VOLUME 9 • NUMBERS 1 & 2 • 2008

SPECIAL: Biodiversity & Agriculture

KNOWLEDGE - CONSERVATION - SUSTAINABILITY

Biodiversity

JOURNAL OF LIFE ON EARTH

The Value of Biodiversity to Food & Agriculture

Journal OBJECTIVE

To contribute to the understanding, protection and restoration of the diversity of living things

PARTNERSHIPS

Biodiversity is sincerely grateful to the partners listed below for their financial assistance and in-kind contributions to the production and publication of this special issue. *Biodiversity* is also grateful to all members of the Special Board of Editors and many volunteers who have spent many working hours to ensure the success of this issue.

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Canadian Food Inspection Agency | Agence canadienne d'inspection des aliments

Convention on Biological Diversity

IDRC International Development Research Centre | CRDI Centre de recherches pour le développement International

FAO Food and Agriculture Organization of the United Nations

The Ontario Trillium Foundation | La Fondation Trillium de l'Ontario

SPECIAL BOARD OF EDITORS (SBOE)

Front cover illustration. This image, used on the poster for the International Day for Biological Diversity 2008, has been designed from a traditional Gabba embroidered tapestry from Pakistan that was donated to the CBD Museum of Nature and Culture in 2006 by Pakistan's Minister for Environment. Measuring some two meters across and two meters high, the intricately stitched and brightly coloured Gabba depicts scenes of everyday life and the rich heritage of biodiversity and agriculture in a farming landscape of Pakistan.

SPECIAL ISSUE
The Value of Biodiversity to Food and Agriculture

To those who farm the living earth and nurture our livestock– may they reap a rich and full harvest as they continue to respect the diversity of life.

CONTENTS

ARTICLES

Global biodiversity - The source of new crops. *E. Small and P.M. Catling* 3
The value of taxonomy to biodiversity and agriculture. *Chris Lyal, Paul Kirk, David Smith and Richard Smith* ...8
Sustaining livestock biodiversity – From assessment to action. *Dafydd Pilling, David Boerma, Beate Scherf and Irene Hoffmann* 14
Ecosystems and the value of adjacent protected areas to agriculture. *Waltraud Kugler and Elli Broxham Stahl* 19
The maintenance of crop genetic diversity on farm: Supporting the Convention on Biological Diversity's Programme of Work on agricultural biodiversity. *Devra I. Jarvis and Toby Hodgkin* 23
Benefits of sward diversity for agricultural grasslands. *A. Lüscher, J.A. Finn, J. Connolly, M.T. Sebastià, R. Collins, M. Fothergill, C. Porqueddu, C. Brophy, O. Huguenin-Elie, L. Kirwan, D. Nyfeler and A. Helgadóttir* 29
Organic agriculture enhances agrobiodiversity. *Cristina Grandi* 33
Biodiversity, nutrition and livelihoods in aquatic rice-based ecosystems. *Matthias Halwart* 36
The effectiveness of participatory plant breeding as a tool to capitalize on agrobiodiversity in developing countries. *C.J.M. Almekinders, S. Humphries and A. von Lossau* 41
Opportunity for conserving and utilizing agrobiodiversity through agroforestry in Southern Africa. *Paxie W. Chirwa, Festus K. Akinnifesi, Gudeta Sileshi, Stephen Syampungani, Elix K. Kalaba and Oluyede C. Ajayi* 45
Diversity in local rice germplasm and rice farming: A case study of Thailand. *Benjavan Rerkasem* 49
Ecoregions with crop wild relatives are less well protected. *Sue Stolton,Tim Boucher, Nigel Dudley, Jonathan Hoekstra, Nigel Maxted and Shelagh Kell* 52
Reconciling genetic resources and local knowledge conservation and livelihoods enhancement in research and development: Experiences of Bioversity International in Sub-Saharan Africa. *P. Maundu and Y. Morimoto* 56
Arbuscular mycorrhizal fungi - An underground resource for sustainable upland agriculture. *N. Yimyam, S. Youpensuk, J. Wongmo, A. Kongpan, B. Rerkasem and K. Rerkasem* 61
Towards sustainable management of soil biodiversity in agricultural landscapes in Africa. *Gudeta Sileshi, Festus K. Akinnifesi, Oluyede C. Ajayi, Sebastian Chakeredza, Simon Mng'omba and Betserai Isaac Nyoka* 64
Genebanks in the post-genomic age: Emerging roles and anticipated uses. *Christina Walters, Gayle M. Volk and Christopher M. Richards* 68
Domestication and conservation of indigenous Miombo fruit trees for improving rural livelihoods in southern Africa. *Festus K. Akinnifesi, Gudeta Sileshi, Oluyede C. Ajayi, Paxie W. Chirwa, Simon Mng'omba, Sebastian Chakeredza and Betserai I. Nyoka* 72
Towards protecting soil biodiversity in Europe: The EU thematic strategy for soil protection. *Luca Montanarella* 75
Agrodiversity in the traditional agrosystems of the Rif mountains (north of Morocco). *Younes Hmimsa and Mohammed Ater* 78
Benefits of biodiversity conservation to agriculture and rural livelihoods. *Katrina Brandon, Will R. Turner, Götz Schroth, and Mohamed Bakarr* 82
Pollinating Flies (Diptera): A major contribution to plant diversity and agricultural production. *Axel Ssymank, C.A. Kearns, Thomas Pape & F. Christian Thompson* 86
Developing result-orientated payment schemes for environmental services in grasslands: Results from two case studies in North-western Germany. *Elke Bertke, Sebastian Klimek and Burghard Wittig* ...91
A predictive model of local agricultural biodiversity management in Southern Cameroon. *A.W. Mala, Geldenhuys, R. Prabhu* 96
Pacific Island agrobiodiversity and ethnobiodiversity: A foundation for sustainable Pacific Island life. *R. R. Thaman* 102

IN EVERY ISSUE

EDITOR'S CORNER

Increasing the compatibility of agriculture and biodiversity. *E. Small* 2

SPECIES BY SPECIES

BLOSSOMING TREASURES OF BIODIVERSITY

14. Grass Pea (*Lathyrus sativus*) - Can a last resort food become a first choice? *E. Small & P.M. Catling* 111

BIODIVERSITY NEWS

2008 – The International Year of the Potato; Functional Diversity May Give Resilience to Stresses from Global Warming; World Livestock Production Perilously Dependent on a Few High-Yielding Breeds; Intense Crossbreeding Threatens Uganda's Ankole Cow with Extinction; Unknown Disease Threatens Several Species of Bats with Extinction; Invasive Species: a Global Problem with Local Consequences; Eutrophication and Hypoxia Choking Coastal Waters; Soybean Boom Forcing Paraguay to Examine Pesticide Use; Manifestos on the Future of Food and Seed; Svalbard Seed Vault Opens; Are Rising Global Food Costs Driven by Increased Biofuel Production?; Biotech Companies withdraw from International Agriculture Science and Technology Assessment; Indonesia; Tree Conservation at the Village Level ...117

BOOK REVIEWS

The State of The World's Animal Genetic Resources for Food and Agriculture; Managing Biodiversity in Agricultural Ecosystems; Protected Landscapes and Agrobiodiversity Values; Agroecology in Action; Biodiversity in Agricultural Production Systems; Agriculture Biodiversity and Biotechnology in Economic Development; Development Markets for Agrobiodiversity; Heirloom Seeds and Their Keepers 126

Biodiversity

ISSN 1488-8386

Volume 9
Numbers 1 & 2

2008

Mailing Address:
Tropical Conservancy
94 Four Seasons Drive
Ottawa, Ontario, Canada K2E 7S1
Tel: 1-613-224-9518 or 1-613-325-9518
URL: www.tc-biodiversity.org

Publication Date: 29 April 2008

Biodiversity is supported in part by:

IDRC The International Development Research Centre (Canada)

The Ontario Trillium Foundation

Biodiversity is indexed by Biosis, Cambridge Scientific Abstracts, Environment Abstracts, and Zoological Record.

Back Cover: Rice, *Oryza sativa* L., see caption page 35.
Inside Front Cover Art: The Diversity of Life by *Roelof Idema*

Biodiversity, nutrition and livelihoods in aquatic rice-based ecosystems

Matthias Halwart

AUTHOR'S ADDRESS: Food and Agriculture Organization of the United Nations (FAO), Fisheries and Aquaculture Department, Viale delle Terme di Caracalla, 00100 Rome, Italy

Abstract. The cultivation of rice in irrigated, rain-fed and deepwater systems often offers a suitable environment for fish and other aquatic organisms. Indeed, it comes as no surprise for those who produce rice that a rich source of biological diversity is to be found in rice-based ecosystems. Wild and gathered foods, from the aquatic habitat, provide important diversity, nutrition and food security as food resources from ricefield environments supply essential nutrients that are not adequately found in the diet. Yet this rich and important diversity is often not recognized in national statistics, policies, and legal frameworks. This paper illustrates the critical importance of aquatic biodiversity for poor rice-farming households based on findings from several years of research in Cambodia, Lao PDR, China and Vietnam. An understanding of the value of aquatic biodiversity from rice-based ecosystems for food and nutrition needs to be well integrated into national agricultural systems that embrace the concepts of an ecosystem approach and the important role of agrobiodiversity for people and the environment.

INTRODUCTION

The cultivated rice field has been evolving for millennia and has become the habitat of a variety of wetland species, which have succeeded in adapting their life cycles to the cycles of rice cultivation (Heckman 2005). Over 90% of the world's rice, equivalent to approximately 134 million hectares is grown under flooded conditions.

In many countries, particularly in Asia, rice is the main staple food, but it is accompanied by a highly diverse assortment of other foodstuffs that are prepared in many ingenious ways: finfish, edible leaves, shrimp, crabs, shellfish and snails, turtles, frogs and even insects and snakes are bred or caught in the wild to accompany the rice on the table. Traditionally, farmers in the rice-growing regions make good use of this diversity, collecting the plants for vegetables or animal feeds and using the multitude of animal species available in their fields as an easily accessible source of protein, fatty acids and other nutrients (Balzer *et al.* 2005; Choulamany 2005; Luo 2005; Meusch 2005).

In countries where rice is the staple food of the population, national policies on food security are often equated with rice production (Gregory and Guttman 2002). It has been argued that aquatic production, in addition to the rice crop itself, is a critically important resource for rural livelihoods in many developing countries; local consumption and marketing are particularly important for food security, as it is the most readily available, most reliable and cheapest source of animal protein, fatty acids and other nutrients for both farming households and the landless (Halwart 2006). This is in addition to the significant ecosystem services that aquatic biodiversity in rice provides (Halwart 2005).

ECOSYSTEM ROLES OF AQUATIC ORGANISMS

Many of the aquatic organisms found in rice ecosystems play an important role as the biological control agents of vectors and pests, and are acknowledged elements of Integrated Pest Management (IPM). Fish that are specialized to feed on mosquito larvae or on particular snail species may control vectors of malaria and schistosomiasis. Some fish species contribute to the biological control of rice pests such as apple snails, stemborers, or caseworms. Fish also feed on weeds and other insects thereby reducing potential pest problems and maintaining balance in an ecosystem that, in nearly all cases, does not require insecticide use at all (Way and Heong 1996). Rice fields may also harbour species which are under threat of extinction. The deepwater rice ecosystem and the adjacent flooded grass- and shrub-lands near the Tonle Sap, Cambodia, are habitat for many birds, among them the Bengal Florican, an endangered species of which only two populations remain (Smith 2001). *Ichthyophys bannanicus* is an endangered amphibian found in rice fields in Yunnan, China (Luo 2005).

MORE THAN JUST RICE

Recent studies on the availability and use of aquatic biodiversity from rice-based ecosystems in Cambodia, China, Laos and Vietnam documented 145 species of fish, 11 species of crustaceans, 15 species of molluscs, 13 species of reptiles, 11 species of amphibians, 11 species of insects and 37 species of plants directly caught or collected from the rice fields and utilized by rural people during one season (Halwart and Bartley 2005). Fish usually constitute the major part (Tables 1, 2).

Fish plays the major role in supplying food and small-scale income among the groups encountered. Most of it is consumed fresh, but there are a number of ways to preserve it for periods when the supply of fresh fish is interrupted. Among these, drying and fermenting are the most common methods, but fish is also preserved in salt, or smoked; and some aquatic organisms are preserved in alcohol to be used as medicine (Halwart and Bartley 2005). An indicative list of uses of various aquatic organisms from rice fields is provided in Table 3.

UNDERESTIMATED AND UNDERVALUED

The amount of food produced in inland waters in general (FAO/MRC 2003) and rice fields (other than rice itself) in particular (Halwart 2003) is generally underestimated and undervalued, because it is small quantities (although collected by many individuals and in large areas) which are all locally consumed or marketed, and therefore not recorded in official statistics. As a result, information on aquatic biodiversity and the contribution these resources make to rural livelihoods, food security and nutrition is not available to and not recognized by policy makers. Unfortunately, development plans that focus

Species	English Name	Species	English Name
Thynnichthys thynnoides		*Clarias batrachus*	Broadhead Catfish
Mystus albolineatus		*Anabas testudineus*	Climbing Perch
Osteochilus melanopleurus		*Trichogaster trichopterus*	Threespot Gourami
Leptobarbus hoeveni	Mad Barb	*Rasbora tornieri*	Yellowtail Rasbora
Trichogaster pectoralis	Snake-skin Gourami	*Rasbora trilineata*	Scissortail Rasbora
Botia modesta	Red-tail Botia	*Systomus partipentazona*	
Cyclocheilichthys sp.	Beardless Barb	*Rasbora daniconius*	Slender Rasbora
Hemibagrus spliopterus		*Rasbora borapetensis*	Blackline Rasbora
Xenentodon cancila		*Cirrhinus microlepis*	
Paralaubuca typus		*Monopterus albus*	Swamp Eel
Notopterus notopterus	Bronze Featherback	*Trichopsis vittata*	Croaking Gourami
Trichogaster pectoralis		*Botia* sp.	Sun Loach
Pristolepis fasciatus	Catopra	*Pseudomystus siamensis*	Asian Bumblebee Catfish
Hampala macrolepidota		*Anguilla bicolor*	Shortfin Eel
Oxyeleotris marmorata	Marbled Sleeper	*Parambassis* sp.	Siamese Glassfish
Henicorhynchus siamensis		*Ompok hypophthalmus*	
Channa micropeltes	Snakehead	*Puntius brevis*	Swamp Barb
Macrognathus siamensis	Peacock Eel	*Parambassis wolffi*	Duskyfin Glassy Perchlet
Barbodes altus		*Macrognatus taenigaster*	
Trichogaster sp.		*Osteochilus hasselti*	Silver Sharkminnow
Mastacembelus favus	Tire Track Eel	*Wallago attu*	
Trichogaster sp.	Moonlight Gourami	*Micronema micronema*	
Pangasius conchophilus		*Ompok bimaculatus*	Butter Catfish
Puntioplites proctozysron		*Chitala ornata*	Clown Featherback
Channa striata	Snakehead	*Clarias macrocephalus*	Walking Catfish
Monotreta cambodgiensis		*Mastacembelidae*	
Acantopsis sp.		*Esomus metallicus*	Striped Flying Barb
Mystus mysticetus		*Paralaubuca typus*	
Labiobarbus siamensis		*Clupeichthys* sp.	Thai River Sprat
Barbodes gonionotus		*Trichopsis schalleri*	Pygmy Gourami
Doryichtys boaja	Long-snouted Pipefish	*Macrognatus siamensis*	
Botia helodes	Tiger Botia	*Parachela siamensis*	
Luciosoma bleekeri		*Trichogaster* sp.	
Nandus nandus		*Cyclocheilichthys enoplos*	
Morulius chrysophekadion	Black sharkminnow	*Channa lucius*	

Table 1.
Fish species (n=70) collected from rice fields and used by rural households in Cambodia. Source: Balzer *et al.* 2005.

	Cambodia	China	Laos	Viet Nam	Total
Amphibians	2	3	10	3	11
Crustaceans	6	4	5	3	11
Fishes	70	54	26	14	145
Molluscs	1	5	8	7	15
Reptiles	8	1	7	3	13
Plants	13	20	20	15	37
Insects	2	-	16	6	11
Total	102	87	92	51	232

Note: Specimen were identified to species level, as possible.

Table 2.
Aquatic species (number) collected from rice-based ecosystems and used by rural households*
* Source: Balzer *et al.* (2005), Luo (2005), Choulamany (2005), and Meusch (2005).

only on increasing yields of rice may possibly give people more rice to eat, but at the same time take away many of the aquatic animals and plants harvested from and around the rice fields (Gregory and Guttman 2002). Poorer segments of rural society stand to suffer the most from the negative impacts of such development.

AQUATIC BIODIVERSITY AND NUTRITION

For many rural populations in lowland Southeast Asia, rice and fish are the mainstay of their diet. Aquatic animals represent a significant, often the most important, source of animal protein and are also essential during times of rice shortages (Meusch *et al.* 2003). Aquatic organisms

Table 3. Indicative list of uses of various aquatic organisms from rice fields

Taxon	Image	Scientific Name	Uses
Fish		*Cyclocheilichthys* sp.	As food (consumed fresh, fermented into fish paste and fish pieces; dried salted fish; fish sauce)
Reptile		*Erpeton tentaculatum*	As medicine
Amphibian		*Bufo melanostictus*	As food and medicine (anthelmintic properties)
Crustacean		*Somanniathelphusa* sp.	As food, feed, bait
Mollusc		*Pila* sp.	As food, feed, bait; for trade on markets
Plant		*Nelumbo nucifera*	As food (flowers, leaves, seeds, rhizomes), for trade on market; for decoration, as wrapper for food, and as medicine
Insect		*Lethocerus* sp.	As food and medicine

supply essential and limiting micronutrients that are not found in rice (or found in limited quantities), particularly calcium, iron, zinc and vitamin A. The nutrient content in different fish species and preparations may vary by several orders of magnitude. Of particular importance are the small fish which are usually eaten whole. Hansen *et al.* (1998) showed that small (4–10 cm) fish eaten with the bones as part of the everyday diet in many Asian countries contribute considerable amounts of calcium. The recommended daily calcium intake for adults can be met by eating 34–43 g of these fresh small fish daily, collecting them from rice fields, ponds and ditches. Similar considerations apply for vitamin A, as this is found particularly in eyes and viscera of small fish (Roos *et al.* 2002). In Bangladesh, it is commonly believed that the small fish mola (*Amblypharyngodon mola*) is 'good for your eyes', a perception that may have originated from indigenous knowledge that night blindness can be cured by eating mola. Another group of particular nutritional importance are the essential fatty acids which are critical for maternal, foetal and neonatal nutrition. A review of the literature is provided by Elvevoll and James (2000).

Many rural farmer and fisher families in developing countries cannot obtain a sufficient variety of nutritious food in their local markets or are simply too poor to purchase it. Cultivated species may be complemented by harvested wild species that can be of particular significance for indigenous communities and for poor and vulnerable communities especially in times of shortage of main staples. Wild and gathered foods, including from the aquatic habitat, therefore provide important diversity, nutrition and food security (Halwart and Bartley 2007).

Available information on nutrient composition of aquatic species and their consumption is limited, and sometimes inadequate (Halwart *et al.* 2006). A recent consumption study in Laos shows that rice fields are the source of about two thirds of all aquatic organisms consumed by rural households, whilst for fish alone it is about 50 percent. About one third of all consumed organisms are frogs and most of these come from rice fields (Box 1).

PRODUCTIVE ECOSYSTEM UNDER THREAT

All of the above cited studies present anecdotal evidence of diminishing fish catches over the last years. While the per-

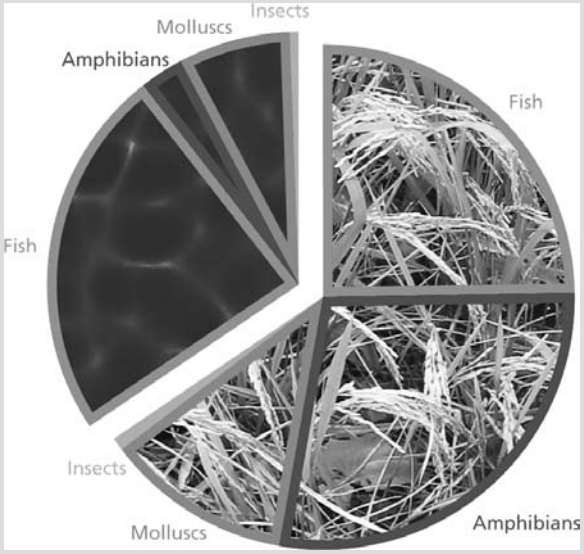
person amount of aquatic organisms consumed has remained constant, a decade ago rice-based capture supplied half of this consumption; in contrast nowadays only one-fifth to one-third is derived from capture in rice-based farming and the remainder has to be bought or farmed. The quantity collected in one day nowadays is equivalent to what was collected a decade ago in one hour (Luo 2005). Similarly, Cambodian villagers have experienced reduced fish catches at household level over the past decade (Schilling 2004) and estimate that in three to five years there will not be enough fish to make a living (Balzer *et al.* 2005).

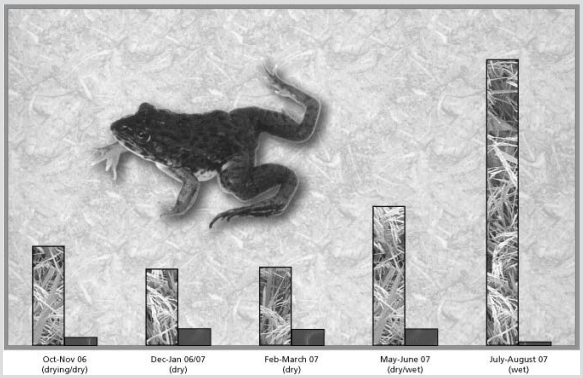
Increases in the human population and the resulting increased fishing pressure on aquatic resources are important factors in the decline of living aquatic resources; and there are a number of concomitant factors involved: pesticide use, destruction of fish breeding grounds, and illegal fishing tools. The result is that fish populations cannot maintain themselves. Development efforts urgently need to address these threats.

NEED TO MAKE THE INVISIBLE VISIBLE

The diversity of aquatic species is usually invisible, both to human sight in the rice field itself as well as in terms of aquatic production in national statistics. The studies cited above allow an increased understanding and appreciation for the rich diversity and value of aquatic resources as well as for the indigenous knowledge and ingenious practices related to their capture and culture. It is particularly the rural poor who are the most dependent on aquatic biodiversity in rice

Aquatic biodiversity and nutrition - the contribution of rice-based ecosystems in the Lao PDR





A monthly household survey has been conducted in 240 households in three provinces of the Lao PDR. The survey yielded information on acquisition, amount and uses of fish and other aquatic animals (OAAs) based on 24-hour recall of the respondents over a one-year period ending October 2007. Data were obtained on catch and habitats, species and biodiversity, household consumption of fish and OAAs, and relationship between catches and village resources/village pesticide use.

The results of this survey show that rice fields contribute far more to people's livelihood and food security than just the rice alone: Two thirds of all the aquatic animals and 50% of all fish consumed by the surveyed households come from the ricefield habitat.

Generally, habitats outside the ricefield zone play a more important role as food source for rural people in the dry season, while the importance of habitats within the rice-based ecosystem increases in the wet season. Exceptional in this respect are frogs which make up around one third of all the aquatic animals consumed and are thus second in importance for food supply after the fish. Frogs are caught predominantly in the rice fields, even in the dry season.

The study has impressively demonstrated that ricefield habitats including the rice fields themselves, natural ponds/trap ponds in rice fields and rice field streams/canals are important for aquatic animals which in turn are important as an everyday source of food for the people in rural areas.

Source: FAO/LARReC 2007.

fields. While focusing on high-yielding rice cultivars and intensive agricultural practices, decision-makers have lost sight of the importance of the natural diversity of the rice-based ecosystems and the protein and micronutrient supply that these ecosystems provide for rural people.

Clearly, there has not been given enough attention to the aquatic diversity naturally found in rice fields and its importance to rural livelihoods. Raising awareness and making this aquatic biodiversity in rice "visible", is important and supported by relevant international codes and guidelines (FAO 1995, 2005). As the first international forum, the International Rice Commission (IRC) has recognized the above results and recommended that "Member countries should promote the sustainable development of aquatic biodiversity in rice-based ecosystems, and policy decisions and management measures should enhance the living aquatic resource base" (FAO 2002). It is important that rice producing countries mainstream these recommendations into their agricultural and nutritional development plans, policies and strategies, as is currently the case in Lao PDR (Vatthanatham *et al*. 2007). Ultimately, the understanding for the value of aquatic biodiversity from rice-based ecosystems for food and nutrition needs to be well integrated into national agricultural systems that embrace the concepts of an ecosystem approach and the role of agrobiodiversity for people and the environment.

ACKNOWLEDGMENTS

The valuable comments and contributions of Peter Balzer, Penroong Bamrungrach, Caroline Garaway, David James and Chanthone Photithay are gratefully acknowledged.

REFERENCES

Balzer, T., P. Balzer, and S. Pon. 2005. Traditional use and availability of aquatic biodiversity in rice-based ecosystems. I. Kampong Thom Province, Kingdom of Cambodia. In Halwart, M., Bartley, D. (Eds.), H. Guttman (guest Ed.). 2005. *Aquatic biodiversity in rice-based ecosystems. Studies and reports from Cambodia, China, Lao People's Deomcratic Republic and Viet Nam*. [CD-ROM], Rome, FAO. Also available at ftp://ftp.fao.org/FI/CDrom/AqBiodCD20Jul2005/Start.pdf

Choulamany, X. 2005. Traditional use and availability of aquatic biodiversity in rice-based ecosystems. III. Xieng Khouang and Houa Phanh provinces, Lao PDR. In Halwart, M., Bartley, D. (Eds.), S. Funge-Smith (guest Ed.). 2005. *Aquatic biodiversity in rice-based ecosystems. Studies and reports from Cambodia, China, Lao People's Deomcratic Republic and Viet Nam*. [CD-ROM]. Rome, FAO. Also available at ftp://ftp.fao.org/FI/CDrom/AqBiodCD20Jul2005/Start.pdf

Elvevoll, E.O. and D.G. James. 2000. Potential benefits of fish for maternal, foetal and neonatal nutrition: a review of the literature. *fn/ana* 27/2000: 28-39.

FAO. 2002. Report of the 20th Session of the International Rice Commission held in Bangkok, Thailand from 23-26 July 2002. FAO, Rome. 46 p.

FAO 1995. Code of Conduct for Responsible Fisheries. FAO, Rome.

FAO. 2005. VOLUNTARY GUIDELINES to support the progressive realization of the right to adequate food in the context of national food security. Adopted by the 127th Session of the FAO Council, November 2004. Available at Guidelines on the Right to Food.

FAO/MRC. 2003. New approaches for the improvement of inland capture fishery statistics in the Mekong Basin. Report of the Ad Hoc Expert Consultation held in Udon Thani, Thailand, 2-5 September 2002. FAO/RAP Publication 2003/01. FAO/RAP, Bangkok. 145 p.

FAO/LARReC. 2007. Aquatic biodiversity in rice-based ecosystems for Lao PDR. Technical Paper. FAO – Netherlands Partnership Programme (FNPP) 2006 – 2007 (unpublished).

Gregory, R. and H. Guttman. 2002. The ricefield catch and rural food security, pp. 1-13. In P. Edwards, D.C. Little and H. Demaine (Eds.) Rural aquaculture. CABI Publishing.

Halwart, M. 2003. Recent initiatives on the availability and use of aquatic organisms in rice-based farming, pp. 195-205. In: Dat van Tran (Ed.). *International Rice Commission - Sustainable rice production for food security*. Proceedings of the 20th Session of the International Rice Commission, Bangkok, Thailand, 23-26 July 2002.

Halwart, M. 2005. The ecology of fish in rice fields, pp. 343-384. In: Fernando, C.H., F. Goeltenboth and J. Margraf (Eds.) *Aquatic ecology of rice fields – a global perspective.* Volumes Publishing, Kitchener, Ontario, Canada, 429pp.

Halwart, M. 2006. Biodiversity and nutrition in rice-based aquatic ecosystems. *Journal of Food Composition and Analysis* 19: 747-751.

Halwart, M. and D. Bartley (Eds.). 2005. *Aquatic biodiversity in rice-based ecosystems. Studies and reports from Cambodia, China, Lao PDR and Viet Nam*. [CD-ROM]. Rome, FAO. Also available at ftp://ftp.fao.org/FI/CDrom/AqBiodCD20Jul2005/Start.pdf

Halwart, M. and D. Bartley. 2007. Aquatic biodiversity in rice-based ecosystems, pp. 181-199. In: D.I. Jarvis, C. Padoch and H.D. Cooper (Eds.) *Managing biodiversity in agricultural ecosystems*. Columbia University Press. 492p.

Hansen, M., S.H. Thilsted, B. Sandstrőm, K. Kongsbak, T. Larsen, M. Jensen, and S.S. Sorensen. 1998. Calcium absorption from small soft-boned fish. *J. Trace Elements Med. Biol.* 12: 148-154.

Halwart, M., D. Bartley, B. Burlingame, S. Funge-Smith and D. James 2006. FAO Regional Technical Expert Workshop on aquatic biodiversity, its nutritional composition, and human consumption in rice-based systems. *Journal of Food Composition and Analysis* 19: 752-755.

Heckman, C.W. 2005. Evolution from marsh to rice field. In: Fernando, C.H., F. Goeltenboth and J. Margraf (Eds.) *Aquatic ecology of rice fields – a global perspective.* Volumes Publishing, Kitchener, Ontario, Canada, 429pp.

Luo, A. 2005. Traditional use and availability of aquatic biodiversity in rice-based ecosystems. II. Xishuangbanna, Yunnan province, P.R. China. In Halwart, M., Bartley, D. (Eds.), J. Margraf (guest Ed.), 2005. *Aquatic biodiversity in rice-based ecosystems. Studies and reports from Cambodia, China, Lao People's Deomcratic Republic and Viet Nam*. [CD-ROM]. Rome, FAO. Also available at ftp://ftp.fao.org/FI/CDrom/AqBiodCD20Jul2005/Start.pdf

Meusch, E. 2005. Traditional use and availability of aquatic biodiversity in rice-based ecosystems. IV. Lai Chau and Hoa Binh provinces, Viet Nam. In Halwart, M., Bartley, D. (Eds.), 2005. *Aquatic biodiversity in rice-based ecosystems. Studies and reports from Cambodia, China, Lao People's Deomcratic Republic and Viet Nam*. [CD-ROM]. Rome, FAO. Also available at ftp://ftp.fao.org/FI/CDrom/AqBiodCD20Jul2005/Start.pdf

Meusch, E., J. Yhoung-Aree, R. Friend, and S. Funge-Smith. 2003. The role and nutritional value of aquatic resources in the livelihoods of rural people. A participatory assessment in Attapeu Province, Lao PDR. FAO/LARReC/IUCN, Bangkok, Thailand. Also available at http://www.iucn.org/themes/wani/pub/FAOIUCNLaoResourcesLivelihoods.pdf

Roos, N., T. Leth, J.Jakobsen, and S.H. Thilsted. 2002. High vitamin A content in some small indigenous fish species in Bangladesh: perspectives for food-based strategies to reduce vitamin A deficiency. *Int. J. Food Sci. Nutr*. 53: 425-437

Schilling, C. 2004. Resource degradation and food security in Cambodia. A baseline study on the impact of the degradation of the natural fish resources upon food security and nutrition on rural households in Kampong Thom/Cambodia. Scientific thesis in human geography, Department of Human Geography, Albert-Ludwigs-University, Freiburg, F.R. Germany (unpublished).

Smith, J.D. (Ed). 2001. *Biodiversity, the life of Cambodia – Cambodian Biodiversit Status Report*. Cambodia Biodiversity Enabling Activity. Phnom Penh, Cambodia.

Vatthanatham, K., C. Phothitay, K. Roger, L. Khamsivilay, C. Garaway, P. Bamrungrach and M. Halwart 2007. Importance of aquatic biodiversity in rice-based ecosystems: policy impact in Lao PDR. In: Book of Abstracts. Fisheries and Aquaculture: Strategic outlook for Asia. 8th Asian Fisheries Forum, 20-23 November 2007, Kochi, India. 244-245.

Way, M. J. and K. L. Heong. 1994. The role of biodiversity in the dynamics and management of insect pests of tropical irrigated rice - a review. *Bulletin of Entomological Research* 84: 567-587.