Animal Source Foods to Improve Micronutrient Nutrition and Human Function in Developing Countries

Small Indigenous Fish Species in Bangladesh: Contribution to Vitamin A, Calcium and Iron Intakes[1,2]

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ABSTRACT Fish play an important role in the Bangladeshi diet, constituting the main and often irreplaceable animal source food in poor rural households. Fish consumption is dominated by wild small (length <25 cm) indigenous fish species (SIS). The vitamin A content in SIS varies, from <100 μg of retinol equivalents (RE)/100 g raw edible parts, to >2,500 μg RE/100 g raw edible parts in mola (*Amblypharyngodon mola*). The study addressed the dietary contribution of fish to vitamin A, calcium and iron intakes and the potential of integrating SIS, including mola, into existing carp polyculture ponds. Fish consumption (wild and cultured fish) was surveyed by 5-d recall interviews in 84 poor rural households in Kishoreganj district in 1997–1998. Fifty-nine of the households cultured carp and SIS in small (mean size 400 m^2) domestic ponds. Total household fish consumption was unaffected by the domestic aquaculture production. SIS from wild sources contributed 84% of the total fish consumption. In the peak season (October), SIS contributed 40% (median 23%) of the recommended vitamin A intake at the household level (n = 84). Thirty-four households cultured mola along with carp. Cultured mola used for household consumption contributed 20% (median 18%) of the recommended intake of vitamin A at the household level. Wild SIS is an important source of vitamin A and calcium in Bangladesh. Mola can be integrated in existing carp culture without negative effects and can contribute to increased vitamin A intake in rural households. J. Nutr. 133: 4021S–4026S, 2003.

KEY WORDS: • *Bangladesh* • *vitamin A* • *calcium* • *iron* • *aquaculture*

Rice and fish dominate the diet of Bangladeshis to such an extent that the old proverb, "machee bhatee bangali," which can be translated as "fish and rice make a Bengali," continues to hold true. Fish is an essential and irreplaceable food in the rural Bangladeshi diet. Together with boiled rice, which is eaten at least twice per d, small amounts of vegetables and fish make up the typical meal. Meat, pulses and fruits are eaten less frequently and in smaller amounts. In the national nutrition survey conducted in rural Bangladesh in 1981–1982, average fish intake was 23 g raw fish/person/d, whereas average meat consumption was 5 g/person/d (1). Rice contributed >80% of the dietary energy and protein. In terms of weight of food consumed, fish ranks third after rice and vegetables. More recent regional studies have confirmed the importance of fish in the Bangladeshi diet (2,3). Fish intake is affected by several factors, such as year, season, location, water level and household income. **Table 1** shows regional and seasonal fish intakes from selected studies in Bangladesh.

Small indigenous fish species (SIS)[4], which are defined as species attaining a maximum length of 25 cm (4,5) contribute considerably to total fish intake. A study conducted in Mymensingh, Northern Bangladesh showed that fish intake increased with income (6).

Fish provide the main source of income to ~2 million households that either fish for a profession or are involved in related trades (7). Many more households catch fish for a part-time income and for food. In communities with access to fisheries, studied by the International Center for Living Aquatic Resources Management, an estimated 87% of all households caught fish for some part of the year (8).

The role of fisheries and aquaculture

Bangladesh is dominated by floodplains and rivers, which are rich ecosystems for freshwater fish. The floodplains, which comprise over half of the country, are inundated annually

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[4] Abbreviations used: MAEP, Mymensingh Aquaculture Extension Project; NCR, Nutrient Contribution Ratio; SIS, small indigenous fish species.

TABLE 1

Fish intake in Bangladesh from selected studies[1]

Location	Year/season		SIS[2] g/person/d	Large fish[3] g/person/d	Total fish g/person/d	Method	Reference
Rural Bangladesh	1981–1982	Annual	NA	NA	23	600 hh, 12 locations, 24-h food weighing	(1)
Manikganj	1995	Oct–Nov	28 ± 45(8)	29 ± 51(0)	57 ± 62(42)	152 hh, 769 individuals, 24-h food weighing	Inge Tetens (unpublished); (3)
	1996	Jan–Mar	25 ± 47(0)	12 ± 36(0)	37 ± 56(19)	145 hh, 717 individuals, 24-h food weighing	
Mymensingh	1995	Oct–Nov	14 ± 33(0)	24 ± 38(6)	38 ± 47(25)	152 hh, 765 individuals, 24-h food weighing	
	1996	Jan–Mar	12 ± 22(0)	20 ± 34(0)	32 ± 37(24)	146 hh, 729 individuals, 24-h food weighing	
Kapasia							
Small farm	1998–1999	Aug–Jul	NA	NA	83	20 hh, 84 d, 24-h food weighing	(19)
Medium farm	1998–1999	Aug–Jul	NA	NA	85	36 hh, 84 d, 24-h food weighing	
Large farm	1998–1999	Aug–Jul	NA	NA	96	12 hh, 84 d, 24-h food weighing	
Mymensingh							
Low income	1997	Feb–May	12 ± 17(4)	8 ± 13(2)	20 ± 21(14)	104 hh, 24-h recall	(6)
Medium income			13 ± 19(4)	12 ± 18(3)	26 ± 26(19)	104 hh, 24-h recall	
High income			14 ± 19(6)	16 ± 21(3)	29 ± 26(24)	105 hh, 24-h recall	
Low income	1997	Jun–Sep	21 ± 24(136)	9 ± 16(0)	30 ± 27(23)	104 hh, 24-h recall	
Medium income			30 ± 38(18)	11 ± 17(3)	41 ± 38(30)	104 hh, 24-h recall	
High income			28 ± 31(21)	13 ± 26(0)	41 ± 37(32)	105 hh, 24-h recall	
Dinajpur (Ashurar Beel)	1999	Feb–May	8 ± 7(6)	5 ± 8(3)[4]	13 ± 11(11)	90 hh, 24-h food weighing, 7 d/mo	Paul Thompson (unpublished)
		Jun–Sep	24 ± 19(20)	2 ± 4(0)[4]	26 ± 19(23)		
		Oct–Dec	29 ± 17(25)	5 ± 7(3)[4]	34 ± 19(31)		
Kishorganj (Kali Nadi)	1999	Jan–May	18 ± 9(16)	8 ± 7(6)[4]	26 ± 14(23)	90 hh, 24-h food weighing, 7 d/mo	
		Jun–Sep	20 ± 10(19)	9 ± 8(7)[4]	28 ± 13(26)		
		Oct–Dec	28 ± 15(25)	12 ± 12(8)[4]	40 ± 21(36)		

1 Values are means ±SD (median). All values are raw whole fish, except values from Manikganj and Mymensingh 1995–1996, which are raw edible parts.
2 Small indigenous fish species defined as species attaining a maximum length of 25 cm.
3 Large fish include fish species attaining a maximum length of >25 cm.
4 The species magur, rita, baila, bara baim, bhangon and kakila are included as large fish in this study.
hh, households; NA, data not available.

during the monsoon season, and agriculture and natural fisheries complement one another. In the monsoon to postmonsoon season (June–November), the floodplains provide an ideal habitat for the wide diversity of wild fish species, whereas in the dry season, the land is cultivated with rice.

Since the green revolution, Bangladesh has made tremendous strides in increasing rice production. This success has taken place through many changes in the overall agricultural production and the management of land and water. More areas have been brought under rice production, irrigation has expanded greatly and large areas have been drained and protected by flood control embankments. These changes have been at the expense of fish: the area of inland water and the duration of inundation have decreased, so there has been a reduction in the habitat for fish.

Fish catches relative to area are reported to have decreased by 81% in waters affected by flood protection (9). Although official figures show that the number of floodplain fisheries increased in the 1990s, after decreasing in the 1980s, it is widely held that floodplain catches have been falling. This apparent discrepancy may be due to more intensive monitoring of floodplain stocking in the early to mid-1990s as well as differences in the areas monitored (7,10).

Although capture fisheries dominate total production, freshwater aquaculture production has grown rapidly, and contributes an increasing share of fish available for consumption. Fish from aquaculture trebled in the period from 1989 to 1999 (11). The proportion of cultured ponds increased from 27% to 52% between 1984 and 1996 (12). Cultured ponds typically yield 1.0–3.7 tons fish/hectare/y (t/ha/y) (7), whereas noncultured ponds yield ~0.5 t/ha/y. About 85% of fish produced in ponds are carp (11), either exotic carp species such as silver carp (*Hypothalmichthys molitrix*) or common carp (*Cyprinus carpio*), or indigenous carp species such as rui (*Laboe rohita*) and mrigal (*Cirrhinus cirrhosus*; alternative scientific name is *Cirrhinus mrigala*). This has important implications for the availability of fish for poor people and the nutritional contribution of the fish that is consumed.

Nutritional contribution of fish

The importance of fish as a rich source of animal protein is well established and this is frequently used to justify fish as a valuable food, whereas very little attention has been given to the role of fish in supplying vitamin A and minerals in the diet. The protein content of fish ranges from 14 to 18 g/100 g raw edible parts (13). From the last national survey in rural Bangladesh, the mean total protein intake was 48 g/person/d, of which fish contributed 3 g (1). The value of fish in the Bangladeshi diet should not focus on the contribution made to protein, because protein recommendations in the typical diet are met provided that the energy recommendations are met (5). Rather, focus should be placed on the composition of the fish and the contribution of micronutrients, especially vitamin A and minerals, from the different types of fish species.

The variation in vitamin A content in fish species is extreme (14). The content per 100 g raw edible parts in 27 species ranged from <100 μg RE in most species to 2680 μg RE (SD = 220, n = 7 samples) in mola (*Amblypharyngodon mola*). Based on their vitamin A content, species can be categorized as shown in **Table 2**. Species with very high, high and medium vitamin A content are all SIS, whereas other SIS and cultured carp species have a low vitamin A content.

Most of the vitamin A in fish is concentrated in the eyes and viscera (14). This distribution makes the cleaning practice extremely important for the retention of vitamin A. Cleaning practices depend on the fish species, size of fish and the person cleaning the fish. The waste can include the gill cover, jaw, head, tail and/or viscera (partial or full). For mola, the head and eyes are normally included as edible parts (5,14). Vitamin A in fish is found as retinol and dehydroretinol isomers. In mola, 80–90% of the total vitamin A is present as dehydroretinol (14). In estimating the total vitamin A content, it is estimated that the dehydroretinol isomers have 40% of the biological activity of all-*trans* retinol (15).

The mineral content of fish, unlike its vitamin A content, is apparently not species specific. The content of total iron and calcium in some commonly consumed Bangladeshi fish is shown in **Table 3**. Small fish are generally eaten with bones, although some bones may be discarded as plate waste, whereas in large fish most or all bones are discarded as plate waste. Therefore, small fish are an excellent source of calcium. In studies with both humans and rats it is shown that the bioavailability of calcium from whole small fish (mola) is as high as that from milk. In humans, the fractional calcium absorption is found to be 24 ± 6% from small fish and 22 ± 6% from milk (16).

SIS in aquaculture

Floodplain fisheries are still the main source of fish eaten by rural people, with SIS contributing the most. However, with the present trends of decreasing floodplain fisheries and increasing aquaculture, the total fish intake may fall and a larger proportion of SIS in the Bangladeshi diet will be substituted by carp. This will have a negative impact on the nutritional contribution from fish, especially because the content of vitamin A and calcium is very much less in carp species than in SIS. To maintain and enhance SIS intake, sustainable management and restoration of floodplain fisheries must be given high priority. However, the drainage of floodplains and the increasing population limit the scope. Rather, incorporating nutrient-dense fish species in the production systems used in the continued expansion of aquaculture is a means of abating the above trends.

TABLE 2

Categories of Bangladeshi fish species based on vitamin A content in edible parts[1]

Category of fish species	Vitamin A content RE/100 g raw edible parts	Common name[2]	Scientific name
Very high content	>1500	Mola (SIS)	*Amblypharyngodon mola*
		Chanda (SIS)	*Parambassis baculis*
High content	500–1500	Dhela (SIS)	*Osteobrama cotio cotio*
		Darkina (SIS)	*Esomus danricus*
Medium content	100–500	Chanda (SIS)	*Parambassis ranga*
		Koi (SIS)	*Anabas testudineus*
		Golsha tengra (SIS)	*Mystus bleekeri*
		Chanda (SIS)	*Chanda nama*
		Taki (SIS)	*Channa punctata*
		Chela (SIS)	*Chela cachius*
Low content	<100	Baim (SIS)	*Macrognathus aculeatus*
		Baim (SIS)	*Macrognathus pancalus*
		Kachki (SIS)	*Corica soborna*
		Gutum (SIS)	*Lepidocephalus guntea*
		Chapila (SIS)	*Gudusia chapra*
		Puti (SIS)	*Puntius chola*
		Puti (SIS)	*Puntius sophore*
		Khalisha (SIS)	*Colisha fasciatus*
		Shing (SIS)	*Heteropneustes fossilis*
		Magur (SIS)	*Clarias batrachus*
		Baim (SIS)	*Mastacembelus armatus*
		Puti (SIS)	*Puntius ticto*
		Chata (SIS)	*Colisa lalia*
		Tilapia (small exotic species)	*Oreochromis niloticus*
		Mrigel (large indigenous species)	*Cirrhinus cirrhosus*
		Rui (large indigenous species)	*Labeo rohita*
		Silver carp (large exotic species)	*Hypophthalmichthys molitrix*
		Hilsha (large indigenous species)	*Tenualosa ilisha*
		Common carp[2] (large exotic species)	*Cyprinus carpio*
		Grass carp[2] (large exotic species)	*Ctenopharyngodon idella*

1 Fish species listed in descending order of vitamin A content in each category.
2 From (20).

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TABLE 3

Mineral content in some commonly consumed Bangladeshi fish species[1]

Common name	Scientific name	n[2]	Fe (mg/100 g raw edible parts)	Ca (mg/100 g raw edible parts)	Ca[3] (mg/100 g raw edible parts corrected for plate waste)	Dry matter (%)
SIS:						
Baim/Chikra	Macrognathus aculeatus, Macrognathus pancalus, Mastocembelus armatus	5	2.4 ± 0.4	462 ± 56	203 ± 25	25 ± 1
Chanda	*Parambassis ranga, Parambassis baculis,* Chanda nama	5	1.8 ± 0.7	955 ± 342	878 ± 314	24 ± 2
Chapila	Gudusia chapra	3	7.6 ± 5.3	1063 ± 51	786 ± 38	27 ± 3
Darkina	Esomus danricus	3	12.0 ± 9.1	891 ± 357	775 ± 321	23 ± 3
Kachki	Corica soborna	2	2.8 ± 1.2	476 ± 37	347 ± 34	16 ± 1
Mola	Amblypharyngodon mola	3	5.7 ± 3.7	853 ± 86	776 ± 78	20 ± 1
Puti	*Puntius sophore, Puntius chola,* Puntius ticto	4	3.0 ± 0.9	1171 ± 216	784 ± 145	25 ± 1
Taki	Channa punctuatus	3	1.8 ± 0.4	766 ± 183	337 ± 81	22 ± 1
Tengra	Mystus vittatus	2	4.0 ± 0.4	1093 ± 334	480 ± 147	26 ± 4
Shrimp (Chingri)	Macrobracium sp.	3	3.1 ± 2.2	687 ± 23	687 ± 23	21 ± 2
Large fish						
Mrigel	Cirrhinus cirrhosus	3	2.5 ± 1.3	960 ± 104	0 ± 0	24 ± 3
Silver carp	Hypophthamichthys molitrix	3	4.4 ± 1.8	903 ± 361	37 ± 14	23 ± 2

1 Values are means ± SD of n samples.
2 n = number of samples. A sample contained 10–300 fish for SIS and 1–2 fish for larger fish.
3 Calcium content of raw edible parts is corrected for plate waste using a correction factor based on the proportion of a species reported to be eaten without bones (5).

A field study was therefore conducted with the aim of investigating the production potential and nutritional benefits of integrating mola and other SIS in carp polyculture in small seasonal ponds. The readily available carp polyculture production systems practiced in ponds can be altered to include the production of SIS by using simple technologies and local resources. The production and profitability of carp and SIS cultures were measured, as well as the nutritional contribution of the fish produced in relation to the total fish consumption in the household. The study was conducted in collaboration with the Mymensingh Aquaculture Extension Project (MAEP) in Kishoreganj district, northern Bangladesh. Through local extension officers, MAEP trains poor farmers in carp culture in small homestead ponds. A semiintensive carp production system is practiced, based on the use of local low grade feeds and fertilizers (rice bran, banana leaves, manure) supplemented by chemical fertilizers (urea and phosphate). A production of 2–4 t/ha/y is obtained compared to 0.5 t/ha/y in ponds having wild fish. From 1989 to 1999, >40,000 farmers were trained. MAEP is implemented jointly by the government of Bangladesh, Danish International Development Assistance and a number of local nongovernmental organizations.

METHODS AND SUBJECTS

Fifty-nine poor rural households with small seasonal ponds were selected in Kishoreganj District. The households owned <0.8 ha land and had an annual income of <35,000 taka ($780 in U.S. dollars). From June 1997 to January 1998, the field trial was conducted. The ponds (mean size 396 m^2, range 212–850 m^2) were stocked with fingerlings of silver carp, grass carp (*Ctenopharyngodon idella*), mrigal, common carp and rui, with a mean fish size of 35 g, a ratio of 8:4:4:1 and at a density of 8,500/ha. In 34 of the ponds, mature mola, with a mean size of 1.6 g/fish, was stocked with the carps at a density of 25,000 mola/ha. Mola was collected from local ponds that had natural stocks. In 25 ponds, carp species were cultured with the other SIS. The culture period ranged from 6 to 8 mo. Small amounts of cheap local feed (rice bran, duckweed and banana leaves) were used and the ponds were fertilized with cow dung, urea and phosphate. Details of the pond management have been reported (5,17).

The total fish consumption, including fish bought in the local markets, captured from wild stocks and harvested from the ponds, was surveyed in the 59 households participating in the trial, as well as in a control group of 25 neighboring nonfish-producing households with similar socioeconomic status. This was done three times: preharvest season (July, 1997), harvest season (October, 1997) and postharvest season (February, 1998), using a recall method. The head of the household and the housewife were jointly interviewed about the fish consumption of the household in the past 5 d. Fish species, origin, price, amount of raw fish cooked and the parts of the fish consumed were recorded. The amount of fish was estimated from fish models, and the amount of raw edible parts was calculated by subtracting the cleaning waste (5). The average cleaning waste of SIS was 13% of the whole fish, whereas for large fish it was 22% of the whole fish, including 8% plate waste consisting mainly of bones. The nutritional contribution from fish is presented as a Nutrient Contribution Ratio

TABLE 4

The economics of carp and mola production in ponds[1]

	Taka × 1,000/ha/season[2]
Carps, value	73.6 ± 26.6
Mola, value	5.0 ± 4.6
Expenditures	48.7 ± 11.1
Net profit	28.1 ± 23.9

1 Values are means ± SD for 34 ponds.
2 U.S. $1 = 48 taka (1997). The production season ranged from 6 to 8 mo.

TABLE 5

Seasonal household fish consumption and Nutrient Contribution Ratio (NCR) in rural households[1,2]

	N	Consumption			NCR		
		SIS[3] (g/person/d)	Large fish (*g/person/d*)	Total (*g/person/d*)	Vitamin A (%)	Calcium (%)	Iron[4] (%)
July, 1997	84	28 ± 26(21)	10 ± 17(5)	37 ± 33(27)	16 ± 20(8)	16 ± 10(14)	4 ± 3(3)
October, 1997	84	65 ± 55(45)	18 ± 25(7)	82 ± 65(64)	40 ± 49(23)	31 ± 21(26)	9 ± 7(6)
February, 1998	84	38 ± 40(25)	16 ± 18(12)	55 ± 48(42)	20 ± 29(6)	20 ± 19(14)	7 ± 5(5)

1 Values are means ±SD (median).
2 Expresses a nutrient intake relative (%) to the sex- and age-specific recommended intakes (20) on household level. Values are means ± SD (median).
3 SIS, small indigenous fish species.
4 Based on recommended iron intakes for diets with low iron bioavailability.

(NCR), which expresses the intake of a nutrient from fish as a percentage of the FAO/WHO recommended intake (18). Fish consumption was recorded at the household level, and the recommended intake was totaled for all household members, based on sex- and age-specific recommendations.

RESULTS

Fish production and profit

The average total fish production was 2.87 t/ha (SD = 0.9, n = 59) for a 7-mo production season. The mean fish production was similar in the 34 ponds in which carp species were cultured with mola and the 25 ponds with carp and other SIS. The mean production of mola was 0.34 t/ha/season (SD = 0.21, n = 34). Mola contributed 10.3% of the total fish production in the 34 carp-mola ponds. A summary of the economics of the carp-mola ponds is shown in **Table 4**. The mean net income from pond production, including the value of the consumed fish, was 1230 taka/household/season ($30/household/season in U.S. dollars).

Within the range of a total fish production of 0.71–4.42 t/ha/season recorded in the 59 trial ponds, there was no indication of a negative correlation between the production of SIS and total carp production when either parametric (analysis of covariance) or nonparametric (similarity ranking) statistical methods were used (5).

Fish consumption and contribution to vitamin A and calcium intakes

Fish was consumed daily in 48% of the households in October 1997 and in 25% of the households in July 1997 and February 1998. Ninety-eight percent of the households consumed fish at least 1 d out of the 5 d surveyed in all seasons. The diversity of fish species in the diet was high. A total of 44 fish species by common names was recorded, comprising up to 60 scientifically distinct species. SIS dominated the total fish intake in terms of amount as well as frequency of consumption, contributing 84% of the total fish intake. There was no difference in fish intake in the fish-producing households (n = 59) and the nonfish-producing control households (n = 25). Fish bought in the local markets and wild-captured fish contributed >90% of the total fish consumption in both the fish-producing as well as the nonfish-producing households. The seasonal fish consumption and the NCR for vitamin A, calcium and iron are shown in **Table 5**. The contribution to the recommended iron intake was modest and depended on the assumption made for bioavailability. Fish contributed <10% of the recommended protein intake.

Forty-seven percent of the mola harvested from the 34 carp-mola ponds was consumed in the households, contributing an average of 4 g raw edible parts/person/d. This amount of mola was sufficient to cover 21% (median = 18%) of the recommended intake of vitamin A of the household in the 7-mo production season. NCR for iron, calcium and protein from SIS harvested from the ponds were all low, <5%.

The consumption survey confirmed that fish is an important part of the diet of most people in rural Bangladesh. Fish was eaten in small amounts, but with a high frequency in nearly all households. Changes in fish supply and species available for consumption therefore affect the diets of most people in rural Bangladesh. Floodplain fisheries are the main source of fish for consumption, and aquaculture in small homestead ponds has little impact on the household fish consumption. In Bangladesh, aquaculture is typically a secondary activity, supplementing more traditional farming activities. Nevertheless, aquaculture can make an important nutritional contribution through the production of vitamin A–dense SIS. By integrating vitamin A–dense SIS, such as mola, with existing carp production in semiintensive cultured ponds, the nutritional quality of the production can be improved without any negative impact on the total fish production. This production system offers great potential for providing a valuable source of dietary vitamin A in rural Bangladesh. If only 10 kg/y of mola were produced in each of the estimated 1.3 million ponds in Bangladesh, the annual recommended vitamin A intake of >2 million children would be met.

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