.
- Evaluation and standardization of existing information on partial budget; whole farm budget and case studies. Partial budget does not provide sufficient information; whole farm budget is needed which includes recycle element. Data on whole farm practices are needed which could come from the resource flow approach combined with participatory rapid appraisal (PRA).
- PRA can be used to identify the area for case studies. Case studies of whole farm practice (with resource flow model), monitoring and evaluation can be addressed through farmer participatory.

- Resource flow model could also form the basis for on-farm research, e.g., examine the ICLARM/IIRR Cavite data.
- Standardize the data collection for new data.
- Consider farm level and society level in the analysis.
- Other benefits - e.g., recycling, vegetables on dikes, nutrients in pond water.
- Price of fish is one of the system parameters. Use fish price in terms of price of rice for standardization.

Constraints to Adoption

Much information on constraints (e.g., fish seed production in Indonesia) are available and should be summarized. Many of these are tied to economic constraints:

- Is fish culture or IPM limited by labor or by many other factors? What is the insurance or risk value?
- What are the constraints and entry points from the farmers' point of view?
- On the process of IPM adoption in Bangladesh: what makes sense to the farmers - how many things does he have to change in order for him to qualify as an IPM farmer?
- What does standardization of IPM mean? Should it focus on fish?

Entry Points

A number of entry points exist and should be considered for evaluation: fish-->rice; fish-->IPM and IPM-->fish/ALM. Fish -->rice has been the basic entry point. Then the old and new FAO IPM occurred as another promising possibility: the old IPM (Saltin, this vol.) activities first started in 1980 in the Philippines; while the modified or new IPM (Farmer Field School approach) began in 1988 in Indonesia. The new IPM now includes the Philippines, Cambodia and Vietnam. Malaysia has also been involved. Through the old or new IPM, farmers learn the ecosystem of the field. As an entry point for rice-fish culture, the old and new IPM should be differentiated from each other. The synergism between fish culture and IPM should be established. Questions or observations that need answers or confirmations are as follows:

- Does introduction of fish lead farmers to adopt IPM? Or does an IPM focus change farmers' perception and lead to fish and/or Aquatic Life Management? As an example, in Nueva Ecija, Central Luzon, Philippines, did farmers change the management of their field?
- Why would a farmer not practice fish culture in all his fields?
- The reintroduction of fish in the ricefields and the system where knowledge on fish is gone should be differentiated.

Effects of Pesticides and Pesticide Residues on Fish and Aquatic Organisms

Toxicities of pesticides on fish, particularly the new products, should be screened. Chronic effects of residues on fish and aquatic organisms and environment should be evaluated.

Rice-Fish Culture Research Resolution

Towards the end of the workshop, the participants wrote a resolution to ICLARM, IRRI and donor agencies indicating the progress achieved in rice-fish culture research, and outlining the importance and need for coordinating future research in rice-fish in the region. The text of the resolution is as follows:

JUSTIFICATION FOR CONTINUED SUPPORT FOR RICE-FISH CULTURE RESEARCH

(A resolution of the participants of the Third Asian Regional Rice-Fish Research and Development Workshop held at SURIF, Subang, West Java, Indonesia on 6-11 June 1993)

Rice-fish culture research and development have progressed considerably over the past decade. Emphasis has been shifting from simple reporting of production to exploration of ecological mechanisms and implication affecting rice-fish culture systems.

Rice-fish culture spans diverse rice ecosystems. The clear need to structure and review existing knowledge from many countries on an ecosystem-specific basis was unanimously recognized by workshop participants.

Understanding sustainability requires consideration and quantification of environment, health, nutrition, and equity at a scale from the plot to the society level. This allows evaluation of ecosystems and development of strategies to achieve sustainability where required. This often, in reality, means alleviation of poverty for the farmer.

Overcoming constraints to sustained adoption of rice-fish is the key to achieving a more widespread participation. These constraints are ecosystem and scale dependent. Within intensively managed irrigated ecosystems an overriding limitation is the high level of pesticide applications. With adoption of integrated pest management (IPM) practices a major constraint to fish culture has been removed. However, other constraints for adoption such as diminishing water resources need to be further considered before identifying target areas with high potential for rice-fish.

This workshop has proposed a structure to evaluate and develop interdisciplinary research at diverse scales. This allows existing research to be reviewed on an ecosystem basis and enables NARS to take a lead role in research and its prioritization.

There is a clear need for collaboration with organizations having appropriate expertise to complement the work of NARS and NGO's. Continued support for research in rice-fish by donors and international organizations is needed to assure that the potential benefits of the technology are realized as efficiently and rapidly as possible.

Session I

RICEFIELD ECOLOGY AND FISH

Summary of Presentations

Dr.C.R. dela Cruz

Agricultural practices alter the equilibrium of soil, water, biological and physico-chemical subsystems in ricefield ecosystem. Simpson reported that based on IRRI's experiments, agricultural practices (nitrogen [N] fertilizer, pesticides and green manures) have affected the population dynamics of aquatic invertebrates in ricefield floodwater in different ways. Oligochaetes, ostracod and dipteran larvae responded positively to N fertilizer if applied by broadcasting but not when applied by deep placement. The indigenous snail populations are strongly negatively affected by broadcast application of N fertilizer. Green manure *Sesbania* positively affected population densities of aquatic oligochaetes. On the other hand, N management practices have limited and inconsistent effects on copepod and cladoceran populations.

Application of pesticides carbofuran and butachlor do not affect significantly populations of microcrustaceans, dipteran larvae or benthic molluscs. Aquatic oligochaetes, considered as beneficial soil bioaerators, were adversely affected by pesticide application during one dry season, but showed a stimulatory effect the following year. Cagauan et al. indicated that pesticides reduced the oligochaetes by 49-80%.

The introduction of fish in ricefields revealed positive effects on the productivity of and human disease vector control in ricefield ecosystems. The positive effects according to Cagauan et al. were: increased rice yields (10%) and cycling of nutrient (nitrogen); weeds reduction (67%); and indications of positive influence on soil conditions. Fish, however, reduced the population of aquatic oligochaetes by 80-89%. Nalim reported that after five years, fish culture in ricefields had also reduced the incidence of malaria cases in Central Java, Indonesia from 16.49% to 0.20%.

Ali investigated the feeding habits of *Trichogaster pectoralis*, a major component of fish harvest from ricefields in Malaysia. *T. pectoralis* change their diets from microcrustaceans to aquatic vegetation and insects as they grow bigger. Between 30-60 mm total length, the fish feed primarily on microcrustaceans; fish greater than 61 mm feed primarily on aquatic vegetation with aquatic insects occurring also in the diets. Greater amount of detritus are found in the diets of fish caught in ricefield environments which seemed to lack live food.

Chapman investigated the feeding ecology of *O. niloticus* and *C. carpio* in the rainfed lowland ricefields of Northeast Thailand. *O. niloticus* feed mainly on periphytic detrital aggregate (PDA) in the upper water column and plants. Scarcity of cyanobacteria or blue-green algae may have led to its dietary reliance on PDA and plants. *C. carpio* relies heavily on bottom detrital aggregates. The discrete component of its diet is small but distinct and consists mainly of chironomids, corixids, and Gramineae seeds. Microcrustaceans appear in the diet in the early part of the season, whereas insects are eaten later. The low abundance of chironomids and microcrustaceans may have caused the reliance on detrital aggregate.

The culture of giant freshwater prawn (*Macrobrachium rosenbergii*) had been shown by previous reports to be feasible in the deepwater ricefields of Bangladesh, India and Vietnam. The suitability of irrigated ricefields as an alternative nursery and growout for this species was explored by Hadidjaja and Yunus. In nursery operations, the survival and body weights up to juvenile size, were 17.12-58.80% and 1.17-1.87 g, respectively. The highest growth rate expressed as percentage of initial stocking weight obtained was low (94.5%) compared to 465% usually obtained in ponds. For growout, the survival rates, weights and productions obtained were 68.2-87.6%, 16.6-17.6 g and 3.6-4.4 kg/250 m^2, respectively. Wide temperature fluctuation (>5 °C), low morning dissolved oxygen (DO) (1.8-2.4 ppm), and relatively high carbon dioxide concentration (9.72-11.05 ppm) at the time of low DO, could have affected the growth and survival of the prawn.

Abstracts

The Impact of Agricultural Practices on the Aquatic Invertebrate Food Supply of Fish in Ricefields

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Abstract

Fish in ricefields feed extensively on the aquatic invertebrates in the soil-floodwater ecosystem. The effect of agricultural practices on this fauna is largely undocumented. Field experiments were conducted at the International Rice Research Institute (IRRI) between 1989 and 1993 to assess the impact of nitrogen (N) fertilizer, pesticides (carbofuran and butachlor) and green manures (*Azolla* and *Sesbania*) on the population dynamics of aquatic invertebrates in irrigated ricefields.

Aquatic oligochaete densities were estimated by wet sieving plow-layer-depth soil cores. Water-column invertebrates were enumerated by suction collection of floodwater and surface-soil (2-3 cm) from cylinder samplers. Benthic molluscs were quantified by wet sieving surface-soil collected from quadrats.

Aquatic oligochaetes were more dense at transplanting where *Sesbania* had been incorporated than in zero and broadcast N treatments. Populations in all treatments increased to similar maxima by 30 days after transplanting (DAT) and then declined rapidly before 49 DAT. They recovered in the *Sesbania* and broadcast N treatments, but remained significantly lower in the zero N control. Aquatic oligochaetes were adversely affected by the application of pesticides during the 1990 dry season. Before transplanting, populations were similar in all treatments. In treatments with carbofuran and butachlor before 20 DAT population densities remained constant; however, in the absence of pesticides, numbers increased. All populations had increased by 50 DAT, but the increases were markedly greater in treatments which did not receive carbofuran applications. Towards the end of the crop cycle all populations declined, but lower pesticide inputs still corresponded with higher oligochaete densities. In the 1991 dry season, contradictory evidence was found that aquatic oligochaetes densities were stimulated by carbofuran applications.

Mosquito and chironomid larvae proliferated rapidly to transient peaks, particularly in treatments where N fertilizer was broadcast. Deep-placement of N fertilizer considerably reduced peak population densities of dipteran larvae. This practice could be adopted as part of vector control programs to reduce disease transmission by mosquitoes. Where *Azolla* was incorporated, chironomid larvae densities increased rapidly to 6 DAT. Mosquito larvae densities were extremely low throughout the crop season in *Azolla* plots. There was no consistent evidence of pesticide impacts on mosquito or chironomid larvae.

Ostracod densities increased rapidly in response to the broadcast application of N fertilizer. Peak population densities were maintained between 27 and 45 DAT, followed by a rapid decline. Ostracod population dynamics in other N management treatments were similar to each other. There was limited evidence that ostracods were negatively affected by the application of carbofuran and butachlor.

Generally, population densities of cladocerans and copepods increased towards the end of the season. There was limited evidence that copepods were more abundant after broadcast N applications and where *Azolla* was incorporated. Differences were observed amongst populations in pesticide treatments, but the trends were inconsistent. Cladoceran populations were relatively insensitive to N management, but they were abundant in the absence of pesticides (52 to 85 DAT). There was also evidence that the timing of the expansion of cladoceran populations towards the end of the crop season was delayed by carbofuran applications.

Before transplanting, length-frequency distributions of benthic snails were similar in all treatments. Smaller individuals were depleted in the broadcast urea treatments by 20 DAT and continued to decline as the crop developed. In contrast, smaller snails in control and *Azolla* treatments, increased markedly by 20 DAT, remained stable until 48 DAT and then declined. Population densities were low and length-frequency distributions similar in all treatments by 99 DAT.

The negative impacts of broadcast urea fertilizer and crop development on benthic snails were confirmed the following dry season. Additional evidence for the negative impact of the rice plants was provided by the observation of dense populations in unplanted plots. There was little evidence of pesticide impacts on benthic snail populations.

Agromanagement practices used in intensive rice cultivation can have a profound effect on floodwater invertebrates. Fish which feed on these organisms may be affected accordingly depending on the flexibility of their diet. Aquatic invertebrate population dynamics presented were obtained in irrigated ricefields devoid of fish. It should be appreciated that invertebrate abundance and community structure will change in their presence. However, potential impact of agriculture practices on the aquatic invertebrate food supply of fish have been identified.

This research was conducted under a scientific agreement between IRRI (Philippines), NRI (United Kingdom) and ORSTOM (France).

The Impact of Fish in Enhancing Ricefield Ecosystems

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Abstract

A study was conducted in the terraced fields and highly endemic area for malaria in 1979 in Pagak Village, Banjarnegara Regency, Central Java, to monitor the economic benefit and impact on malaria disease control of fish. Common carp (*Cyprinus carpio*) and *Poecilia reticulata*, a larvivorous fish, were cultured for enhancing farmers' economic benefit and for controlling mosquito larvae.

After five years of fish culture in ricefields, malaria cases decreased from 16.49% to 0.20%. Compared with the control area with DDT spraying twice a year, a prevalence of 2.98% in 1979 remained steady at a prevalence of 3.36% in 1984. Up to the present, malaria is still absent in Pagak Village.

Rice-fish culture has now spread throughout the Banjarnegara Regency. Common carp is distributed and stocked at 9 fish/10 m^2 and raised to and sold at fingerling size. Profit derived in 1982 was Rp133,750/ha (US$66.80) per season.

However, some constraints were encountered in the expansion of rice-fish culture in the regency. These were steep slopes and small ricefield plots which erode easily with standing water. Also, rice-fish culture is perceived to require special practices, thus making farmers reluctant to adopt it. These, however, have not stopped the local government from continuing its campaign to intensify the practice of rice-fish culture in the regency.

Impacts of Fish and Pesticides in Lowland Irrigated Ricefields

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Abstract

An experiment was conducted to compare the impacts of fish on rice pests as against pesticides, and on selected physico-chemical and biological parameters in a lowland irrigated ricefield ecosystem.

The experiment consisting of two trials, was conducted during the 1991 wet season and the 1992 dry season, using 20 300-m^2 plots each with pond refuge (1 m deep) occupying 12% of plot area. Four treatments with five replications each were used as follows: no pesticide, no fish; with pesticide, no fish; no pesticide, with fish; and with pesticide, with fish. The usual culture and management practices for lowland irrigated rice in Nueva Ecija were followed. High-yielding medium maturing rice variety (Philippine Seed Board Rice Cultivar (PSBRC2)) was planted in straight rows at 20 cm x 20 cm spacing. Ammonium phosphate (16-20-0) and urea (45-0-0) were

applied at the rate of 77 kg N/ha and 40 P_2O_5 kg/ha. Treatments with pesticide were applied with carbofuran (16.7 kg/ha) at rice transplanting; organostannous molluscicide (9 tbsp/16 liters spread uniformly over 300 - 350 m^2) at 4-5 days before transplanting; and Butachlor herbicide (20 kg/ha) at 4-5 days after transplanting (DAT). Nile tilapia (*Oreochromis niloticus*) and common carp (*Cyprinus carpio*) were stocked at 104 kg/ha (1:1 ratio by weight). Fish culture periods were 90 and 105 days in trials 1 and 2, respectively. Data gathered were rice, fish, weeds, gross plankton productivity, water quality parameters (temperature, pH, dissolved oxygen [DO] and ammonia), and soil parameters (pH, oligochaetes, bulk density, organic matter, total nitrogen and available phosphorus).

Positive effects from the fish treatments were obtained during the dry season trial: increased rice grain yield by about 10% from 3,264 kg/ha; selective reduction of weed groups from 5-6 to 2-3 species mainly dominated by grasses in the latter, and decreased total abundance by 67% from 2,103 kg/ha particularly affecting sedges; and indications of influence on soil conditions (pH, organic matter, bulk density and available phosphorus). Water depth of 6.5-11.81 cm did not affect weeds. Total weed abundance and fish density and size (7,300-8,533 Nile tilapia/ha with mean weight of 6.3 g; and 11,433-16,700 common carp/ha with mean weight of 3.6 g) were negatively correlated (r = -0.50 to -0.52). During the two trials, fish reduced oligochaete populations by 80-89% (from 5,027-6,548 organisms/m^2).

Pesticides had no significant effect on rice grain yields or fish. Herbicide reduced weeds, but nonsignificantly, by 18.3% (P>0.05) from 1,538 kg/ha in trial 2. Pesticides also reduced oligochaete populations by 49-80% in both trials. Their adverse effect on oligochaetes seems to have influenced the soil bulk density, and the levels of organic matter and phosphorus in the soil.

Results on floodwater parameters affirmed the benefits of pond refuges in rice-fish farming. Pond refuges had lower afternoon water temperatures and less temperature fluctuations than the ricefields: an advantage for the fish. Refuges supported about ten times higher plankton productivities (2.74-3.42 g carbon/m^2/day) than the ricefields. Low DO (<5 mg/l) occurred 6-8 weeks after rice transplanting in both ricefields and pond refuge which was an indication of reduced photosynthetic aquatic biomass (PAB) production or reduced natural food for the fish. This period indicates the time to begin supplemental fish feeding. The increase in pH, to levels (>pH 8.5) conducive to nitrogen loss through ammonia volatilization, was contributed primarily by the PAB. It was hypothesized that fish grazing on the PAB may help minimize rise in pH, particularly in the afternoon. The results, however, did not support this hypothesis, as the afternoon pH values in the ricefields were not affected by fish. This result was possibly affected by fish size and peak of PAB production. Un-ionized ammonia in floodwater occurred in high amounts (0.091-0.238 mg NH_3-N/l and 0.168-0.541 mg NH_3-N/l in trials 1 and 2, respectively), particularly in the pond refuge early in the crop and at high pH.

The above findings revealed some positive and negative impacts of fish *vis-à-vis* pesticide on ricefield ecosystems.

The Feeding of Nile Tilapia and Common Carp in Lowland Ricefields and its Relation to Food Resources

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Abstract

Much of the benefit derived from rice-fish culture stems from its being a low input system with no obligative requirement for constant, high quality organic inputs, since fish growth is generated by the aquatic community that establishes itself in ricefields immediately after the initiation of annual rainfall. An examination of fish feeding ecology is essential because processes such as digestion and energy metabolism are predicated on factors including efficiency of detection, capture, and ingestion of naturally occurring food items. The feeding of Nile tilapia (*Oreochromis niloticus*) and common carp (*Cyprinus carpio*) raised in lowland ricefields in Sakon Nakhon

province, Northeast Thailand was examined by an analysis of stomach contents and observation, during the rainy season of 1989.

Site 1 (1.6 ha) was stocked at a density of 3,158 fish/ha, composed of 4,000 *C. carpio* and 1,000 *O. niloticus*, and 52 Chinese carps (*Aristichthys nobilis* and *Hypophthalmichthys molitrix*). Site 2 (0.84 ha) was stocked at 3,004 fish/ha, composed of 1,500 *C. carpio* and 1,000 *O. niloticus*, and 23 *A. nobilis* and *H. molitrix*. Fingerlings of at least 5 cm total length, stocked in the fields on 24 June 1989, were caught twice monthly until October. Sixteen fish each of *C. carpio* and *O. niloticus* were captured at each site using gill net of varied mesh, at about 08:00 hours. Visual estimates of stomach fullness were made. Volumes of discrete food items were based on the assignment of the shape to a geometrical solid which it best fitted.

Feeding intensity over a 24-hour period was studied twice on a third field. Ten fish of each species were caught every three hours. Feeding behavior was studied from an observation platform placed on the ricefield. Algae, plankton, and benthos in the ricefield soil and overlying water were sampled from one field stocked with cultured fish (site 1) and a contiguous field which received no cultured fish (site 1a).

The volumetric diet analysis of Nile tilapia indicated that detrital aggregate (DA), which from observations was shown to be periphytic (PDA), plant matter, and fish, formed about 75%, 17%, and 5% of the diet, respectively. Analyses by percentage composition and principal components showed a shift in diet from plants to PDA for the fish in site 1 while fish from site 2 relied on PDA all season. The principal component analysis clearly distinguished specimens based on diet. Fish fed homogeneously on either PDA or plant matter. Stomachs were generally 75% full or more.

DA, contributing 93% of the foregut content volume in common carp, was predominant all season. The discrete component was about 9% and 6% in fishes from sites 1 and 2, respectively. In fish from site 1, the abundant discrete food items were corixids, *Cyclestheria hislopi*, Gramineae seeds, and cyclopoids which formed 2.1%, 2.1%, 1.5%, and 1.3% of the diet, respectively. In fish from site 2, the discrete fraction was dominated by chironomids (2.8%), corixids (1.2%), and Gramineae seeds (0.7%). In fish from site 1, whereas *C. hislopi* was present in the diet all season cyclopoids and *Chydorus* appeared early while corixids, chironomids, and Gramineae seeds were seen after August 14. Most foreguts were 25% and 50% full with little foods present at season's end.

In the July study, the feeding intensity of Nile tilapia based on mean food content weight was significantly lower ($P<0.001$) from 24:00 to 06:00 hours than at other times. Feeding intensity in the September study was greatest in the early morning, thereafter decreasing until 18:00. In July, common carp fed least from 24:00 to 06:00 whereas in September feeding peaks occurred at 21:00, 24:00, and 06:00.

Both species were observed most often at the field inlet and in an area with a soft substrate of buffalo faeces, and did not appear widely distributed. Nile tilapia grazed near the surface on periphytic material attached to rotting vegetation, rice tillers and leaves, and plastic inlet netting. Feeding in the soil was greatest in the manure-enriched substrate. The mean number of bites per minute on periphyton from vegetation and netting, and at 3 depths, showed a significantly higher activity at the surface and mid-levels ($P=0.001$) but none between substrates ($P=0.562$). Common carp fed most frequently beneath the substrate.

At site 1, nematode, oligochaete, and chironomid densities declined over the season while the converse was seen at site 1a. Maximum densities of these organisms were about 13,000, 13,000 and 700 individuals/m^2, respectively, in both fields.

Cyclopoid densities were about 58,000 and 75,000 individuals/m^2 in sites 1 and 1a, respectively. The maximum densities of *Chydorus* in sites 1 and 1a, were about 18,000 and 12,000 individuals/m^2, respectively. The peak densities for both animals occurred early in the season at both sites.

Algae were more abundant in site 1a than in site 1. Chlorophytes were the most abundant group throughout the season, in both fields. Blooms of filamentous greens were common. Of the greens, Desmids were the most abundant group. Cyanophytes were more abundant in site 1a than in site 1. In both fields the blue-greens, which were mostly *Anabaena* and *Oscillatoria*, were more abundant after mid-season. Diatoms were rare.

A low abundance of cyanophytes may have led Nile tilapia to the reliance on PDA and plants. Two distinct feeding modes, possibly determined by substrate, were observed; grazing on PDA near the surface and bottom feeding. In ricefields, common carp diets vary considerably. The low abundance of chironomids and microcrustaceans may have caused common carp to rely on DA.

For farmers who can not employ technological advances, managing the ricefield biotope is an important means of promoting fish growth. Habitats, such as streams, that allow ricefields to be recolonized should be protected. An enhancement of the forage base in ricefields would seem to be an important consideration in rice-fish systems.

Food Habits and Feeding Patterns of Fish Obtained from the Ricefields of Northern Peninsular Malaysia

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Abstract

Food habit and feeding pattern studies of *sepat siam* (*Trichogaster pectoralis* Regan) were conducted in North Kerian and Sungai Burung areas of the states of Perak and Penang, respectively. North Kerian farmers practice rice double cropping and the ricefields are more intensively cultivated compared to those in Sungai Burung. Furthermore, fish form an important supplement to the income of North Kerian farmers and are thus harvested seasonally, compared to Sungai Burung.

Length-frequency analysis indicated a bimodal size distribution (40-60 and 140-150 mm-group total length) for Sungai Burung populations whereas those in North Kerian indicated only unimodal distribution (100-180 mm-group total length). *Sepat siam* typically occupies the lower rung of the food chain and forms a major component of fish harvest from ricefields. The fish is a grazer, feeding primarily on algae and aquatic macrophytes although insects and detritus also form important components of the diet. Further characterization of the diets indicated that fish between 30-60 mm total length fed primarily on microcrustaceans (78.3-100% - frequency of occurrence and 50.4-100% - average per cent volume). Fish greater than 61 mm total length fed primarily on aquatic vegetation (53.4-100% - frequency of occurrence and 66.3-97.8% - average per cent volume). Small-sized aquatic vegetation such as *Wolfia* sp. and *Lemna* sp. formed a bridging diet for fish (41-80 mm) switching from rotifers to microcrustaceans to larger aquatic vegetation. Aquatic insects also occurred in the diets, possibly indicating lack of available food in their environment. In general fish change their diets from microcrustaceans to aquatic vegetation and insects as they grow older.

In Sungai Burung, aquatic vegetation was the main diet for larger fish (· 80 mm), whereas in North Kerian detritus was as important as aquatic vegetation in terms of frequency of occurrence, and was dominant in terms of volume. This could be due to the environmental difference between the fish sampling places. Towards the end of the rice growing season, the irrigation or drainage canal for Sungai Burung seemed to have greater available food niches, due to aquatic macrophytes such as *Hydrilla verticillata*, *Ceratophyllum demersum*, *Eichhornia crassipes* and *Ipomoea aquatica*, than the sump ponds in North Kerian ricefields. Thus, food availability towards the end of rice culture is very important in maintaining the *sepat siam* population in ricefields.

Suitability of Short-Cycle Species *Puntius Gonionotus* (Bleeker) for Culture in Ricefields

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Abstract

Farmers in northeastern part of Bangladesh frequently face shortage of water for transplanted aman (wet season) rice cultivation during September-October, due to inadequate rainfall.

Studies were undertaken in six ricefields to evaluate the feasibility of growing short-cycle species *Puntius gonionotus* in the ricefields/ditches to optimize water utilization, reduce risk and maximize benefits. Rice plot sizes were 1,360-2,266 m^2 with 1-m deep ditch in 3% of the field area. *P. gonionotus* fingerlings of 8-10 g (±2.5) size were stocked at a density of 3,000/ha. Fish culture period ranged from 70 to 90 days, of which, fish could be in ricefields for 15-25 days, after which they were restricted to ditches, due to lack of sufficient (<7 cm) water in

ricefields. Supplementary feed consisting of rice bran was provided when the fish were restricted to the ditch. Fish were harvested when water level in the ditch went below 30 cm. At harvest, fish in different fields reached average sizes of 50-99 g, with gross production of 58.0-104.8 kg/ha; size and production increased with increase in rearing period. Incorporation of fish into the system increased production cost on an average by Tk1,211 (US$32.73) per ha, while additional net benefit from fish was Tk3,256 (US$88.00) per ha.

Assessment of comparative benefits to the farmers from excavation of a ditch and incorporation of aquaculture, as against rice production in total area, revealed that excavation of a ditch and integration of aquaculture will not only lessen risk of loss of rice production, but can also give farmers an additional average of 13.5% increase in income.

Some Aspects of Freshwater Prawn (*Macrobrachium rosenbergii*) Culture in Irrigated Ricefields

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Abstract

Prawn postlarvae (PL) are usually reared in nursery ponds to juvenile size (2-5 g) to reduce the culture period in growout ponds. Stocking juveniles in production ponds requires about four months to reach market size (30 g), *vis-à-vis* 6-7 months if directly stocked at postlarval stage (0.02-0.03 g). Thus, three experiments were conducted on rearing PL to juvenile size, and juvenile to market size in irrigated ricefields to determine their suitability as an alternative nursery and growout place for prawns.

There were two experiments on concurrent rice-prawn systems with different stocking densities. In experiment 1, some water quality parameters were measured. Also, the need to prevent the escape of prawns from the plots was considered by covering the dikes of some plots with plastic. In experiment 2, feeding and no feeding treatments were added.

In the third experiment, juvenile prawns were stocked after the rice harvest and grown to market size. Cross and diagonal trenches each measuring 10-, 30- and 50-cm deep served as treatments.

In experiment 1, the prawn survival rates and body weights up to juvenile size were 17.12-56.11% and 1.17-1.87 g, respectively. The highest growth rate obtained among the treatments was 94.5% which was low, *vis-à-vis* 465% usually obtained under pond conditions. Among the stocking densities used (160, 240, 320, 400, and 480 PL/200 m^2), the highest survival rate of 56.11% was obtained in the 240 PL/200 m^2 stocking density and in the plots with dikes not covered by plastic. The highest mean body weight of 1.87 g was obtained in the 480 PL/200 m^2 stocking density, but survival rate was 19.04%. Covering the dikes with plastic to prevent prawn escape did not seem necessary.

Some water quality parameters could have affected the growth and survival rate of the prawns, such as: wide water temperature fluctuation (>5°C); low morning dissolved oxygen (DO) (1.8-2.4 ppm); and relatively high carbon dioxide concentration (9.72-11.05 ppm) at the time of low DO. The other parameters (pH, ammonia, nitrate, alkalinity, hardness and phosphate) seemed to have not affected growth and survival.

The second experiment yielded survival rates of 39.4-58.1% and 45.5-58.8%, for the fed and unfed treatments, respectively. The differences in growth rates between the feeding and no feeding treatments, and among the three stocking densities (1, 3 and 5 PL/m^2) were not significant. However, the 3 PL/m^2 with feeding seemed to be promising in producing juvenile size *vis-à-vis* the 1 and 5 PL/m^2.

The third experiment revealed significant differences ($P<0.05$) between the prawn survival rates, as affected by the trench design. The cross trench with 50-cm depth had 87.6% prawn survival rate, average weight of 16.6 g and highest production of 4.4 kg/250 m^2, after the 55-day culture period, while in the diagonal trench at same depth, the survival rate, average weight and production were 68.2%, 17.6 g and 3.6 kg/250 m^2, respectively.

A problem faced in culturing prawns in ricefields is the rice plants or stubble obstructing feeding and harvesting of prawns.

Session II

FISH AND INTEGRATED PEST MANAGEMENT

Summary of Presentations

Dr. C.R. dela Cruz

Reduction of pesticides or health hazards in the farming community and creation of favorable environment for fish culture from Integrated Pest Management (IPM), and from fish stocking in ricefields are the essence of this topic. In addition, evidence that raising fish in ricefields has generally improved the productivity of ricefields and profitability of farming through increased returns from fish and rice, and has helped control rice pests, is presented.

In Bangladesh, results of rice-fish culture in irrigated and rainfed environments with and without IPM are reported here. Ramaswamy stated that rice farmers trained in IPM had reduced the quantity of pesticides used in irrigated ricefields by 70%. Of this, 80% did not use pesticides at all. Despite this, they produced 11% more rice than farmers without IPM knowledge. The introduction of fish in a field trial in an IPM Field School produced 179 kg/ha of fish with US$114 net profit. This implies that IPM could be an entry point for rice-fish culture.

Kamp and Gregory observed that farmers who stocked fish in their irrigated ricefields, but did not practise IPM, also benefited from increased rice yields, returns from fish and less pesticide use due to the presence of fish. They attributed the 15% increase in rice yields to the accompanying better rice management or changes in rice management practices as a result of the introduction of fish. The income from fish was usually enough to compensate for rice production losses wrought by pests, except the most severe ones. Therefore, stocking fish in ricefields could also be an entry point for IPM adoption.

Increased rice yields were also obtained in rainfed rice environment stocked with fish. In working with 110 farmers with IPM training, Kamp and Gregory reported 7% increase in rice yield with fish. Another group of 52 farmers who stocked their rice plots with *Puntius gonionotus* and *Cyprinus carpio*, either as single species or in combination, was monitored by Akhteruzzaman et al. Of these, 90% did not use pesticides. Sixty-seven per cent of the stocked fields had higher rice yields (averaging 13%) than the unstocked comparable fields. Of the farmers who had increased rice yields, 42% and 25% reported reduced insect infestations and incidence of weeds, respectively.

In Southeast Asia, the culture of fish in irrigated ricefields has contributed to insect pest control. In Vietnam, Nguyen Anh Tuan reported less hopper population in a demonstration rice plot stocked with fish in polyculture (*Puntius gonionotus*, 60%; *Oreochromis niloticus*, 15%; *Cyprinus carpio*, 15%; *Labeo rohita*, 5% and *Hypophthalmichthys molitrix*, 5%), than the surrounding unstocked fields. About 3,800 hoppers/m^2 were recorded from the demonstration farm *vis-à-vis* hundreds of thousands hoppers/m^2 in the adjoining fields. Consequently, the amount of pesticide was reduced 4-5 times. In the Philippines, evidence of arthropods being consumed by *O. niloticus* and *C. carpio* was shown by Halwart through gut analysis. Also, the possibility of fish preying on arthropods was shown by sticky traps indicating that a high proportion of arthropods fall into the water or disperse via water. Stemborer was significantly reduced by *O. niloticus* and *C. carpio*. In Indonesia, Hendarsih et al. reported that fish, as well as insecticide treatments, did not reduce white stemborer (WSB) when infestation was 11.65% in the control. Insecticide treatments became effective when WSB infestation declined at 4.47% in the control, during which slight reduction in infestation was observed in rice-fish culture plots. The presence of fish had reduced the damage on rice by leaffolders and white-backed planthoppers. In screenhouse conditions, *C. carpio* was shown to consume brown planthoppers. *C. carpio, P. javanicus* or *gonionotus*, *O. mossambicus* and *O. niloticus* were also found to be good predators of the young golden snail (*Pomacea caniculata*), a serious rice pest.

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S. RAMASWAMY, *IPM Project GCP-RAS-145-NET, Bangladesh, Food and Agriculture Organization of the United Nations F404, Department of Agriculture Extension, Khamar Bari, Farmgate, Dhaka, Bangladesh*

Abstract

The Department of Agricultural Extension, Khamar Bari and FAO Intercountry Rice Integrated Pest Management Project endeavored to introduce practical Integrated Pest Management (IPM) to rice farmers of Bangladesh from late 1988. Eight "IPM Regions" were selected based on quantity of pesticides used and on the intensive nature of rice cultivation. At each region 3-12 farmers'IPM field schools at one per Tahan (subdistrict) were established. An IPM field school consists of about 20 ha of ricefields where IPM concepts are practiced and another 2 ha where farmers follow their usual pest control practices without any IPM intervention.

Using field schools as training grounds, about 2,000 extension officers from the Government and nongovernment organizations were given practical IPM training. With the help of trained extension officers, 50 rice farmers at each school were given IPM field training for 30 hours, split into eight sessions spread over two cropping seasons. These trained farmers were able to reduce pesticide use by about 70% and yet managed to produce 11% more rice than their neighbors who had no IPM knowledge. Additional but important benefits are the reduction in the health hazards to the farming community at large and the reduction in the environmental pollution.

About 80% of the total pesticides used in Bangladesh are used on rice crops. Pesticides, especially pyrethroids, are sharply poisonous to fish. Over 80% of IPM trained farmers did not use any pesticides at all, and therefore their ricefields became suitable for fish culture. Some experiments conducted faced problems due to flood and due to predators such as snakes and mangooses. However, excellent results were obtained from a field trial at the IPM field school in Muktagacha in Mymensingh where the farmer produced 29 kg of mirror carp (*Cyprinus carpio*) and Thai sarputi or silver barb (*Puntius gonionotus*) from 0.162-ha ricefield representing a net profit of US$46.00. This is about 179 kg/ha of fish and net profit of US$114/ha. Other field trials are in progress.

It is believed that IPM and fish culture with rice are highly complimentary. Knowledge of IPM gives rice farmers confidence in managing their crop with a little or no pesticide thus fostering fish cultivation in those fields. Also, IPM farmers who might be tempted to apply pesticide will probably refrain from doing so if there are fish in those fields.

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Fish Cultivation as a Means to Increase Profitability from Ricefields: Implications for Integrated Pest Management

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Abstract

CARE International and the United Kingdom's Overseas Development Administration (ODA) in Bangladesh are presently working with more than 1,000 farmers in an integrated rice management pilot project. More than 500 of these farmers are cultivating fish in their ricefields. Since the stocking of fish in ricefields is not a traditional practice in Bangladesh, data collected from the rice-fish trials facilitated by CARE are providing a solid foundation from which national rice-fish research and extension strategies in Bangladesh can develop.

For the 1992 irrigated rice season, there were substantial increases in rice production in fields where fish were introduced. A 15% increase in rice yield was calculated based on the difference between the 1991 season without fish and the 1992 season with fish. A similar experiment was carried out during the rainfed season which followed. A group of farmers comprised of 110 individuals who received Integrated Pest Management (IPM) training and cultivated fish in their rice plots had an increase in rice production over the previous year of 7%. These increases are probably due to better rice management accompanying the introduction of fish and to changes in rice management practices made by the farmers.

In both irrigated and rainfed rice cases, rice production increased, pesticide use was reduced, and the production of fish provided substantial additional returns to the ricefield. While overall production per hectare is less in rainfed rice, the profitability of rainfed rice is considerably more than irrigated rice (US $326/ha versus $189/ha, respectively). However, when fish are introduced into rice fields this situation can dramatically change. Income from fingerling production in irrigated rice is usually greater than food fish production from rainfed systems. Savings through the rejection of pesticide use are greater in irrigated systems where they are more extensively used. This results in irrigated rice with fish becoming almost as profitable as rainfed rice production (US $389 versus $410/ha, respectively).

Very little research has been done in Bangladesh or it seems in other countries, to document the economic importance of other aquatic organisms found in the ricefield to rural households. In Bangladesh, snails and mussels are important sources of food for poultry and prawn cultivation, and crabs are used for human consumption in many areas. Small freshwater shrimp are consumed by Bangladeshi farmers on wide scale, and the export of frog legs, at one time, provided a lucrative source of income for many families.

Given the potential returns from fish production as well as other aquatic organisms in ricefields, chemical control of pest outbreaks is not an economically sound option if fish have been stocked in the ricefields and their mortality is an issue. The income generated from fish sales and the nutritional benefits through consumption of fish in the home, would more than compensate for rice production losses in all but the most severe of pest outbreaks. The introduction of fish, therefore, becomes a strong incentive for farmers to reduce pesticide use and adopt more environmentally sound pest management strategies. Fish cultivation in ricefields can therefore be effective in strengthening other non-chemical IPM strategies. A national strategy to expand rice-fish cultivation in Bangladesh is needed to take full advantage of this opportunity for reducing toxic pesticide use and increasing ricefield productivity.

Feasibility of Integrating Aquaculture in Rainfed Ricefields and Possible Implications for Integrated Pest Management

MD. AKHTERUZZAMAN[1], M.V. GUPTA[2], J.D. SOLLOWS[2] and A.H.M. KOHINOOR[1]
[1]Fisheries Research Institute, Mymensingh, Bangladesh; [2]International Center for Living Aquatic Resources Management, MCPO Box 2631, 0718 Makati, Metro Manila, Philippines

Abstract

Studies were undertaken to assess the feasibility and economic viability of integrating fish culture with rainfed (aman or wet season crop) rice farming in the northeastern part of Bangladesh and possible implications for integrated pest management. For the purpose, 52 rice plots of 400-6,800 m^2 each from four thanas (subdistricts) were selected. Farmers in these fields either had a ditch (natural depression) or excavated a refuge covering on an average 6.1% of the ricefield area. The ricefields were transplanted between July and September 1992, primarily with BR-11 and Pajam rice varieties. Normal rice agronomy practices were followed.

Thirty plots were stocked with silver barb (*Puntius gonionotus*), four plots with mirror carp (*Cyprinus carpio*) and 18 plots with a combination of silver barb and mirror carp in 1:1 ratio. Size of fingerlings at stocking averaged 8 cm. Stocking densities varied from farmer to farmer, mostly due to wrong calculations of field areas

and ranged from 2,180 to 7,500 fingerlings per ha. Farmers applied rice bran and duck weeds as supplementary feed, the quantity of which varied greatly from farmer to farmer.

Total fish culture period was 56-121 days (average 84 days), of which ricefields had water (7 cm deep or more) for only 21-80 days. Fish production was 15-127 kg/ha (average 76 kg) from fields stocked with silver barb; 76.7-261.7 kg/ha (average 156.6 kg) from fields stocked with mirror carp; and 14.7-222.5 kg/ha (average 99.7 kg) from fields stocked with a combination of silver barb and mirror carp. Recovery of fish was 68% in the case of silver barb and 53% in the case of mirror carp. Sizes of rice plot and refuge did not have any significant effect on the size of fish at harvest. Stocking density and fish production were positively correlated. Total culture period (number of days between stocking and harvesting) did not have any effect on fish yield, harvested size and recovery. However, the number of days when water level in the field was more than 7 cm had a noticeable effect on production. Cost of production in different fields ranged from Tk1,268-5,090 (average Tk 2,290 or US$58.72) per ha, with an average net benefit of Tk2,118 (US$54.31) per ha.

Rice yields from 67% of the fields stocked with fish were higher than those from comparable, unstocked fields. On average, rice yield from fields with fish was 13% higher.

Only five out of 52 farmers used pesticides. Low weed or pest infestation in plots stocked with fish compared to unstocked fields was reported by 28 and 14% farmers, respectively. Of the farmers who reported increased rice yields, 42% reported reduced insect infestation and 25% reported reduced incidence of weeds. Of the 48 farmers planning to culture fish the following year, 17% indicated that the reduced dependence on pesticides had influenced their decisions. These figures suggest that the potential for mutual support between rice-fish culture and integrated pest management is high.

Culturing Fish in Ricefields as a Means of Preventing Insect Infestations: Preliminary Observations

NGUYEN ANH TUAN, *Faculty of Fisheries, University of Cantho, Vietnam*

Abstract

Rice-fish farming system is a traditional technique in some districts in Mekong Delta, Vietnam.

A demonstration farm consisting of a well irrigated 4,000-m^2 ricefield and connected to a 2,500-m^2 garden with a 1,600-m^2 water surface, was redesigned by digging a 2.5 x 0.8 m peripheral canal to be used as a fish refuge when water level in the ricefield needs to be reduced. Polyculture of silver barb (*Puntius gonionotus*, 60%), tilapia (*Oreochromis niloticus*, 15%), common carp (*Cyprinus carpio*, 15%), rohu (*Labeo rohita*, 5%) and silver carp (*Hypophthalmichthys molitrix*, 5%) was applied at stocking densities of 4 and 6 fish/m^2 in 1991 and 1992, respectively. Rice bran, soaked rice, soft leaves, waste vegetables and kitchen wastes were fed to the fish once daily depending on feed availability. Water was 10-cm deep in the rice area but at spring tide it might have reached 25 cm for few hours. The number of hoppers/m^2 was checked whenever the nearby ricefields were checked.

Seven months after stocking, fish production was 1,280 kg and 2,240 kg in 1991 and 1992, respectively. Some 3,800 hoppers/m^2 were recorded from the demonstration farm compared with hundreds of thousands hoppers/m^2 obtained from the surrounding infested ricefields. Insecticides needed for such a system were reduced considerably to 4-5 times less than those used in previous croppings or in the surrounding fields.

The Impact of Fish on Arthropod Communities in Irrigated Rice in the Philippines

M. HALWART, *Institute of Landscape Planning and Ecology, University of Stuttgart, Stuttgart 1, F.R. Germany, and International Rice Research Institute, PO Box 933, Manila, Philippines*

Abstract

Field experiments were conducted in Central Luzon, the rice bowl of the Philippines, at the Freshwater Aquaculture Center of Central Luzon State University. Fifteen days after transplanting (DAT), 2-6 g common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*) were stocked in separate, replicated 200-m^2 ricefields each provided with a pond refuge. Several sampling methods were used to determine arthropod abundance in the rice canopy, at the water surface, and in the fish gut, as well as damage caused by arthropods. Arthropod abundance in the canopy was determined by sampling from 20 rice hills per plot in biweekly intervals using a suction sampling device (DVac). Information on arthropods at the level of the water table was obtained by using sticky traps. Mylar sheets covered with a sticky substance were cut in circles of 0.25 m diameter and placed around three randomly selected hills per plot for 24 hours. For comparison, arthropods were sorted into guilds of phytophages, predators, parasitoids and transients. Fish were collected in the ricefield, killed, and their gut content examined. In addition, damage caused by the yellow stemborer (*Scirpophaga incertulas*) was assessed by counting deadhearts and whiteheads using a stratified random sampling technique.

For the DVac sampling it was found that abundance of phytophages was relatively constant throughout the season, while predators, parasitoids and transients peaked at about 60 DAT. Of importance were chironomids, whorl maggot (*Hydrellia philippina*), green leafhopper (*Nephotettix virescens*), ripple bug (*Microvelia douglasi atrolineata*), and spiders of the genera *Callitrichia* and *Tetragnatha*. No differences among treatments were detected although sticky trap catches at the water surface showed that many arthropods fall off the rice plants. This was especially true for the phytophages in the early season which were mainly composed of *H. philippina*. The gut content analysis revealed that all guilds are represented in the diet of both fish species regardless of aquatic, semiterrestrial or terrestrial life cycle of the arthropod species. Although only few specimen of *S. incertulas* were found in the guts, significant ($P < 0.05$) differences between rice-fish and rice treatments were detected for stemborer damage (whiteheads). Whiteheads were reduced by 3% in the tilapia and by 5% in the carp treatment. Stemborers lay their eggs in masses, but generally only one larva infests one tiller. The most likely mechanism of control is predation by fish on the neonate stemborer larvae. After hatching they often suspend themselves from the rice leaves with a silken thread to disperse to other hills. Stemborer damage is economically important as the yield of the whole panicle is lost. In this experiment the reduced percentage of whiteheads in fish treatments corresponded to a significant increase in rice yield.

Potential of Fish in Rice-Fish Culture as a Biological Control Agent of Rice Pests

S. HENDARSIH[1], S. SURIAPERMANA[1], A. FAGI[1] AND I. MANWAN[2]
[1]*Sukamandi Research Institute for Food Crops, Subang, West Java, Indonesia;* [2]*Central Research Institute for Food Crops, Bogor, Indonesia*

Abstract

Field experiments to evaluate the effects of rice-fish culture and insecticide application on rice pests infestation, fish and rice yields were conducted at Sukamandi Research Station for Food Crops in the 1989/90 wet season and the dry season of 1990. Nine treatments each with three replications were used: rice only (control),

rice-fish culture (no insecticide) and rice-fish culture with seven insecticide treatments (carbofuran, bensultaf, etoproksifen 95 EC, kilval, MICP 50 WP and BPMC 50 EC). Carbofuran was applied two ways: once, incorporated at transplanting, and twice, incorporated at transplanting and repeated five weeks after transplanting. The other insecticides were sprayed when rice pest populations reached the economic threshold. Common carp (*Cyprinus carpio*, at 25 g) were stocked at the rate of 2,000/ha in the 250-m^2 plots.

Two experiments in a screenhouse followed in the 1992 wet season to determine the predation capacity of fish on the golden snail (*Pomacea caniculata*) and the brown planthopper (*Nilaparvata lugens* Stahl). Each experiment had five treatments and five replications. Five species of fish (150-g common carp, 150-g silver barb (*Puntius gonionotus*), 25-g Nile tilapia (*Oreochromis niloticus*), 25-g *mujaer* (*O. mossambicus*) and 30-g *tambakan* (*Helostoma temmincki*) were used to evaluate their predation ability on golden snail. One fish of each species was allowed to feed on 40 young snails (i.e, 20 one-day old and 20 seven-day old) in a water-filled pail (30-cm diameter x 30 cm high). In evaluating the predation ability of fish on brown planthoppers (BPH), one 25-g common carp was exposed to the rice plants with sufficient water to feed on: 10 BPH+pellet feed, 20 BPH, 20 BPH+pellet feed, 30 BPH, and 40 BPH nymphs. A similar experiment was done with adult BPH.

During the 1989/90 wet season, less rice pests occurred. Damage on rice in rice-fish culture treatments due to rice leaffolder (*Cnaphalocrosis medinalis*) and white-backed planthopper (*Sogatella furcifera*) were less by about 50% and 33%, respectively, than the damage on the control treatment. This difference, however, was statistically nonsignificant. White stemborer (*Scirpophaga innotata* Walker) became the dominant insect pest in the 1990 dry season. Two weeks after the first insecticide spraying, all insecticide treatments as well as the rice-fish culture treatment did not reduce WSB infestation, during which the average WSB infestation in the control was 11.65%. Two weeks after the second or last spraying, the WSB damage declined in all the treatments. Under this condition, the plots treated with carbofuran (applied twice), Kilval, MICP 50 WP and BPMC 50 EC showed significantly less damage (1.43-2.29% infestation) than the control (4.47% infestation) ($P < 0.01$). The rice-fish culture treatment had lower infestation (3.45%) but nonsignificantly different than the control ($P > 0.05$). The differences in infestations between rice-fish culture and all the insecticide treatments were nonsignificant ($P > 0.05$), except MICP 50 WP and BPMC 50 EC ($P < 0.05$).

Rice-fish culture and insecticide treatments did not enhance rice yields. The differences on rice yields between these treatments and the control were not significant. Carbofuran, BPMC 50 EC and kilval appeared to have significantly affected fish survival ($P < 0.01$ for both carbofuran treatments and $P < 0.05$ for the other two).

Under screenhouse condition, common carp consumed 6-16 BPH adults/day (39 to 56%) or 8-28 adults within three days (62-84%). Predation on nymphs was also high: 7-26 or 60-70% in three days. The capacity of the fish to prey on BPH appeared to be density-dependent. Common carp could probably consume more BPH at higher population. High population would cause more BPH to hop on the water, thus increasing the chance for fish to prey on them. The presence of fish pellet as an alternative feed did not affect the results on predation ability.

The fish also showed promising results as a biological control agent for the golden snail. Four of the five fish species preyed on the young golden snail. Common carp was the most voracious predator for having consumed 40 young golden snails in one day. Nile tilapia, silver barb and *mujaer* consumed 84-87% of the same number of young golden snail within four days. *Tambakan* consumed 2% until the third day and 30% during the fourth day.

Session II

FISH AND INTEGRATED PEST MANAGEMENT

Summary of Presentations

Dr. C.R. dela Cruz

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Thirty plots were stocked with silver barb (*Puntius gonionotus*), four plots with mirror carp (*Cyprinus carpio*) and 18 plots with a combination of silver barb and mirror carp in 1:1 ratio. Size of fingerlings at stocking averaged 8 cm. Stocking densities varied from farmer to farmer, mostly due to wrong calculations of field areas

and ranged from 2,180 to 7,500 fingerlings per ha. Farmers applied rice bran and duck weeds as supplementary feed, the quantity of which varied greatly from farmer to farmer.

Total fish culture period was 56-121 days (average 84 days), of which ricefields had water (7 cm deep or more) for only 21-80 days. Fish production was 15-127 kg/ha (average 76 kg) from fields stocked with silver barb; 76.7-261.7 kg/ha (average 156.6 kg) from fields stocked with mirror carp; and 14.7-222.5 kg/ha (average 99.7 kg) from fields stocked with a combination of silver barb and mirror carp. Recovery of fish was 68% in the case of silver barb and 53% in the case of mirror carp. Sizes of rice plot and refuge did not have any significant effect on the size of fish at harvest. Stocking density and fish production were positively correlated. Total culture period (number of days between stocking and harvesting) did not have any effect on fish yield, harvested size and recovery. However, the number of days when water level in the field was more than 7 cm had a noticeable effect on production. Cost of production in different fields ranged from Tk1,268-5,090 (average Tk 2,290 or US$58.72) per ha, with an average net benefit of Tk2,118 (US$54.31) per ha.

Rice yields from 67% of the fields stocked with fish were higher than those from comparable, unstocked fields. On average, rice yield from fields with fish was 13% higher.

Only five out of 52 farmers used pesticides. Low weed or pest infestation in plots stocked with fish compared to unstocked fields was reported by 28 and 14% farmers, respectively. Of the farmers who reported increased rice yields, 42% reported reduced insect infestation and 25% reported reduced incidence of weeds. Of the 48 farmers planning to culture fish the following year, 17% indicated that the reduced dependence on pesticides had influenced their decisions. These figures suggest that the potential for mutual support between rice-fish culture and integrated pest management is high.

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Culturing Fish in Ricefields as a Means of Preventing Insect Infestations: Preliminary Observations

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Abstract

Rice-fish farming system is a traditional technique in some districts in Mekong Delta, Vietnam.

A demonstration farm consisting of a well irrigated 4,000-m^2 ricefield and connected to a 2,500-m^2 garden with a 1,600-m^2 water surface, was redesigned by digging a 2.5 x 0.8 m peripheral canal to be used as a fish refuge when water level in the ricefield needs to be reduced. Polyculture of silver barb (*Puntius gonionotus*, 60%), tilapia (*Oreochromis niloticus*, 15%), common carp (*Cyprinus carpio*, 15%), rohu (*Labeo rohita*, 5%) and silver carp (*Hypophthalmichthys molitrix*, 5%) was applied at stocking densities of 4 and 6 fish/m^2 in 1991 and 1992, respectively. Rice bran, soaked rice, soft leaves, waste vegetables and kitchen wastes were fed to the fish once daily depending on feed availability. Water was 10-cm deep in the rice area but at spring tide it might have reached 25 cm for few hours. The number of hoppers/m^2 was checked whenever the nearby ricefields were checked.

Seven months after stocking, fish production was 1,280 kg and 2,240 kg in 1991 and 1992, respectively. Some 3,800 hoppers/m^2 were recorded from the demonstration farm compared with hundreds of thousands hoppers/m^2 obtained from the surrounding infested ricefields. Insecticides needed for such a system were reduced considerably to 4-5 times less than those used in previous croppings or in the surrounding fields.

The Impact of Fish on Arthropod Communities in Irrigated Rice in the Philippines

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Abstract

Field experiments were conducted in Central Luzon, the rice bowl of the Philippines, at the Freshwater Aquaculture Center of Central Luzon State University. Fifteen days after transplanting (DAT), 2-6 g common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*) were stocked in separate, replicated 200-m^2 ricefields each provided with a pond refuge. Several sampling methods were used to determine arthropod abundance in the rice canopy, at the water surface, and in the fish gut, as well as damage caused by arthropods. Arthropod abundance in the canopy was determined by sampling from 20 rice hills per plot in biweekly intervals using a suction sampling device (DVac). Information on arthropods at the level of the water table was obtained by using sticky traps. Mylar sheets covered with a sticky substance were cut in circles of 0.25 m diameter and placed around three randomly selected hills per plot for 24 hours. For comparison, arthropods were sorted into guilds of phytophages, predators, parasitoids and transients. Fish were collected in the ricefield, killed, and their gut content examined. In addition, damage caused by the yellow stemborer (*Scirpophaga incertulas*) was assessed by counting deadhearts and whiteheads using a stratified random sampling technique.

For the DVac sampling it was found that abundance of phytophages was relatively constant throughout the season, while predators, parasitoids and transients peaked at about 60 DAT. Of importance were chironomids, whorl maggot (*Hydrellia philippina*), green leafhopper (*Nephotettix virescens*), ripple bug (*Microvelia douglasi atrolineata*), and spiders of the genera *Callitrichia* and *Tetragnatha*. No differences among treatments were detected although sticky trap catches at the water surface showed that many arthropods fall off the rice plants. This was especially true for the phytophages in the early season which were mainly composed of *H. philippina*. The gut content analysis revealed that all guilds are represented in the diet of both fish species regardless of aquatic, semiterrestrial or terrestrial life cycle of the arthropod species. Although only few specimen of *S. incertulas* were found in the guts, significant ($P < 0.05$) differences between rice-fish and rice treatments were detected for stemborer damage (whiteheads). Whiteheads were reduced by 3% in the tilapia and by 5% in the carp treatment. Stemborers lay their eggs in masses, but generally only one larva infests one tiller. The most likely mechanism of control is predation by fish on the neonate stemborer larvae. After hatching they often suspend themselves from the rice leaves with a silken thread to disperse to other hills. Stemborer damage is economically important as the yield of the whole panicle is lost. In this experiment the reduced percentage of whiteheads in fish treatments corresponded to a significant increase in rice yield.

Potential of Fish in Rice-Fish Culture as a Biological Control Agent of Rice Pests

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Abstract

Field experiments to evaluate the effects of rice-fish culture and insecticide application on rice pests infestation, fish and rice yields were conducted at Sukamandi Research Station for Food Crops in the 1989/90 wet season and the dry season of 1990. Nine treatments each with three replications were used: rice only (control),

rice-fish culture (no insecticide) and rice-fish culture with seven insecticide treatments (carbofuran, bensultaf, etoproksifen 95 EC, kilval, MICP 50 WP and BPMC 50 EC). Carbofuran was applied two ways: once, incorporated at transplanting, and twice, incorporated at transplanting and repeated five weeks after transplanting. The other insecticides were sprayed when rice pest populations reached the economic threshold. Common carp (*Cyprinus carpio*, at 25 g) were stocked at the rate of 2,000/ha in the 250-m^2 plots.

Two experiments in a screenhouse followed in the 1992 wet season to determine the predation capacity of fish on the golden snail (*Pomacea caniculata*) and the brown planthopper (*Nilaparvata lugens* Stahl). Each experiment had five treatments and five replications. Five species of fish (150-g common carp, 150-g silver barb (*Puntius gonionotus*), 25-g Nile tilapia (*Oreochromis niloticus*), 25-g *mujaer* (*O. mossambicus*) and 30-g *tambakan* (*Helostoma temmincki*) were used to evaluate their predation ability on golden snail. One fish of each species was allowed to feed on 40 young snails (i.e, 20 one-day old and 20 seven-day old) in a water-filled pail (30-cm diameter x 30 cm high). In evaluating the predation ability of fish on brown planthoppers (BPH), one 25-g common carp was exposed to the rice plants with sufficient water to feed on: 10 BPH+pellet feed, 20 BPH, 20 BPH+pellet feed, 30 BPH, and 40 BPH nymphs. A similar experiment was done with adult BPH.

During the 1989/90 wet season, less rice pests occurred. Damage on rice in rice-fish culture treatments due to rice leaffolder (*Cnaphalocrosis medinalis*) and white-backed planthopper (*Sogatella furcifera*) were less by about 50% and 33%, respectively, than the damage on the control treatment. This difference, however, was statistically nonsignificant. White stemborer (*Scirpophaga innotata* Walker) became the dominant insect pest in the 1990 dry season. Two weeks after the first insecticide spraying, all insecticide treatments as well as the rice-fish culture treatment did not reduce WSB infestation, during which the average WSB infestation in the control was 11.65%. Two weeks after the second or last spraying, the WSB damage declined in all the treatments. Under this condition, the plots treated with carbofuran (applied twice), Kilval, MICP 50 WP and BPMC 50 EC showed significantly less damage (1.43-2.29% infestation) than the control (4.47% infestation) ($P < 0.01$). The rice-fish culture treatment had lower infestation (3.45%) but nonsignificantly different than the control ($P > 0.05$). The differences in infestations between rice-fish culture and all the insecticide treatments were nonsignificant ($P > 0.05$), except MICP 50 WP and BPMC 50 EC ($P < 0.05$).

Rice-fish culture and insecticide treatments did not enhance rice yields. The differences on rice yields between these treatments and the control were not significant. Carbofuran, BPMC 50 EC and kilval appeared to have significantly affected fish survival ($P < 0.01$ for both carbofuran treatments and $P < 0.05$ for the other two).

Under screenhouse condition, common carp consumed 6-16 BPH adults/day (39 to 56%) or 8-28 adults within three days (62-84%). Predation on nymphs was also high: 7-26 or 60-70% in three days. The capacity of the fish to prey on BPH appeared to be density-dependent. Common carp could probably consume more BPH at higher population. High population would cause more BPH to hop on the water, thus increasing the chance for fish to prey on them. The presence of fish pellet as an alternative feed did not affect the results on predation ability.

The fish also showed promising results as a biological control agent for the golden snail. Four of the five fish species preyed on the young golden snail. Common carp was the most voracious predator for having consumed 40 young golden snails in one day. Nile tilapia, silver barb and *mujaer* consumed 84-87% of the same number of young golden snail within four days. *Tambakan* consumed 2% until the third day and 30% during the fourth day.

Session III

RICE-FISH RESEARCH METHODOLOGY AND ANALYSIS

Summary of Presentations

Dr. C.R. dela Cruz

Papers presented showed the ECOPATH II application in modeling and analyzing irrigated rice and rice-fish ecosystems. Methodologies in quantifying nitrogen (N) within the soil-plant system, and in an economic evaluation of the role of fish on rice-IPM were suggested.

Cagauan et al. developed steady-state models of N flows in irrigated rice and rice-fish ecosystems through ECOPATH II, an ecological modeling software. The analysis of the models revealed that: 1) higher N transfer efficiencies were obtained in all trophic levels, suggesting that fish helps in improving N utilization within the ecosystem; 2) the rice-fish system has a higher capacity to produce and capture N within the system than rice monoculture; 3) rice showed a negative impact on natural fish food; 4) Nile tilapia and common carp did not improve rice yield; and 5) common carp showed better performance in rice pest control than Nile tilapia. The fish, however, negatively affected oligochaetes and zooplankton in the ecosystem.

The effect of introducing rice-fish production within irrigated rice systems can best be understood if its influence on the soil-plant N relationship is quantified. Under irrigated rice management, the soil microbial biomass has an important role in N supply during a crop cycle. Gaunt et al. discussed the quantification of N in floodwater, soil solution, soil exchangeable and soil microbial biomass N pools relative to plant N uptake during a crop cycle. A framework by which the effects of introducing fish can be conceptualized was provided, including methodologies for mechanistic quantification of the N economy of rice-fish systems.

An economic framework for assessing the role of fish on combining rice-fish system with IPM and equating this to ricefield ecosystem management was proposed by Purba. It was hypothesized that rice-fish culture together with IPM is an alternative compromise in narrowing the opposing difference between intensive rice monoculture and ricefield ecosystem management. Initial results of interviews on pesticide use in and economics of rice-fish culture and IPM of four groups of farmers (rice-fish farmers; IPM farmers; rice-fish+IPM farmers; and conventional farmers) indicated that: 1) rice-fish farmers were the highest users of pesticides, while both IPM and rice-fish + IPM farmers had reduced pesticide use drastically, indicating that IPM is a vital component in initiating pesticide reduction in ricefield ecosystem; 2) both rice-fish culture and IPM demand more labor than conventional rice farming. Savings from adopting IPM can be used in purchasing fish seed, and the income from fish could compensate for the risks in adopting IPM.

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Nitrogen Models of Lowland Irrigated Ecosystems With and Without Fish Using Ecopath II

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Abstract

Ways for better management of rice-fish ecosystems can be brought about from an understanding of ecological interactions of rice and fish. One approach to study this is through ecological modeling of nitrogen (N) flows in the ecosystem. Nitrogen is described as the kingpin in rice farming. Its flows in lowland irrigated ricefields could possibly be influenced by growing fish in ricefields. Bioperturbation of the soil by fish may increase the thickness of the aerobic zone and make nutrients more available for plant use. Fish as a component of the rice ecosystem could make a difference in improving the sustainability of rice production than when rice is cultured alone. Thus, steady-state N models for rice and rice-fish systems in lowland irrigated ricefields were constructed using ECOPATH II in view of the major role of this nutrient in increasing rice yield. The N flows, impacts and interactions of the different ecosystems components particularly of rice and fish were differentiated and assessed.

Quantitative data were generated from a 3-crop on-station experiment at the Freshwater Aquaculture Center (FAC), Central Luzon State University (CLSU), Philippines. Treatments composed of rice monoculture and concurrent rice-fish culture had three 300-m^2 plots each provided with pond refuge occupying about 10% of the plot area. All plots were treated with pesticide. Among the different components of the ecosystem, the values gathered from the on-station experiment were phytoplankton, weeds, rice snails, oligochaetes, Nile tilapia and common carp. These values were averaged and inputed in the models. Data on insects, microbiomass, biological nitrogen fixation (BNF) and detritus were obtained from rice experiments at the International Rice Research Institute.

Results on higher N transfer efficiencies in all trophic levels in rice-fish model suggest the role of fish in ameliorating N utilization within the ecosystem. Higher throughput (or sum of all flows) in the rice-fish system than rice alone indicates that it had a higher capacity to produce and to capture N within the system. In both systems, the largest nutrient throughput comes mainly from microbial biomass and also from rice, weeds and phytoplankton. Mixed trophic impact showed the negative impact of rice on phytoplankton, weeds, oligochaetes, zooplankton, microbiomass, tilapia, carp and detritus. This negative impact of rice on natural food of fish partly limits fish yields in rice-fish systems. Rice negatively affected soil microbial biomass indicating that crop intensification could lead to reduction of soil fertility.

Nile tilapia and common carp did not enhance rice yield. Common carp had a negative impact on weeds while tilapia enhanced it. This result is attributed to the benthic feeding of carp and the surface feeding of tilapia. Mixed trophic impacts also showed the negative impact of carp on weeds, snails and insects which imply the usefulness of this fish species for biological pest control leading to less use of pesticide in rice production. Fish food organisms such as oligochaetes and zooplankton were negatively affected by carp.

The models revealed selected interactions of rice and fish leading to a better understanding of both systems. Results from the analysis using ECOPATH II could be improved by more field measurements of some ecosystem groups, refinement of existing methodologies to measure various groups, and reassessment of diet compositions. Data generated from long-term experiments may possibly improve trophic impacts particularly of fish on rice yield enhancement.

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Integrated Rice-Fish System: Methodologies for the Quantification of Nitrogen Within the Soil-Plant System

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Abstract

Ricefields cover a range of ecosystems, including irrigated, rainfed, tidal wetland and deepwater environments. The irrigated rice ecosystem accounts for only 55% of the world's harvested rice area (approximately 81 million ha) but provides 76% of global rice production. A shortfall of rice in Asia is predicted by the year 2000. The potential to increase the land area under rice is limited as is further expansion of irrigated land. More importantly, there are concerns that yield under intensive cultivation has declined in long-term field experiments and that yields may have reached a plateau in farmers fields. Due to the variable productivity of the rainfed environment, stable future rice supplies will rely mainly on sustainable increases in production from the irrigated system.

Throughout Asia, intensified rice production associated with heavy pesticide use resulted in a decline in fish grown with rice due to the toxicity of pesticides. However, environmental concerns regarding the heavy use of agrochemicals and the decreased reliance on pesticides through adoption of integrated pest management (IPM) strategies, may benefit rice-fish cultivation. Concurrent culture of fish within irrigated rice has been reported to increase nitrogen (N) concentration and uptake by rice and rice yields. In long-term studies, a reduction of soil N supplying capacity has been hypothesized as a key factor in this decline. Thus there is a clear need to gain a mechanistic understanding of the interactions of fish on N supply within the soil-plant system to verify these increases in crop N uptake and establish the mechanisms involved. This is a particularly complex issue, due to probable interactions between the control of rice pests, diseases and N uptake.

It is essential that management practices are evaluated in the light of potential capacity of the system and the inputs required to achieve that potential. Introduction of fish in intensively cultivated rice systems is only practical within an IPM strategy. Thus when comparing N economy of irrigated rice ecosystems with and without concurrent cultivation of fish, pest management practices have to be selected to evaluate or account for this potential interaction between fish, pests and N cycling.

In addition to measurement of agronomic and nitrogen use efficiency, soil N status and plant N uptake can be measured during a crop cycle to establish the contribution of soil N pools to plant uptake. The measurement of labile N as soil exchangeable, soil solution and soil microbial biomass pools over time in the 0-15 cm puddled layer in intensively cultivated irrigated rice indicated that inorganic N was immobilized within the soil microbial biomass until flowering. The biomass pool size was constant after flowering, indicating that any subsequent crop N uptake was derived from fertilizer topdressing or mineralization of soil organic matter. Such measurements provide great insight into the mechanisms of N supply in the system.

Given that the impact of fish during the crop cycle may be to change both the quantities and characteristics of N supply, continuous monitoring of the N content in the crop for each management practice is needed. Non-destructive plant sampling to measure nitrogen concentration of leaves should be used. This can be done using a chlorophyll meter, correcting values for the specific leaf weight.

Specific experiments to establish a mechanistic understanding of the seasonal N supply should be linked with studies of long impact of rice-fish management. It is important to evaluate the performance of the system through measurements such as total factor productivity as well as specific components such as soil fertility.

A key component determining the long-term N fertility of soils is soil organic matter. Changes in the quantity and nature of soil organic matter will inevitably affect soil fertility. A large proportion of total soil carbon is relatively inert and thus its measurement is a poor indicator of soil fertility. Much research has identified the soil microbial biomass as a labile organic matter pool that is sensitive to impacts due to management practice. When the soil system is at a steady state, soil microbial biomass will form a constant proportion of total carbon (C). Where soil organic matter is accumulating or declining, this relationship with total C breaks down, however the relationship between biomass and labile C will remain constant. If such relationships are established and verified in rice soils they may provide an index of soil fertility that avoids complex studies of soil organic matter.

It should be recognized that rice-fish cultivation is practised in many agricultural ecosystems. It is essential that future research should be oriented on an ecosystem basis with a clear understanding of the interactions between resource and socioeconomic factors that determine the success of the cultivation practice. Through these, exploration domains and constraints to adoption can be identified clearly.

An Economic Framework for Assessing the Role of Fish on Rice-IPM: Case Study from North Sumatra, Indonesia

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Abstract

Intensive rice monoculture system and ricefield ecosystem management are considered to be contradictory to each other. As farmers move toward intensive rice cropping, the ecology of ricefields tends to be ignored. This is especially true in Indonesia, where most of the technologies - such as the *supra insus*, a program promoting super intensive rice production - introduced to farmers during the green revolution, relied heavily on inputs for increasing yields, which include inorganic fertilizers and pesticides. Moreover, the cropping intensity of rice increased from one crop per year before the green revolution, to 4-5 times in two years. In the postgreen revolution technology, however, the concern on ricefield ecology management has greatly gained support. Along with this is a growing interest in raising fish in ricefields and in improving the productivity of rice-fish farming. This raised the hypothesis that rice-fish culture system, in combination with other complementing technology such as IPM, could be an alternative compromise between the two contradicting systems. Research done in the past had ignored the possible role of IPM in ricefields stocked with fish or conversely, the role of fish in ricefields employing IPM. Thus, the potential of fish as a part of intensive rice culture and IPM is being investigated in North Sumatra, Indonesia. An economic framework for assessing the role of fish on rice-IPM is being proposed from this on-going research.

Simalungun and Deli Serdang Districts in North Sumatra Province were selected as the sites of the study. Four groups of randomly selected farmers have been identified and interviewed in this study: 1) rice-fish farmers; 2) IPM farmers; 3) rice-fish+IPM farmers; and 4) conventional rice farmers (no fish, no IPM). Of the 43 farmers interviewed on economic and pesticide use data, 27 provided information on the latter (7 rice-fish farmers; 11 IPM farmers; 5 rice-fish+IPM farmers; and 4 rice farmers).

Initial results of the study indicated that IPM and not rice-fish culture could reduce pesticide use in ricefields. Most of the farmers in the rice-fish group applied intensively herbicides and insecticides (not only for rice insects but for predators of fish as well) into their ricefields. They had the highest pesticide dosages (2,901±2,093 ml/ha [mean ± standard deviation] for insecticides and 681±1,093 ml/ha for herbicides) and application frequencies (5.8±2.6 and 1.1±0.6, respectively). Conventional rice farmers, who used pesticides for rice pests only, had the second highest dosages (1,992±1,249 ml/ha for insecticides and 51±59 ml/ha for herbicide), and application frequencies (4.2±0.4 and 0.7±0.4, respectively). Rice-fish IPM farmers reduced drastically pesticide use but at a level still slightly higher than the IPM farmers. The dosages applied were 494±664 ml/ha for insecticides and 58±42 ml/ha for herbicides at frequencies of 2±2.5 and 0.8±0.4, respectively. IPM farmers applied the lowest dosage of insecticides (443±570 ml/ha) at frequency of 0.9±1.3. However, the herbicides applied at dosage of 459±554 ml/ha and frequency of 1.1±0.7 were higher than the rice-fish IPM farmers.

Both rice-fish and IPM demand more labor than rice farming alone. IPM can reduce capital requirement which can be used to buy fish seed or fingerlings. For the farmers, additional income from fish can lower the risk of IPM adoption.

At this point, rice-fish culture alone can not be equated with Aquatic Life Management (ALM) in the context discussed by Horstkotte (this vol.). ALM connotes the presence of broader range of aquatic organisms other than fish, such as frogs, shrimps, snails, crabs in ricefields. Rice-fish culture appeared to need IPM in initiating pesticide reduction in ricefields. As a system (rice-fish+IPM or fish + rice-IPM), the synergistic benefits from fish and IPM could work together in facilitating and sustaining enhancement of biodiversity in ricefield ecosystem. Therefore, a new concept is proposed which initially is: rice-fish plus IPM equals ricefield ecosystem management (EM). Gradually, this system will naturally evolve to rice-ALM + IPM = EM.

Session IV

METHODOLOGY FOR RICE-FISH AND IPM ADOPTION

Summary of Presentations

Dr. C. R. dela Cruz

Important developments or considerations were presented which could facilitate the adoption of rice-fish farming. Horstkotte pointed out that the technical complementarities between Aquatic Life Management (ALM) and Integrated Pest Management (IPM) and the existing socioeconomic relationships need to be understood clearly when it comes to adoption of either technology. The changing perception of farmers with regard to ricefield ecology and pest management could be the key to an environmentally sound production technology in which ALM and IPM go hand in hand. Setboonsarng supported this by indicating that, in promoting rice-fish culture, farmers' perception on the implication of the technology to their existing source of livelihood should be considered. Contrary to the recommended practice in rice-fish culture to eliminate fish predators, a survey of 88 Northeast Thai farmers revealed that the so-called fish predators (*Channa striata, Clarias batrachus, Anabas testudineus*) were perceived as valuable products. Farmers view fish predators as low input, high output products which can be sold at a higher price than cultured fish. The monetary value of wild fishes trapped in a hectare of ricefields in Northeast Thailand could be as high as the value of rice yield in that field. For these reasons, farmers object to averting predators from entering their ricefields. Thus, adoption of rice-fish culture technology could be made easier if recommended practices accommodate farmers' goals and aspirations.

The positive progress of the FAO Intercountry Programme on IPM is another development which could facilitate the adoption of rice-fish farming in the region. The Farmer Field School (FFS) training approach in IPM as used in Bangladesh, the Philippines and Vietnam was described and found effective in helping farmers understand the ecology of ricefields particularly in identifying, monitoring, and controlling rice pests.

The FFS began in Bangladesh in 1988 (Ramaswamy, this vol.), in 1991 in the Philippines; and in 1989 in Vietnam. The FFS, training 25 farmers at a time, was nonformal, participatory and intensive in nature. The farmer trainors and trainees met weekly and observed, counted, identified, drew and discussed the rice pests and other organisms found in the ricefield ecosystem at the FFS site throughout the rice growing season. Saltin said that through the FFS, the farmer trainees were transformed into being the ecologists of their own farms. In Vietnam, Nguyen

Huu Huan and Ngo Tien Dung reported that the high, extensive and scheduled use of broadspectrum pesticides led to the outbreak or resurgence of brown planthoppers (BPH) in ricefields, pollution of the environment, and increased farm production cost. Through the FFS, the trained farmers became convinced that early infestation of defoliating insects does not inflict rice yield losses, thus early spraying of insecticides is unnecessary. The IPM concept is now the key component in the Vietnamese agricultural policy in increasing farmers' income by reducing unnecessary pesticides treatments.

Thus, through the FFS and anticipated enhancement of ricefields' environment, as a result of reduced pesticide use by IPM farmers, farmers' appreciation to incorporate fish culture in their ricefields will soon develop and occur naturally.

Socioeconomic Complementarities Between Integrated Pest Management and Aquatic Life Management — the Key to Long-Lasting Adoption?

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Abstract

Environmental degradation due to intensive rice monoculture and declining fish catches due to depleted and polluted marine resources are two of the major problems that farmers and fishers in many Asian countries have to cope with today. In response to these problems, two technologies have been promoted in recent years: Integrated Pest Management (IPM); and rice-fish culture (which will here be called Aquatic Life Management (ALM) to include other aquatic organisms apart from fish). Adoption of both technologies has been slow. Many farmers have cooperated only for the duration of an external influence (government programs, projects), due to a number of drawbacks on the technologies when implemented individually. However, by looking at IPM and ALM simultaneously, areas of complementarity can be found which suggest that the existing problems can be overcome through an integration of both technologies.

Most of these complementary effects are economic in nature: the stocking of fish and other aquatic organisms in the ricefield will shift the economic threshold (one of the main decision-criteria in IPM) to a level which is very rarely reached by pests. Instead of teaching complicated identification and sampling methods for insect pests and telling farmers not to spray as long as the threshold level has not been reached, the extension message for IPM can take on the much more attractive form 'stock fish'. This way of integration can increase greatly the acceptance of IPM among farmers.

One of the major problems in rice-fish programs has been the massive use of pesticides, either by the farmer himself or by other farmers within the same irrigation system. This led to a low acceptance of rice-fish programs which can be overcome if they are implemented in IPM areas.

The main question that is currently under research in the Philippines is, 'do farmers automatically become aware of these complementary effects when they start practicing one of the two technologies'? In other words, do farmers who learn more about IPM change their attitudes towards the aquatic organisms in the field, and do rice-fish farmers start to change their pest management strategies in the fields where they stock fish? If this is the case, then a combined promotion of both technologies could build on the notion that IPM and ALM form a natural partnership, not only in the view of scientists but also in the perceptions of farmers. It is hypothesized that an integrated approach to IPM and ALM will increase adoption and make it long-lasting.

A study is currently being undertaken in the Philippines in which rice-fish farmers, IPM-farmers and conventional farmers are compared with regard to their pest management strategies and perceptions of aquatic life. It is hoped that the results of this study will help to answer the questions put forward in this paper.

IPM Field Training: Farmers Becoming Ecologists

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Abstract

The Integrated Pest Management (IPM) Program in the Philippines started in 1978, when the country hosted the "Regional Training Seminar on Integrated Pest Control for Irrigated Rice in South and Southeast Asia". Demonstration of and training on different pest control strategies followed. The Economic Threshold Level

(ETL) was introduced as the basis for insecticide treatment of rice pests. From 1984 to 1989, the IPM Program trained 737 Subject Matter Specialists as core trainors in the country; 168,291 farmers and 10,028 agricultural production technicians of the Department of Agriculture. Subsequent evaluation made on the actual adoption of farmers trained in IPM showed only 4% adoptors in Region VI (Western Visayas) and 12% in Region III (Central Luzon). Among the major constraints identified were: a) the ETL was too technical for farmers and seemed difficult for local adoption: and b) the training strategy was not very effective, since the flow of information from the resource person to the receiver (farmers) was one sided.

The Season Long Training (SLT) on IPM at Culasi, Antique, Philippines, in 1991, used a different approach. The concept of IPM was introduced to the farmers through the Farmer Field School (FFS) which was nonformal and participatory training in nature. Each batch of FFS participants consists of 25 selected farmers. An FFS has a learning field of not less than 1,000 m^2, which is divided into two sections: one is treated following the usual farmers' practice, while the other is treated according to IPM principles. FFS participants were exposed to the different stages of the growth of the crop from land preparation to harvest by meeting one day a week for not less than 12 weeks. A typical FFS day consists of three parts: agroecosystem drawing and analysis, and its relevance to the stage of rice growth; a group dynamics activity; and a group discussion on special topics related to specific conditions or problems, such as on rice tungro virus supplemented with infected plants and insect vectors. The agroecosystem drawing reflects the following: agronomic characteristics of the rice plant; abiotic factors (field and weather conditions); leaf damage assessment; visual counts of rice insect pests; visual counts of predators and parasitoids; and presence of weeds, golden snails and others. Through Agroecosystem Analysis, the participants were able to experience and understand the ecological factors interacting upon the rice agroecosystem. In effect, the participants, by using their rice farms as actual laboratories, were transformed into ecologists of their own farms.

Initial evaluation of the project site in Antique, Philippines, showed that the farmers involved in SLT on IPM use significantly less pesticides. They also aim for an insecticide-free season of growing rice. Of long-term significance is the awakened farmers' interest in crop ecology, and receptiveness to the adoption of other agricultural innovations they perceived to be for their own good.

The Progress of IPM Implementation in Vietnam

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Abstract

Prior to the adoption of Integrated Pest Management (IPM) concept for crop protection, Vietnamese rice farmers practised preventive pesticide treatments for rice pest control. Pesticide application based on calendar spraying was common. Extensive use of broadspectrum pesticides was observed to cause adverse disruption to the rice agroecosystem. As a result severe brown planthopper (BPH) outbreaks occurred in 1977-78 and 1990-92.

Following the 1977-78 BPH outbreak and from early 1980, IPM (then called Integrated Pest Control or IPC) was implemented in the whole country through field demonstration combined with limited short training (2-3 sessions per season) of farmers. This IPC resulted in 40-60% reduction of pesticide use. Among the IPC methods, however, farmers practised two main methods only: growing resistant rice varieties and pesticide application. Ninety-eight per cent of the farmers in the Mekong Delta believed that pests could be controlled only by pesticides.

In 1989, Vietnam became a participant in the Food and Agriculture Organization (FAO) Intercountry IPM Programme. This changed remarkably the agricultural policy and scenario of rice pest management in the country. During 1990-91, 120 demonstration fields were organized in 25 provinces combined with short training course on IPM for farmers. In 1992, the IPM implementation used new approaches in its training program. This

program consists of training of trainers, which emphasizes on the study of rice ecosystem and learning about technical IPM, and methods for farmer training based on nonformal adult education principles.

The Farmer Field School (FFS), which emphasized learning by doing, was implemented to train farmers. A group of 25 farmers met weekly for 12-13 weeks or throughout the rice growing season. Weekly observation of two rice ecosystems in a 1,000-m^2-study field consisting of separate IPM and farmers' practice plots, was being done followed by analysis and making management decisions. The farmer also conducted special studies, such as the relationship between natural enemies and insect pest. Group dynamic activities were also emphasized. Through the FFSs established in some key provinces, the IPM-trained farmers became fully convinced that early infestation of defoliating insects, such as rice leaffolders, does not inflict yield losses to the rice crop; hence, the use of early spray insecticides is unnecessary and wasteful.

After three seasons, 140 FFSs have been organized, with 3,780 farmer participants. Use of pesticides decreased by 60-80%, which resulted to higher benefits although yields remain the same or increased slightly. At present, the teams organizing training of trainers (TOT) courses and FFSs are also conducting studies on rice-fish culture to know its ecosystem. Rice-fish culture methods will be developed with farmers who have attended the FFS and acquired IPM experience. With reduced use of pesticides, fish cultivation in ricefields might be possible again.

In the coming years, more TOTs and FFSs are planned in more than 43 (out of 53) provinces in the whole country. The IPM concept is now the key component in the Vietnamese agricultural policy to increase farmers' income by reducing unnecessary pesticides treatments. IPM training for rice farmers is now the main plant protection activity in Vietnam.

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Farmers' Perception Towards Wild Fish in Ricefields: "Product not Predator" — an Experience in Rice-Fish Development in Northeast Thailand

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Abstract

In the effort to promote rice-fish culture in Northeast Thailand, predation of stocked seedfish by wild fish has been identified as one of major production constraints. Predation by carnivorous fish such as snake head (*Channa striata*), catfish (*Clarias batrachus*) or climbing perch (*Anabas testudineus*) leads to poor and/or unpredictable harvest of stocked fish. This has led fisheries biologists and extension workers to recommend averting "predators" from the ricefield. Such recommendation, however, is virtually ignored or even opposed by farmers.

A survey carried out by the Ubon Rachatani Farming System Research and Development Unit on 88 farmers in Ubon Ratchatani in Northeast Thailand revealed that farmers' perceptions toward wild fish were totally opposite to that of fisheries biologists and extension workers. Farmers usually encourage wild fish to enter their ricefields to maximize wild fish yields. Farmers perceive wild fish as traditional, valuable products and not predators. The survey revealed that various techniques are being practiced by farmers to attract wild fish to enter ricefields e.g., putting compost, decayed woods and termites in strategic locations in ricefields.

Marketing wild fish is easy. Wild fish can be sold to catching teams at twice the price of cultured fish. In addition, farmers are accustomed to the taste and cooking and preserving methods used for native fish. For these reasons, preventing predators from entering ricefields faced strong objections from farmers. Cultured fish is considered a secondary product in the system. Farmers are interested in stocking fish to augment the supply of wild fish during the dry season. Compared to wild fish, cultured fish require much higher capital and labor inputs, both of which are scarce resources to small-scale farmers. Viewing fish as one product with two different production methods, wild fish is one associated with low input, high output and higher price and hence will definitely be chosen over cultured fish. Only when this method of production can no longer be viable will an alternative method be sought.

Poor adoption of so-called "mature technologies" are often blamed on farmers' ignorance by the better informed outsider. This study points out that there is a need to reexamine the popular view that farmers could be ignorant or irrational and have to be protected against the consequence of their own actions. This survey's results confirmed that each particular natural setting is known to the farmer. Farmers' accumulated wisdom gained from years of living in their environment taught them to adjust toward the limitations and opportunities they faced. Much of this wisdom can be used to guide research work. Farmers are rational beings who, subject to their own household constraints, would maximize the use of their resource when appropriate technologies exist. In order to assist farmers, the research community needs to understand farmers' overall situation and to see things from the farmers' point of view. It is essential that more applied research be guided by actual experience under farm conditions. This study points out that in planning to extend rice-fish technologies as an "entry point" to IPM in rice farming, researchers must include evaluations in a broader socioeconomic context and acquire an understanding of farmers' goals and aspirations.

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Workshop Program

6 June, Sunday

Arrival of participants

7 June, Monday

0800 Registration and opening ceremony
1000 Coffee break
1015 Picture taking
Visit to on-station rice-fish research

SESSION 1: RICEFIELD ECOLOGY AND FISH

Chairman: DR. A.B. ALI

1100 *The impact of agricultural practices on the aquatic invertebrate food supply of fish in ricefields* • I. C. SIMPSON
1120 *The impact of fish in enhancing ricefield ecosystems* • S. NALIM
1140 *Impacts of fish and pesticide in lowland irrigated ricefields* • A.G. CAGAUAN, C.R. DELA CRUZ, F. FLORBLANCO, E. CRUZ and R.C. SEVILLEJA
1200 Lunch
1330 *The feeding of Nile tilapia and common carp in lowland ricefields and its relation to food resources* • G. CHAPMAN
1350 *Food habits and feeding patterns of fish obtained from the ricefields of northern Peninsular Malaysia* • A.B. ALI
1410 *Suitability of short-cycle species* Puntius gonionotus *(Bleeker) for culture in ricefields* • A.H.M. KOHINOOR, S.B. SAHA, MD. AKHTERUZZAMAN and M.V. GUPTA
1430 *Some aspects of freshwater prawn (*Macrobrachium rosenbergii*) culture in irrigated ricefields* • H. HADIDJAJA and M. YUNUS

SESSION 2: IPM AND FISH

Chairman: DR. V.R. CARANGAL

1450 *Integrated Pest Management and its role in fostering fish culture in ricefields in Bangladesh* • S. RAMASWAMY
1510 Coffee break
1530 *Fish cultivation as a means to increase profitability from ricefields: implications for Integrated Pest Management* • K. KAMP and R. GREGORY
1550 *Feasibility of integrating aquaculture in rainfed ricefields and possible implications for Integrated Pest Management* • MD. AKHTERUZZAMAN, M.V. GUPTA and J.D. SOLLOWS
1610 *Culturing fish in ricefields as a means of preventing insect infestations: preliminary observations* • NGUYEN ANH TUAN
1630 *The impact of fish on arthropod communities in irrigated rice in the Philippines* • M. HALWART
1650 *Potential of fish in rice-fish culture as a biological control agent of rice pests* • S. HENDARSIH, S. SURIAPERMANA, A. FAGI and I. MANWAN
1900 Reception

8 June, Tuesday

SESSION 3: RICE-FISH RESEARCH METHODOLOGY AND ANALYSIS

Chairman: DR. I. C. SIMPSON

0800 *Nitrogen models of irrigated lowland ecosystems with and without fish using ECOPATH II* • A.G. CAGAUAN, C.R. DELA CRUZ and C. LIGHTFOOT

0820 *Integrated Rice-Fish Systems: Methodologies for the quantification of nitrogen within the soil-plant system* •J. L. GAUNT, H.U. NEUE and I.F. GRANT

0840 *An economic framework for assessing the role of fish on rice-IPM: case study from North Sumatra, Indonesia* •S. PURBA

0900 Discussion

SESSION 4: METHODOLOGY FOR RICE-FISH AND IPM ADOPTION

Chairman: MR. J. D. SOLLOWS

0920 *Socioeconomic complementarities between Integrated Pest Management and Aquatic Life Management - the key to long-lasting adoption?* •G. HORSTKOTTE

0940 *IPM field training: farmers becoming ecologists* • R. SALTIN

1000 Coffee break

1020 *Integrated Pest Management training program in Vietnam* •NGO TIEN DUNG

1040 *The progress of IPM implementation in Vietnam* •NGUYEN HUU HUAN

1100 *Farmers' perception towards wild fish in ricefields: "Product not predator" an experience in rice-fish development in Northeast Thailand* •S. SETBOONSARNG

1120 Discussion

SESSION 5: WORKSHOP SESSION

1140 Workshop Organization and Discussion by Working Groups

1200 Lunch

1330 Working Group Discussion

9 June, Wednesday

0800 Field trip

10 June, Thursday

0800 Working Group Discussion

1000 Coffee break

1020 Working Group Discussion

1200 Lunch

1330 Working Group Discussion/Report Preparation

1500 Coffee break

1520 Working Group Reports

1630 Closing Ceremony

11 June, Friday

Departure of Participants

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Role of fish in enhancing ricefield ecology and in integrated pest management. C.R. dela Cruz, Editor. 1994. ICLARM Conf. Proc. 42, 50 p. 18 x 25 cm. Saddle-stitched. ISSN 0115-4435, ISBN 971-8709-51-7. US$5.75 airmail, $3.25 surface, P57.00.

Titles of Related Interest

Rice-fish research and development in Asia. C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao, Editors. 1992. ICLARM Conf. Proc. 24, 457 p. 18 x 25.5 cm. Perfect binding. ISSN 0115-4435, ISBN 971-1022-88-5. US$36 airmail, $17 surface, P400.

Integrated agriculture-aquaculture farming systems. R.S.V. Pullin, Z.H. Shehadeh, Editors. 1980. Reprinted 1984. 1986. ICLARM Conf. Proc. 4, 258 p. ISSN 0115-4389. Available in photocopied form at US$39, P360. Includes airmail cost.

The ICLARM-CLSU integrated animal-fish project: poultry-fish and pig-fish trials. 1981. ICLARM Tech. Rep. 2, 29 p. Superseded by Tech. Rep. 5. Available in photocopied form at US$14, P135. Includes airmail cost.

The ICLARM-CLSU integrated animal-fish farming project: final report. K.D. Hopkins and E.M. Cruz. 1982. ICLARM Tech. Rep. 5, 96 p. ISSN 0115-5547. Available in photocopied form at US$14, P135. Includes airmail cost.

Research and education for the development of integrated crop-livestock-fish farming systems in the tropics. P. Edwards, R.S.V. Pullin and J.A. Gartner. 1988. ICLARM Stud. Rev. 16, 53 p. ISSN 0115-4389. ISBN 971-1022-46-X. English edition at US$6 airmail, $3.50 surface, P60. French edition at US$8.50 airmail, $5.50 airmail, P60.

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