

POLYCULTURE WITH CARP, NUTRIENT-RICH SMALL FISH AND PRAWN

SUNILA RAI, SHAKUNTALA H. THILSTED,
MADHAV K. SHRESTHA, MD. ABDUL WAHAB AND MAHESH C. GUPTA

Malnutrition among women and children is prevalent in Nepal. The most common forms of malnutrition are undernutrition and deficiencies of vitamins and minerals, including vitamin A, iodine and iron. The United Nations International Children's Fund reported about 41 percent of children under five years of age are stunted (UNICEF 2012). Similarly about 36 percent of women, age 15-49, are anemic (Ministry of Health and Population 2006). The limited availability of food, especially in variety and with high nutrient content, high poverty rates and the low status of women in society have been major contributors to high rates of malnutrition.

Nepalese have a plant-based diet. Vegetables grown in a home garden play a vital role in the supply of nutrients for the resource poor. However, essential amino acid content and the quality and bio-utilization of animal protein is greater than those of plant protein (Pulami and Poudel 2004). Therefore, there is a need for inclusion of some animal protein in the diet. Fish are an important source of nutrients and micro-nutrients because fish are rich in protein, essential fatty acids, and essential vitamins and minerals, which are important for the cognitive and physical development of humans (Roos *et al.* 2006).

In light of this knowledge, a three-year pilot project entitled "Improvement of women's livelihoods, income and nutrition through Carp-SIS-Prawn polyculture in Terai, Nepal" was initiated in 2008 in Chitwan (Central Region) and Kailali (Far Western Region) districts of Nepal to help address malnutrition among poor women and children. The approach includes farming in household ponds of carp (rohu, mrigal, silver carp and bighead carp), freshwater prawn and Small Indigenous Fish Species (SIS), such as dedhuwa (*Esomus danricus*), mara (*Amblyparyngodon mola*) and pothi (*Puntius sophore*).

Carp and prawn are sold for household income, whereas SIS are consumed by the family through regular partial harvests. Regular intake of SIS has the potential to improve the nutritional status of family members because these fish are rich in vitamins and minerals (Thompson *et al.* 2002, Roos *et al.* 2003, Akpaniteaku *et al.* 2005, Roos *et al.* 2007a, b). Moreover, because SIS are eaten whole, without loss of nutrients from cleaning or plate waste, the contribution to micronutrient intake is greater.

Small fish, along with other fish with relatively greater market value, is often collected from natural waters such as rivers, streams, ponds and ricefields. The catch from such fisheries is low and

SMALL FISH HAVE BEEN CONSIDERED TRASH FISH AND WERE OFTEN REMOVED FROM PONDS, BASED ON A MISCONCEPTION THAT SIS EXERT COMPETITION FOR FOOD AND SPACE WITH THE MAIN SPECIES CULTURED. PRODUCTION WAS GREATER IN PONDS WITH SIS THAN THOSE WITHOUT SIS, SUGGESTING A SYNERGISTIC EFFECT OF SIS ON CARP PRODUCTION. SMALL FISH CONTRIBUTED AN AVERAGE OF 20 PERCENT OF TOTAL FAMILY CONSUMPTION AMONG SIS-GROWING FARMERS. SIS-STOCKED PONDS PROVIDED 28 PERCENT GREATER INCOME OVER CARP-ONLY PONDS BECAUSE OF COMPARATIVELY GREATER PRODUCTION. FEMALE FARMERS HAVE LEARNED TO STOCK AND GROW SIS.

inconsistent because the fish stock is depleted rapidly by use of poisons and electrofishing as fishing gear. Hence, there is a need to produce fish in ponds to provide consistent yield for household consumption and economics and for decreasing fishing pressure on capture fisheries. Small fish also accidentally enter fish ponds from the water supply canal.

Though SIS contributes

significantly to the fish catch from both natural waters and pond harvest, there is no data on the amount caught, consumed and sold.

Small fish have been considered as "weed" or "trash" fish and were often removed from ponds, based on a misconception that SIS exert competition for food and space with the main species cultured. Farmers and extension workers have not been aware of the nutritional value of SIS. Therefore, their culture potential has always been overlooked. Against this background, the project on Carp-SIS-Prawn Polyculture began in Terai, Nepal among poor Tharu and Danuwar women, who are ethnic and marginalized. Involvement of Tharu and Danuwar women in income-generation activity through fish farming helps empower them economically and socially. Moreover, their involvement in group activities, such as meetings, fingerling procurement and delegation to District Agriculture Development Office (DADO) for advocacy, provide them opportunities to come out of the house and share their opinions, problems and experiences.

The approach was implemented by Institute of Agriculture and Animal Science (IAAS), Rampur, in collaboration with Fisheries Development Centre (FDC), Rural Integrated Development Society (RIDS) and Rural Empowerment Society (REST), with technical assistance from Bangladesh Agricultural University (BAU). The duration of the project was three years (December 2008 — November 2011) and it was funded by the Ministry of Foreign Affairs in Denmark (Danida).

FISH PRODUCTION

Altogether, 126 female farmers were selected, 100 in Terai, Chitwan (Central Region) and 26 in Kailali (Far Western Region). In each household, a small pond (average size ~100 m², ranging from 35 to 236 m²) was dug near the house. Most ponds were dug with excavator, but dikes were prepared manually. Few farmers dug their own ponds. The cost of pond construction was supported by the project. All ponds were supplied with canal water derived from nearby rivers and rivulets.



FIGURE 1. Ms. Bhagawati Mahato collecting dedhuwa from netting for preparation of a fish curry.



FIGURE 2. Sun-drying surplus dedhuwa on bamboo plates for future consumption.

The stocking combinations were: 1) carp only, 2) carp and prawn, 3) carp, prawn and dedhuwa, 4) carp, prawn and mara, 5) carp, prawn and pothi, 6) carp and dedhuwa, and vii) carp and pothi. Carp, prawn and pothi were stocked by ten farmers each whereas carp only, carp and dedhuwa, and carp and pothi were stocked by 24, 30 and 32 farmers, respectively.

Farmers stocked fingerlings of rohu (35 ± 2 g), mrigal (6 ± 1 g), silver carp (2.7 ± 0.3 g), bighead carp (7 ± 2 g), dedhuwa (0.99 ± 0.01 g), mara (1.39 ± 0.01 g) and pothi (1.94 ± 0.04 g) in March 2010 and juvenile prawn (0.21 ± 0.01 g) in July 2010. Fingerlings of rohu, mrigal, silver carp and bighead carp were procured from the nurseries of RIDS and FDC, Bhandara and dedhuwa and pothi were collected from the ponds of IAAS and mara from natural ponds of Sarlahi District. The project supported RIDS to establish a nursery in Kathar as a partial support towards making the organization sustainable.

Prawn juveniles were transported from a private hatchery of Mymensingh, Bangladesh. Juveniles were transported by flight in oxygenated plastic bags from Dhaka to Kathmandu, and by van from Kathmandu to IAAS, Rampur where these were nursed for 30 days in ponds. The stocking densities used by farmers were: carp 1/ m^2 , prawn 0.5/ m^2 and SIS 3/ m^2 .

Urea and diammonium phosphate were applied at 0.4 g N/ m^2 /day and 0.1 g P/ m^2 /day (Knud-Hansen *et al.* 1993), respectively. Farmers fed fish with farm feed ingredients such as rice bran, mustard oil cake, soybean cake and corn flour at 3 percent of body weight (Rai *et al.* 2010). Growth and production were monitored by two field supervisors and three research students.

Fish were harvested in December 2010 after 270 days of production, whereas prawn was harvested after 160 days. During the production period, farmers regularly harvested SIS (up to two times per month after breeding of stocked brood SIS) for family consumption after three months of stocking, whereas carps and prawn were harvested all at once at the end of the culture period.

Farmers obtained an extrapolated total production of carp, SIS and prawn of 3.2 t/ha/y. Total production was greater in Chitwan (3.6 t/ha/y) than in Kailali (2.8 t/ha/y). Production was greater in ponds with SIS than those without SIS, suggesting a synergistic

effect of SIS on carp production. Greatest mean total production (38.9 kg/pond) and carp production (36.0 kg/pond) was obtained in carp-dedhuwa-prawn polyculture in nine months, which was 41 percent greater than carp polyculture.

Among SIS, pothi and dedhuwa performed better than mara. Average production of pothi, dedhuwa and mara was 3.6, 2.7 and 0.9 kg/pond in 270 days, respectively. Mara bred only in a few ponds, which affected the size of partial harvests and overall production. Small fish contributed 10 percent to total production in Carp-SIS-Prawn polyculture ponds. Prawn production was very low due to high mortality. Therefore, the contribution of prawn to total production was negligible (<1 percent).

FISH CONSUMPTION

Carp was the major food from the pond consumed by households: 64 percent of total production was consumed by the family, ranging from 3 to 45 kg per household in 270 days. Average fish consumption per household was 21 kg in 270 days, equivalent to a per capita fish consumption of 4.8 kg/y, whereas the average national fish consumption rate in Nepal was 1.8 kg/yr (Ministry of Agriculture and Cooperatives 2009).

Small fish consumption ranged from 0.5 to 6.4 kg per household in 270 days (maximum 23 g/capita per household per day over 270 d). Small fish contributed an average of 20 percent of total family consumption among SIS-growing farmers. Fish consumption was greater in ponds with SIS than without SIS. Farmers growing SIS carried out regular partial harvests of these fish, increasing household consumption by 38 percent over carp-growing households (Fig. 1). Farmers consumed fresh and sun-dried SIS. A few farmers preserved excess dedhuwa by sun-drying for later consumption (Fig. 2).

MICRO-NUTRIENTS IN SIS

Vitamin A, iron and zinc in SIS were analyzed in a laboratory at the University of Copenhagen. Samples ($n=36$) of dedhuwa, mara and pothi were collected from farmers' ponds. Among the four SIS, vitamin A content was greatest in mara, whereas iron and zinc were

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FIGURE 3. Ms. Bhikhani Chowdhary teaching about fish disease to women farmers during carp-SIS-prawn polyculture training organized at Majhui, Chitwan.

greatest in dedhuwa followed by pothi (Table 1). Vitamin A was comparatively lower in mara than reported by Roos *et al.* (2003, 2007a, b) in Bangladesh. The difference may be explained by the sample from project ponds containing juveniles, which have a lower vitamin A content than adults. Roos *et al.* (2002) reported that vitamin A accumulates with age in fish.

Iron content was lower in raw, cleaned samples than raw, whole samples, indicating that iron is concentrated in gut tissues. Because people commonly eat cleaned SIS (without guts), there is a loss of a substantial amount of iron during cleaning. Micronutrients in SIS are much greater in large carps in Bangladesh (Roos *et al.* 2003, Roos *et al.* 2007a). Regular intake of micronutrient-dense small fish can mitigate the malnutrition problems of women and children who often suffer from malnutrition.

INCOME

Almost all farmers sold carps and prawn and increased household income, empowering women economically. Both men and women were involved in the sale of fish and most were sold to locals in the neighbourhood, with a few sold to local vendors who re-sold fish in local markets. Farmers used revenue earned from carp and prawn sales on household needs and microcredit savings. Carp were sold for US\$ 3/kg and prawn for US\$ 9/kg. The amount of carp sold ranged from 2-32 kg per household



FIGURE 4. Women farmers participating in the carp-SIS-prawn polyculture training organized at Majhui, Chitwan.

(US\$ 6-91) and that of prawn ranged from 0.4-0.6 kg per household (US\$ 3-5). Average income generated by farmers was US\$27 per household in 270 days. SIS-stocked ponds provided 28 percent greater income over carp-only ponds because of comparatively greater production.

WOMEN FISH FARMERS' GROUPS AND COOPERATIVE

Seven woman fish farmers' groups were formed, with groups ranging from 15 to 26 members. Each group held monthly meetings during which problems were discussed, such as fish disease, poisoning of water sources, adequacy of water supplies, advocacy to DADO, solutions to problems and future activities, such as where and how to procure fingerlings (Fig. 3). A monthly deposit of US\$ 0.14-0.35 per member was made in each group's account. The accounts were used to provide loans (US\$ 7-70/ person) to needy group members, with an interest rate of 1-2 percent per month, and for repairs of equipment, including pumps and fish nets.

Sundardeep Women Fish Farmers' Co-operative (SWFFC) was established in December 2012 by women fish farmers of the Carp-SIS-Prawn project at Majhui, Khairani-3, Chitwan. The cooperative had 25 women members. The cooperative aimed to improve economic and social status of members through their participation in income-generating activities, such as fish farming, integrated fish farming and marketing.

TABLE 1. VITAMIN A, IRON AND ZINC CONTENT IN FOUR COMMON SIS OF TERAI, NEPAL. ALL VALUES EXPRESSED PER 100 G OF RAW CLEAN SAMPLE. RAE IS RETINOL ACTIVITY EQUIVALENTS.

SMALL INDIGENOUS FISH SPECIES	VITAMIN A (RAE)	IRON (MG)	ZINC (MG)
Dedhuwa (<i>Esomusdanricus</i>)	107.5	6.2	4.5
Faketa (<i>Barilius sp.</i>)	84.5	1.0	3.6
Mara (<i>Amblypharyngodon mola</i>)	685.5	2.4	4.3
Pothi (<i>Puntius sophore</i>)	56.0	3.1	4.2



FIGURE 5. Representatives of government offices, non-government organizations and international non-government organizations observing fish netting at Majhui, Chitwan.

TRAINING IN POND POLYCULTURE

Trainers from RIDs and REST provided a two-day workshop on Carp-SIS-Prawn farming (Fig. 4). The training was very useful because all farmers had no previous experience with aquaculture. During the training, farmers were supplied a Carp-SIS-Prawn Polyculture manual and a record book to record the numbers and weights of fish harvested, consumed and sold, including mortality losses. The amounts of feed and fertilizer applied to ponds were also recorded. Records were regularly monitored by project staff. Farmers visited Chapia, in Rupendehi, to observe commercial carp farming. Chapia is one of the biggest fish-producing areas in Rupendehi.

FIELD VISITS AND DISSEMINATION

A joint field visit was organized to disseminate project activities in December 2010. Representatives of several government organizations, local NGOs and international NGOs (DADO, Manahari Development Institute, Forum for Rural Welfare and Agricultural Reform for Development, Helen Keller International, International Development Enterprises, International Rice Research Institute, WorldFish Center, BAU, IAAS and farmers) participated in a field visit and had full-day interactions with the farmers (Fig. 5). Farmers raised different issues, concerns and problems they faced with pond management, such as algal scum and fish kills. In addition, Bangladeshi scientists and staff of the USAID-funded Cereal Systems Initiative for South Asia (CSISA), Bangladesh, also visited project sites.

VISIT TO BANGLADESH

Eight female farmers and eight project staff visited Bangladesh for one week in October 2010. Six of the farmers were leaders of female fish farmers' groups. The visit was organized, managed and hosted by the Faculty of Fisheries, BAU and the WorldFish Center, Bangladesh. Participants visited the fisheries facilities at BAU, including the field station and several fish farms and hatcheries in Mymensingh. The Nepalese team learned about



FIGURE 6. The Nepalese team, together with their Bangladeshi hosts admiring cucumber and bottle gourd grown on pond dykes, Gauripur, Mymensingh.

different fish farming systems. They were impressed to see the integration of fisheries and vegetable growing on the dykes of ponds (Fig. 6). The Bangladesh visit was a turning point for the Nepalese farmers and project staff, with a firm belief of "we can also do." They shared their experience with their fellow farmers.

ACHIEVEMENTS

Small fish were previously considered to be undesirable in ponds. Its role was in food security only. Now the status of SIS has been changed from low-value fish to nutrient-rich fish. Hopefully people will be attracted to SIS and eat more, which will ultimately improve the nutrition of household members. Extension officers and farmers are well aware of the nutrient value of SIS. Its potential role to address malnutrition problems is highlighted at the local and national level.

Carp-SIS-Prawn Polyculture can play a vital role in reducing fishing pressure on natural waters. Growing fish in ponds and partial harvesting systems have changed their practices from fishing to farming. Compared to the first year of the project, the contribution of wild fish to household fish consumption decreased by 36 percent by the third year of the project (Rai 2012). Implementation of such projects in heavily fished areas can be of great help in fisheries conservation and management.

Three projects have used the carp and SIS polyculture technology. Those projects are implementing carp and small fish polyculture as a major farming practice in five districts. Currently, 1200 households have the technology.

CONCLUSION

Unlike Bangladeshis, Nepalese do not eat fish routinely, except in Tharu, Danuwar, Bote communities. Fish production (57,520 t) and consumption (2 kg/capita/y) in Nepal are low (Directorate of Fisheries Development 2013). Indian and Chinese carp are the main fish grown and eaten in Nepal but carp have less vitamins and minerals than SIS, particularly mara and dedhuwa. Polyculture of carp, small fish and prawn in ponds can contribute to the improvement of family nutrition and income in

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rural areas. In the past, SIS was not valued and their presence in ponds was undesirable. This project has contributed to changing the attitude toward SIS. Female farmers have learned to stock and grow SIS. The nutritional value of SIS has been accepted. Mara, which performed poorly in project ponds, needs further research to improve its production and breeding performance.

Family fish consumption among farmers increased with project implementation but it needs to be increased further by raising production through improved technology, such as multiple stocking and harvesting systems for carp. Farmers have already started to adopt this system in Chitwan, achieving good initial results.

Freshwater prawn is an exotic species in Nepal and is still under experimentation. There is a potential for prawn farming in Terai and there is demand but a reliable seed supply is essential. Prawn hatcheries should be developed in the country. To increase benefits, scaling up the technology is needed in other parts of Terai, which may need collaborative efforts among rural communities, government line agencies, research institutions and donors.

Notes

Sunila Rai, Aquaculture Department, Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal. Corresponding author: Sunila Rai, Post Box No. 26032, Kathmandu, Nepal. sunilarai@yahoo.com

Alternate address: Aquaculture and Fisheries Department, Agriculture and Forestry University, Rampur, Chitwan, Nepal. Shakuntala H. Thilsted, World Fish Centre, Dhaka, Bangladesh. Madhav K. Shrestha, Aquaculture Department, Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal.

Alternate Address: Aquaculture and Fisheries Department, Agriculture and Forestry University, Rampur, Chitwan, Nepal. Md. Abdul Wahab, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Mahesh C. Gupta, Fisheries Development Centre, Geta, Kailali, Nepal.

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