Archana Sinha
Aparna Roy
Pranab Gogoi *Editors*

Perspectives and Applications of Indigenous Small Fish in India

An Introduction

Springer

Perspectives and Applications of Indigenous Small Fish in India

Archana Sinha • Aparna Roy •
Pranab Gogoi
Editors

Perspectives and Applications of Indigenous Small Fish in India

An Introduction

Springer

Editors
Archana Sinha
Division of Aquatic Environmental Biotechnology
ICAR-Central Inland Fisheries Research Institute
Barrackpore, Kolkata, West Bengal, India

Pranab Gogoi
Riverine and Estuarine Fisheries division
ICAR-Central Inland Fisheries Research Institute
Barrackpore, Kolkata, West Bengal, India

Aparna Roy
Extension and Training Cell
ICAR-Central Inland Fisheries Research Institute
Barrackpore, Kolkata, West Bengal, India

ISBN 978-981-97-1585-5 ISBN 978-981-97-1586-2 (eBook)
https://doi.org/10.1007/978-981-97-1586-2

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Foreword

Fish is a vital aquatic food in India, contributing to the diets and nutrition of many population groups. Many fish species in India, especially indigenous Small Fish species, are rich sources of micronutrients—minerals and vitamins, essential fatty acids, and amino acids, crucial for human growth, development, and cognition. Growth in the fisheries sector in India has increased, with higher production—both in aquaculture and capture fisheries, increased consumption in India as well as increased export. To meet this demand, emphasis is being given to the culture of large and medium fish species, for example, major and minor carp and catfish species. Only very recently, recognizing the exceptional nutritional value of indigenous Small Fish species, some attention has been given to understanding and increasing their production, management, and consumption patterns, in some states in India. This book, titled ***Perspectives and Applications of Indigenous Small Fish in India: An Introduction***, is the outcome of a well-coordinated and concentrated effort by the editors and a team of contributors to describe many important aspects of Small Fish species found in India, including their contribution to food and nutrition security. The many topics include identification and description of common Small Fish species from inland water bodies in India, as well as growth, feeding, disease and health management of these Small fish species. The supply chains and products derived from Small Fish species from different regions in India are described as well as indigenous knowledge, climate change impacts, and conservation and management practices to maintain the diversity of indigenous Small Fish species. This book provides valuable information for all, including farming communities, entrepreneurs, policy makers, students, and researchers who are interested in gaining knowledge and skills to contribute to improving food and nutrition security of all in India, and in particular, the important role that indigenous Small Fish species can play.

2021 World Food Prize Laureate

Montpellier cedex 5, France — Shakuntala Haraksingh Thilsted

Preface

Hunger and malnutrition are important and challenging issues around the globe. Aqua food is a vital source of the dietary component for people's well-being. It contains high-quality protein and low fat. Low-income populations in developing countries depend on "Small Fish" to combat the hidden hunger for their food security and nutrition. Indigenous Small Fishes like Mola (*Amblypharyngodon mola*), Chela (*Salmophasia bacaila*), Punti (*Puntius* sp.), Tangra (*Mystus vittatus*), Pabda (*Ompok pabda*), Singhi (*Heteropneustes fossilis*), etc. have traditionally been an integral part of the rural household diet. These tiny native fish were frequently referred to as "weed fish" or "trash fish." Commonly, these Small Fishes are termed as Small Indigenous Fish (SIF), but technically Small Fish is a specific terminology and should be recognized accordingly. Therefore, the Editors have taken initiative to consider Small Fish as a cohesive word instead of SIF. These Small Fish are rich in a range of micronutrients, such as iodine, iron, zinc, vitamins A, D, and B12, n-3 long-chained polyunsaturated fatty acids (LC-PUFA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), and nowadays they are referred to as "Nutri-fish." However, there is limited academic and policy attention to small fish as part of local diets, particularly for people living in poverty. The fact that the rural populace does not consider Indigenous Small Fish (IFS) to be as profitable for culture as Indian Major Carps (IMC) and exotic species has exacerbated the problems in conservation efforts. The book *Perspectives and Applications of Indigenous Small Fish in India: An Introduction* comprises a set of chapters written by different authors on important issues of the small fish for global nutritional security. The editors tried to raise policy issues in addition to scholarly points. This book will certainly be a complete knowledge guide on nutritious small fish. The editors sincerely acknowledge the contribution of authors, experts, and especially rural fish farmers for their contribution in adding value to the book. The authors are indebted to **Dr. Himanshu Pathak**, Secretary DARE and Director General, Indian Council of Agricultural Research, New Delhi; **Dr. Joykrushna Jena**, Deputy Director General (Fisheries Science), Indian Council of Agricultural Research, New Delhi; **Dr. Dilip Kumar**, Former Vice Chancellor, ICAR-Central Institute of Fisheries Education (Deemed University), Mumbai; **Prof (Dr.) Anil Prakash Sharma**, Former Director, ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata; and **Dr. Basanta Kumar Das**, Director, ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, for their ready support and encouragement. The authors are privileged to extend their gratitude to **Dr. Shakuntala Haraksingh Thilsted,** Director, Nutrition, Health and Food Security Impact Area Platform CGIAR; the 2021 World Food Prize Laureate, for her support and guidance in presenting the book to academicians, researchers, and policy makers to develop guidelines for Securing Sustainable Small-Scale Fisheries in the context of Food Security and Poverty Eradication, in 2024; and aim to reach the targets of the Sustainable Development Goals (SDGs) by 2030.

Barrackpore, Kolkata, West Bengal, India Archana Sinha
Barrackpore, Kolkata, West Bengal, India Aparna Roy
Barrackpore, Kolkata, West Bengal, India Pranab Gogoi

Contents

Editors and Contributors

About the Editors

Archana Sinha Head, Division of Aquatic Environmental Biotechnology, ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI), Kolkata, India, has working experience of 34 years in the field of fisheries and aquaculture research, education, and extension. She completed several externally funded and in-house research projects and developed technology for fisheries and aquaculture, especially in fish breeding and culture, fish feed technology, open water fish culture practices and management. She has organized more than 100 short-term training programs on fish breeding and culture including fish feed technology for unemployed youth, women, farmers, and entrepreneurs for the development of fisheries and aquaculture. She has published 100+ research papers in national and international journals, five books, and several technical and training manuals.

Aparna Roy of Agriculture Research Service (ICAR-CIFRI) has been a creative field worker and is well known in the field of fisheries extension and training in India. Her work in Ganga-Brahmaputra-Meghna (GBM) basin is quite noteworthy. She has worked on small fishes to boost livelihood and nutritional security and prepared a roadmap to establish model nutri-smart village in deltaic Sundarban. She has worked on the livelihood mapping of Ganga basin and livelihood improvement initiatives in Sagar Island of the Indian Sundarbans for tribals and women. Presently, she is working for empowering women of wetland-dependent fisherfolk community of lower Gangetic plain through cost-effective technologies. She is also working in a collaborative project with Worldfish on “small scale fisheries in wetlands for livelihood and nutritional security” covering both Ganga and Brahmaputra basin. Dr. Roy has several publications including 34+ research papers and more than 70 extension publications either authored or coauthored.

Pranab Gogoi is a fisheries graduate. He did his master’s in the discipline of fisheries resource management from ICAR-Central Institute of Fisheries Education, Mumbai. He is presently working as a scientist in the Division of Riverine Estuarine Fisheries at ICAR-CIFRI, Kolkata, India. His area of research is riverine and estuarine ecology with ecohydrological interactions of biotic community therein.

Mr. Gogoi has published more than 30 research papers in peer-reviewed research journals of national and international repute. Besides these he has also contributed to various book chapters and popular articles in the field of inland fisheries management.

Contributors

R. Anandan ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India

K. K. Anas ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India

Raju Baitha ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Amjad Balange Indian Agricultural Research Institute (IARI), Dhemaji district, Assam, India

Ben Belton International Food Policy Research Institute, Dhaka, Bangladesh

Punyasloke Bhadury Indian Institute of Science Education and Research Kolkata (IISER-K), Nadia, West Bengal, India

Sanjenbam Bidyasagar ICAR-Central Institute of Fisheries Education, Mumbai, Maharastra, India

Biswajyoti Bordoloi Fisheries Research Centre, Assam Agricultural University, Jorhat, Assam, India

Simanku Borha ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Vishnumurthy Mohan Chadag WorldFish, Jalan Batu Maung, Bayan Lepas, Penang, Malaysia

Binay Kumar Chakraborty Department of Fisheries, Dhaka, Bangladesh

Shobhit Institute of Technology and Engineering, Merrut, UP, India

Bimal Kinkar Chand Directorate of Research, Extension & Farms, West Bengal University of Animal & Fishery Sciences, Kolkata, West Bengal, India

Gyan Chandra College of Fisheries, Kishanganj, BASU, Patna, India

Thangjam Nirupada Chanu ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Bibha Chetia Borah Fisheries Research Centre, Assam Agricultural University, Jorhat, Assam, India

Diksheeta Chutia Department of Zoology, Gauhati University, Guwahati, Assam, India

Basanta Kumar Das ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Rajdeep Das Department of Zoology, Gauhati University, Guwahati, Assam, India

Rashmi Ranjan Das WorldFish, New Delhi, India

Adity Deka Department of Zoology, Gauhati University, Guwahati, Assam, India

Manoharmayum Shaya Devi ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Sourabh Kumar Dubey WorldFish, New Delhi, India

Anjana Ekka ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

K. S. Fathima Rafni ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India

Kalpajit Gogoi WorldFish, New Delhi, India

Pranab Gogoi Riverine and Estuarine Fisheries Division, ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Makamguang Kamei School of Fisheries, Centurion University of Technology and Management, Paralakhemundi, Odisha, India

Gunjan Karnatak ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

A. Kathirvel Pandian ICAR-National Bureau of Fish Genetic Resources, Lucknow, Uttar Pradesh, India

Mohammad Hossein Khanjani Department of Fisheries Sciences and Engineering, Faculty of Natural Resources, University of Jiroft, Jiroft, Kerman, Iran

Deepak Kumar ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, Uttarakhand, India

Kavita Kumari ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Lekshmi R. G. Kumar ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India

Shivendra Kumar College of Fisheries (Dr. Rajendra Prasad Central Agricultural University, Pusa), Dholi, Muzaffarpur, India

V. Santhana Kumar ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Jham Lal College of Fisheries (Dr. Rajendra Prasad Central Agricultural University, Pusa), Dholi, Muzaffarpur, India

Kamei Lanthaimeilu ICAR-Central Institute of Fisheries Education, Mumbai, Maharastra, India

B. K. Mahapatra Kolkata Research Centre, ICAR-CIFE, Mumbai, Kolkata, India

Priti J. Majhi ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

H. M. Manas ICAR-Central Marine Fisheries Research Institute, Kochi, India

Ranjan Kumar Manna ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Praveen Maurye ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

P. Mishal ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Vidya Mohanan ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India

Sangeetha M. Nair ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Sudarshana Nandi Department of Zoology, SRM University Sikkim, Gangtok, India

Aquatic Ecology and Fish Biology Laboratory, Department of Zoology, Visva-Bharati, Santiniketan, West Bengal, India

Jayanta Kumar Nath Department of Zoology, Gauhati University, Guwahati, Assam, India

S. K. Nayak College of Fisheries (Dr. Rajendra Prasad Central Agricultural University, Pusa), Dholi, Muzaffarpur, Bihar, India

George Ninan ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India

Arun Padiyar WorldFish, New Delhi, India

Ashmita Pandey Indian Agricultural Research Institute (IARI), Dhemaji district, Assam, India

Pramod Kumar Pandey ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, Uttarakhand, India

Arun Pandit ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

P. A. Pavithra ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India

Anjali Pushp College of Fisheries, Kishanganj, BASU, Patna, India

Manchi Rajesh ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, Uttarakhand, India

Francois Rajts WorldFish, Jalan Batu Maung, Bayan Lepas, Penang, Malaysia

R. Bharathi Rathinam ICAR-Indian Agricultural Research Institute, Jharkhand, India

Aparna Roy ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

H. S. Sahil Mogalekar College of Fisheries (Dr. Rajendra Prasad Central Agricultural University, Pusa), Dholi, Muzaffarpur, Bihar, India

Anu Saikia Department of Zoology, Gauhati University, Guwahati, Assam, India

Surjya Kumar Saikia Aquatic Ecology and Fish Biology Laboratory, Department of Zoology, Visva-Bharati, Santiniketan, West Bengal, India

Rupam Samanta College of Fisheries, Kishanganj, BASU, Patna, India

Srikanta Samanta ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Dhruba Jyoti Sarkar ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Soma Das Sarkar ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Uttam Kumar Sarkar ICAR-National Bureau of Fish Genetic Resources, Lucknow, Uttar Pradesh, India

Dandadhar Sarma Department of Zoology, Gauhati University, Guwahati, Assam, India

Kangkan Sarma Department of Zoology, Gauhati University, Guwahati, Assam, India

Jyoti Saroj College of Fisheries, ANDUAT, Ayodhya, UP, India

Arya Sen ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Moslem Sharifinia Shrimp Research Center, Iranian Fisheries Science Research Institute (IFSRI), Agricultural Research, Education and Extension Organization (AREEO), Bushehr, Iran

Asem Sanjit Singh Department of Molecular Reproduction, Development and Genetics, Indian Institute of Science, Bangalore, India

Yumnam Bedajit Singh College of Fisheries, Lembucherra, Central Agricultural University, Imphal, India

Archana Sinha Division of Aquatic Environmental Biotechnology, ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

Shubham Soni Indian Agricultural Research Institute (IARI), Dhemaji district, Assam, India

Keisham Sushma College of Fisheries, Dholi, Rajendra Prasad Central Agricultural University, Samastipur, Bihar, India

Manoj Talukdar Department of Zoology, Gauhati University, Guwahati, Assam, India

C. S. Tejpal ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India

Naisringdi Thaosen Department of Zoology, Gauhati University, Guwahati, Assam, India

Gayatri Tripathi CAR-Central Institute of Fisheries Education, Mumbai, India

Gusheinzed Waikhom College of Fisheries, Lembucherra, Central Agricultural University, Imphal, India

Global Status of Indigenous Small Fishes (ISFs)

1

Binay Kumar Chakraborty

Abstract

Indigenous small fish (ISF) species play a major role in the security of rural populations' livelihood and nutrition. Copper, zinc, selenium, iodine, calcium, phosphorus, magnesium, iron, cobalt, chromium, vitamins A, D, and E, as well as vitamins B_1, B_2, B_3, and B_{12} are frequently deficient in low-income homes and are especially important for pregnant women and children. Fish were previously abundant in the floodplains and rivers. Currently, various anthropogenic hazards to the environment are putting pressure on aquatic biodiversity, limiting ISF availability. For conversion of wetlands, overfishing, invasive alien fish species, climate change, and flood control structures are some of these stresses. The IUCN classifies the 142 freshwater ISF species as critically endangered (CR), endangered (EN), vulnerable (VU), lower risk (LR), least concern (LC), and data deficient (DD). However, 21 (15%) of the 142 ISF fish species are classified as critically endangered (CR), 31 (21%) endangered (EN), 39 (27%) vulnerable (VU), 22 (15%) lower risk (LR), and 31 (22%) least concern (LC). *Amblypharyngodon mola, Puntius sophore, Esomus danricus, Osteobrama cotio, Trichogaster fasciata, Anabas testudineus, Labeo bata, Systomus sarana, Ompok pabda, Mystus cavasius, Mystus tengara, Heteropneustes fossilis*, and *Macrognathus aral* are used for induction of spawning, nursing, and growth trials. The ISF aquaculture program fosters nutritional and livelihood security in rural communities.

Keywords

Small fishes · Micronutrients · Minerals · Vitamins · Livelihood

B. K. Chakraborty (✉)
Swami Vivekanand Subhertyi University, Merrut, Meerut, UP, India

Department of Fisheries/Mud Eel, Mud Crab, Aquaculture and Management Centre, Bangladesh DoF, Dhaka, Bangladesh

A. Sinha et al. (eds.), *Perspectives and Applications of Indigenous Small Fish in India*, https://doi.org/10.1007/978-981-97-1586-2_1

1.1 Introduction

Indigenous small species (ISF) is fish that reach a mature or adult size of 25 cm (9 inches) in their life cycle (Felts et al. 1996; Roos et al. 2002; Hossain et al. 2006). Some ISF, like as *Heteropneustes fossilis*, can grow larger than 9 inches (25 cm). Bangladesh has 260 freshwater fish species (Rahman 1989), including 143 reported as ISF. Felts et al. (1996) added 45 fish species to the list of ISF, including carps and minnows (18 species), catfishes (9 species), perches (9 species), and more. These fish are an essential source of nutrition and livelihood in Bangladesh's major rural areas. Fish alone meet a per capita fish consumption requirement of 62.58 g/day. Bangladesh's fisheries sector contributes for 58% of protein intake. However, the miscellaneous small fish captured from floodplains by the rural poor have been ignored in official statistics and regulations. The ISF is regarded as a vital source of essential macro- and micronutrients, which contribute significantly to the country's malnutrition elimination (Ahmed et al. 1977), because ISF is high in protein, vitamins, and minerals (Thilsted et al. 1997). Small fish with bones have also been identified as a calcium-rich dietary source (Larsen et al. 2011).

Previously, the ISF considered it to be weeds and removed them from fish culture ponds. The dramatic reduction of small fish in natural resources throughout the last 1990s has highlighted the importance of ISF culture and conservation (Wahab 2003). The culture of ISF has yet to be tried on a wide basis in the country. However, aquaculture can contribute to the production and conservation of small fish for Bangladesh's rapidly growing population. Because there are numerous homestead ponds in rural regions that have the potential for aquaculture, they can help nutritional upliftment and livelihood improvement of rural Bangladeshis.

1.1.1 Vital Source of Fish Protein for the Underprivileged

Poor households typically have a low income and restricted access to food. They purchased some basic food items that may be staples, such as cereals or grains. Cheap non-staple foods, such as vegetables, would only be purchased once income and staple foods were secure (Brinkman et al. 2009). Although low-income households rely mostly on fish as a source of animal protein, they consume less fish overall than wealthier households (Bose and Dey 2007). The difference in the amount of meat, eggs, milk, and milk products that the rich and the poor consume has increased significantly, in contrast to fish (Mazumder 1998). This is because animal foods are expensive for the poor to purchase; therefore, they turn to fish for a cheaper option. Fish is a significant protein source for underprivileged families. Eating more fish from their fish ponds has improved the nutritional status of farmers who practice small-scale aquaculture. The income from fish sales also provided farmers with more nutritional foods. Furthermore, by making fish available at a low cost, ISF farmers can improve the nutritional status of local people (Aiga et al. 2009; Roos et al. 2007a). The extensive and semi-intensive technologies are easily adapted to small-scale aquaculture. Small-scale aquaculture uses traditional fish species such

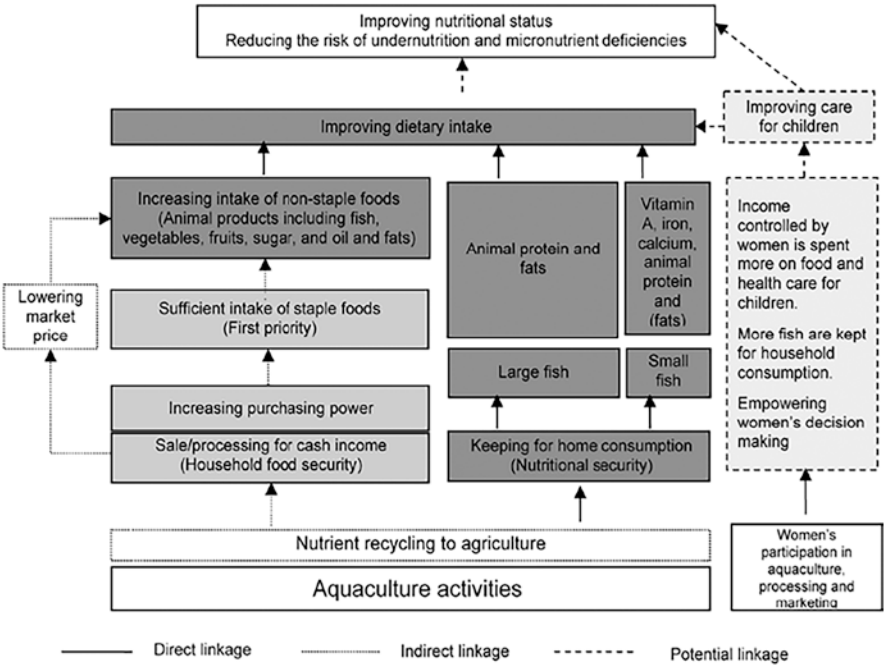

Fig. 1.1 The pathways through which aquaculture can improve the nutritional status (Adapted to Kawarazuka 2010)

as carps and catfish. As a result, polyculture is a viable option for maximizing local nutrient availability. Thus, aquaculture of small indigenous species compensates for nutritional shortages. Large fish species and prawns produced an important supply and provided a significant source of income for households through sale (Roos et al. 2007; Thilsted et al. 1997). Aquaculture would improve nutritional status by experimenting with various interventions and achieving agriculture-aquaculture integrated interventions, such as rice-fish culture and vegetable growing on fishpond dykes. Figure 1.1 depicts the interplay and outcome of aquaculture's contribution to nutritional status. Farmed fish is relatively important to aquaculture households since it is typically preserved for household consumption or sold as a source of income. Aquaculture has always been employed in the context of human nutrition to directly boost nutritional intake. Fish raised on small farms serves as the main source of animal protein and essential micronutrients for communities in many underdeveloped nations (Goswami and Sathiadhas 2000).

1.1.2 Enhancing Nutrition with Fish-Based Diets

Numerous studies have been conducted worldwide to examine the nutritional advantages of fish and their effects on human health. The health benefits of polyunsaturated fatty acids (PUFAs), which reduce the risk of heart disease, prevent blood pressure from rising, and support neonatal growth and cognitive development, have piqued the curiosity of numerous scientists and academics (Wang et al. 2006). In underdeveloped nations, the role of fish in meeting nutritional demands has been highlighted in public health discussions about under nutrition and micronutrient deficiencies. A healthy diet should include enough protein, various important amino acids and fatty acids (EPA/DHA), as well as vitamins and minerals, and fish can supply a rich source of these nutrients to the human population (Allison et al. 2013; Rangel-Huerta et al. 2012).

Fish protein is more important for humans since it is roughly 5–15 times more digestible than plant-based proteins. According to Tacon and Metian (2013), animal-based foods, particularly fish, include certain necessary amino acids that are beneficial to human health. The presence of both methionine and lysine in certain foods may aid in the digestion of important amino acids. Fish can compensate for amino acid deficiencies that other diet items do not cover, resulting in greater protein in overall intake. Many low-income food-deficit countries depend heavily on plant-based diets, making this critical.

1.1.3 Aquaculture in Relation to Food Security

On small rural farms, aquaculture produces high-quality animal protein and essential vitamins and minerals to pregnant and breastfeeding mothers, babies, and preschool children. Malnutrition accounts for nearly half of all fatalities worldwide (Rajee and Mun 2017). Fish contains essential nutrients such as vitamins A and B12, calcium, and potassium, which can prevent childhood blindness and new born death (Ahmed and Garnett 2011). Small fish, including heads and bones, contain more micronutrients, vitamins, and minerals than larger fish (Ahmed and Garnett 2011). Small indigenous fish harvests from natural open water and ponds have provided an important source of nutrition for poor rural communities while also helping to reduce infant malnutrition rates. Larger fish species cannot give the same quantity of nutrients as smaller fish. The mola (*Amblypharyngodon mola*) is an example from Bangladesh. According to Bouis (2000), small fish have higher nutritious contents than larger species. It was found that although major invasive species had less than 100 retinols (RE), or the equivalent of vitamin A content, 100 g of edible mola possesses more than 1500 RE (Roos et al. 2003).

1.2 Beneficiaries of Small-Scale Aquaculture

Smallholder farmers in rural areas need to include aquaculture into their farming methods and lifestyles, as it is a vital source of high-quality food in developing nations (Harrison 1997). Rural aquaculture is intended to help the poor in conventional agriculture systems. Small-scale aquaculture is a technology used to improve the resilience of rural lives in developing Asian countries (Belton 2013; Shrestha and Pant 2012).

Table 1.1 Chemical compositions of some ISF

Name of SIS	Water (%)	Fat (%)	Protein (%)	Ash (%)	Calcium (mg/100 g)	Phosphorus (mg/100 g)	Iron (mg/100 g)
Anabas testudineus	70.0	8.80	14.8	2.00	410	390	135
Channa punctatus	74.0	0.60	19.4	2.60	610	530	130
Glossogobius giuris	79.7	0.60	14.5	2.30	370	330	104
Heteropneustes fossilis	68.0	0.60	22.8	1.70	670	650	226
Labeo bata	79.0	2.48	14.3	2.00	79.0	200	1.09
Notopterus notopterus	73.0	1.00	19.8	2.50	590	450	169
Salmostoma bacaila	77.5	4.30	14.6	2.10	590	340	1.96
Systomus sarana	70.2	9.50	16.5	1.53	220	120	0.54

[a] Source CSIR-India (1962)

Fish is an easily digestible diet and a valuable source of animal protein. ISF species contain a significant quantity of vitamins A and D, both of which are needed for human bones, teeth, skin, and eyes. ISF also contains adequate levels of calcium, phosphorus, iron, iodine, zinc, nickel, and cobalt. These minerals are essential for developing the body's resilience to disease (Table 1.1). Some ISF, such as punti (*Puntius* spp.), can double the quantity of iron. Mola (*Amblypharyngodon mola*) is another ISF that contains three times more calcium and 50 times more vitamin A (Villif and Jorgensen 1993).

1.2.1 ISF Resources and Their Micronutrients

Bangladesh has around 150 ISF of fish in its water bodies, among 260 inland fish species (Saha and Barman 2020). Different types of water bodies (floodplains, rice fields, haors, baors, beels, ponds, etc.) are ideal breeding, nursing, and rearing grounds because they provide an abundance of natural food, space, and a favorable habitat (Mohanty et al. 2013). They can spread swiftly to other natural water bodies because of their capacity to spawn in narrow and shallow water bodies; as the rainy season progresses, their abundance increases, particularly when water bodies reach their peak levels. There are no naturally occurring species-specific populations in these aquatic bodies. It primarily assists with producing the basic brood stock required for pond production through breeding and recruitment (Saha and Barman 2020).

Different types of indigenous fish species (ISF) live in natural resources such as rivers, canals, floodplains, ponds, low water bodies, and rice fields in varying numbers. They inhabit diverse and plentiful environments. People catch small fish from open water bodies and sell them at the local market. The soil topography and ecosystem samples of numerous rivers, canals, and rice fields in Bangladesh and the

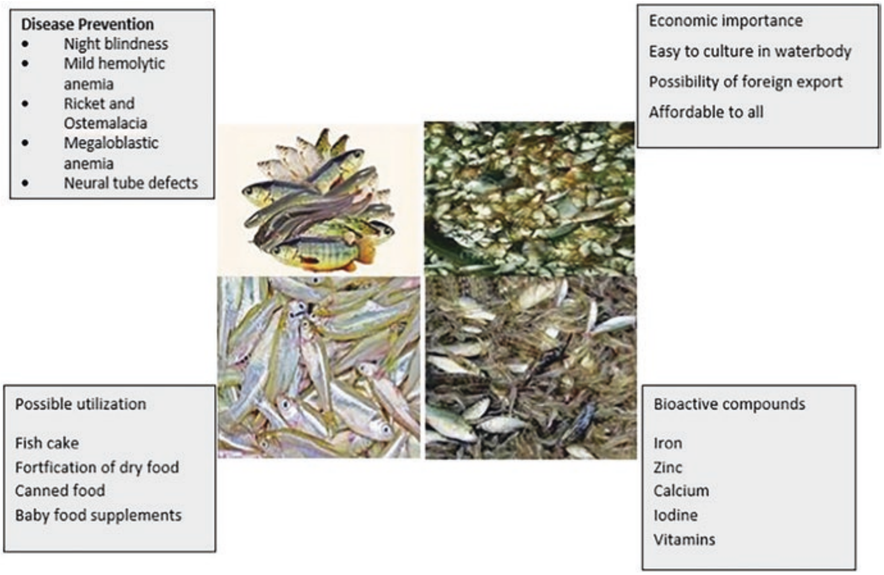

Fig. 1.2 A diagram showing the optimal use of ISF, their economic significance, and their impact on the human body

north-eastern part of India provide variation among small fish. The relative abundance of these species reflects observations made in paddy fields, low water bodies, and associated trap ponds in the corresponding areas (Tacon and Metian 2013). Traditional fishing gear has been used to capture ISF from paddy fields, low water bodies, and trap ponds. Because of the structural properties of the equipment (Faridullah et al. 2022), fish with low biomass are more susceptible to such traps than fish with large biomass, resulting in species size and composition as found in many ISF species offered on the market. The biomass and abundance parameters of ISF are comparable to those observed in the Padma River in Bangladesh (Bayen et al. 2016). Small fish ensure the next generation's talent and health (Fig. 1.2). ISF's entire body, including the skull, bones, eyes, and viscera, is edible, and there is no plate waste, resulting in nutrient-dense cuisine.

1.2.2 Vitamins

Every animal requires relatively small amounts of vitamins to carry out its basic functions. Micro-element deficiencies are the root cause of both physical and mental diseases. Vitamins are either fat-soluble (vitamins A, D, E, and K) or water-soluble (vitamins C and B complex) (Thilsted et al. 2016; Roos et al. 2003). The vitamin B series (vitamins B1, B2, B3, B5, B6, B7, B9, and B10) functions as coenzymes or cofactors.

1.2.2.1 Vitamin A

Immunity, cell development, reproduction, and eye health all depend on vitamin A (retinol, retinoic acid) (Thilsted et al. 2016). Night blindness, or limited vision at night, is the most prevalent and early sign of Vitamin A insufficiency. The primary sources of vitamin A are indigenous small mola (*Amblypharyngodon mola*) and dela (*Osteobrama cotio*) fish. Mola fish contains the greatest vitamin A in its eyes; therefore, when cleaning it, take care not to separate the head from the body and consume the head, eyes, and bones together. Vitamin A levels in sun-dried fish are nearly negligible (Saha and Barman 2020).

1.2.2.2 Vitamin B_{12}

Fish and shellfish are rich in vitamin B_{12}, which is necessary for cell division, blood creation, DNA synthesis, neuron function, and other processes. The vitamin B_{12} concentration of small fish ranged from 0.90 to 12.8 μg per 100 g, with different testing methods used (Roos et al. 2003). The largest amount was discovered in shing fish (*Heteropneustes fossilis*) and the lowest in Meni fish (*Nandus nandus*) (Roos et al. 2003). Small fish is a good source of vitamin B_{12} and are is becoming increasingly significant to reduce deficiency and to maintain a healthy diet (Hossain 2010).

1.2.2.3 Vitamin D

Fish eat zooplankton and microalgae, which are thought to be plankton sources of vitamin D2 (Hossain 2010). Vitamin D promotes calcium and phosphorus absorption, inhibits infection, lowers inflammation, and protects cancer, among other things. ISF has been regarded as an excellent source of vitamin D (Thilsted et al. 2016).

1.2.2.4 Vitamin E

Vitamin E occurs naturally in eight chemical forms: alpha-, beta-, gamma-, and delta-tocopherol and alpha-, beta-, gamma-, and delta-tocotrienol. Out of the 28 species examined, two (koi, *Anabas testudineu*s; chapila, *Gudusia chapra*) lacked alpha-tocopherol. Mola (*Amblypharyngodon mola*) has the highest concentration (0.91 μg), whereas kachki (*Corica soborna*) has the lowest concentration (0.09 μg). Vitamin E plays a role in immunological function, blood clotting prevention, metabolic processes, gene expression control, and protein kinase activity and promotes the expression of two genes (Wahab et al. 2008).

1.2.2.5 Vitamin B_9 (Folate)

Foli had the highest amount of vitamin B9 at 18 μg, while Bashpata (*Ailia punctata*) and Kajuli (*Ailia coila*) had the lowest amount at 2.9 μg. Adults need 500–600 μg of vitamin B9 daily, whereas children only need 80–150 μg. The majority of children's vitamin B9 needs are satisfied by eating tiny, native fish, which is found in Bangladesh (Roos et al. 2003).

Maximum vitamin B_9 was detected at 18 μg in Foli (*Notopterus notopterus*) and at a minimum of m 2.9 μg in Bashpata (*Ailia punctata*) and Kajuli (*Ailia coila*). Adults require 500–600 μg of vitamin B_9 per day, while children require 80–150 μg per day. In Bangladesh, indigenous small fish is the primary source of this vitamin (Roos et al. 2003).

1.2.3 Minerals

Minerals have a key role in controlling a variety of physical and biological processes. Minerals are classified into two types: micronutrients and macronutrients. Small fish typically contain a high concentration of macrominerals such as calcium, zinc, iron, and phosphorus (Mohanty et al. 2013). For optimal health, one must consume a certain quantity of specific minerals (such as copper, zinc, selenium, iodine, magnesium, iron, cobalt, and chromium) in their diet.

1.2.3.1 Iron

Iron's fundamental role in the body is to generate hemoglobin, which is made up of pure heme. Approximately three species (chapila, *Gudusia chapra*; darkina, *Esomus danricus*; mola, *Amblypharyngodon mola*) can meet 25% of the RNI for PLW with iron concentrations ranging from 0.46 to 19 mg/100 g (Bogard et al. 2015). Iron content analyses may indicate systematic or actual changes in iron buildup among different species, depending on the situation. Several regionally indigenous small fish species contribute to the consumption of iron, the most important trace element in the Bangladeshi diet, which is as bioavailable as animal-derived foods (Negesse and Tera 2010).

1.2.3.2 Zinc

Zinc plays a role in around 200 enzymatic events, including catabolism, immunological response, wound healing, and sexual maturation (Roos et al. 2003). Zn is highly concentrated in indigenous fish species. Zinc concentration in fish ranges from 0.60 to 4.7 mg/100 g (Grases et al. 2001). Approximately four species, namely, chela (*Salmostoma phulo*), darkina (*Esomus danricus*), mola (*Amblypharyngodon mola*), and rani (*Botia dario*), meet 25% of the RNI for PLWs, with only chela and mola meeting 25% of the RNI criterion for babies. Another six other ISF fish species, namely, dhela (*Osteobrama cotio*), ekthute (*Dermogenys pusilla*), kachki (*Corica soborna*), mola (*Amblypharyngodon mola*), and tengra (*Mystus tengara*), occupy 20–25% of RNIs and dhela (*Osteobrama cotio*), ekthute (*Dermogenys pusilla*), kachki (*Corica soborna*), mola (*Amblypharyngodon mola*), tengra (*Mystus tengara*), darkina (*Esomus danricus*), rani (*Botia dario*), and tit punti (*Pethia ticto*) contribute to 20–25% of RNIs for newborns (Roos et al. 2003). ISF is high in zinc; thus, they can readily be incorporated into diet regimens to meet zinc requirements.

1.2.3.3 Calcium

Calcium is the most vital mineral in the human body that makes about 1.5–2.0% of the body's total weight. Researchers recommend taking 100 mg of calcium per day (Roos et al. 2003). Because ISF is ingested whole with bones, calcium is regarded as a readily available dietary food item for the general population. Small fish have a critical role in addressing calcium deficiencies. In order for muscles to contract and relax, for the heart to beat normally, for fatty acids to be oxidized, for neurons to function, and for mitochondria to transport ATP, calcium is necessary (Hossain 2010).

1.2.3.4 Iodine

The iodine content of food is inherently dependent on its environmental conditions. Small freshwater fish have an average iodine content of 43.6 μg/100 g, with darkina (*Esomus danricus*) having the highest value at 81 μg/100 g and kachki fish (*Corica soborna*) having the lowest at 6 μg/100 g. Koi (*Anabas testudineus*), shing (*Heteropneustes fossilis*), and foli (*Notopterus notopterus*) are especially iodine-rich (Bogard et al. 2015). Iodine is vital for controlling the biochemical operations of the human body, maintaining hormone levels, and maintaining the release of thyroxin hormone to assist metabolism.

1.2.3.5 Selenium

Selenium is essential for enzymatic contrast, antioxidant and catalyst formation, cellular production, immunological function, fertilization, and other processes in the human body. Selenium helps to grow human skin, hair, and nails. Small fish contain selenium, which improves thyroid function. Selenium helps to prevent cancer, cardiovascular disease, thyroid disorders, oxidative stress, inflammation, and the arterial aggregation (Mohanty et al. 2013).

1.2.4 Other Minerals

Phosphate is required for the creation of teeth and bones, as well as the production of energy. According to FAO (Roos et al. 2003), the phosphorus range in edible sections of small fish species should be 140–190 mg/100 g. This includes bones. Magnesium levels were between 21 and 57 mg/100 g throughout the total fish body. It is required for protein synthesis, cell reproduction, energy metabolism, muscular contraction, nerve conduction, and so on (Hossain 2010). Skeletal tissue and scales contain around 50–70% of the fish's magnesium. The sodium concentration of fish ranged from 26 mg to 110 mg/100 g. The human body requires 90 grams of sodium ions (Suo et al. 2021). The potassium level in fish ranged from 58 to 350 mg/100 g. Potassium consumption is linked to lower adult blood pressure, which reduces the risk of coronary heart disease and stroke. Again, age-related bone loss and kidney stone development can both be avoided with digestible potassium.

The manganese level in fish ranged from 0.021 to 2.3 mg/100 g, as reported in indigenous small fish species. Manganese's general health benefits include gluconeogenesis and its impact on cofactors of various enzymes involved in glucose metabolism (Hossain 2010). The copper content in the fish varied from 0.029 to 0.094 mg/100 g, which is consistent with previous investigations of indigenous small fish. Cytochrome-C-oxidase, an essential cofactor of the mitochondrial respiratory chain enzyme, has a role in iron metabolism (Hossain 2010). Almost every fish species displayed a comparable amount of chromium. There is one exception, cultured mola (*Amblypharyngodon mola*), which has extraordinarily low chromium levels of 0.027 mg/100 g.

1.3 Present Biodiversity Status of ISF Species in the Fresh Waterbodies of Bangladesh

Figures 1.3 and 1.4 show the current status of open positions for freshwater ISF species. Table 1.2 (A–F) describes the IUCN's ISF biodiversity status as well as the current status of 142 freshwater ISF species. According to the IUCN 2000, the 142 freshwater ISF species have varying statuses. Four (03%) commercially important species were at an extremely high risk of extinction (Critically endangered, CR) on a daily basis. Around 18 (13%) major value ISF fish species were facing extremely high risk of extinction (Endangered, EN), 13 (09%) ISF species were facing high risk of extinction (Vulnerable, VU), and 17 (12%) ISF species were categorized as Lower Risk (LR). Sixty-six ISF fish species (46%) have been identified as least concern (LC), while 24 fish species (17%) are categorized as data deficient (DD) (Fig. 1.3). The current status of 142 freshwater ISF fish species is similarly classified as different status. About 21 important ISF fish species (15%) are at an extremely high risk of extinction (Critically endangered, CR) day by day. Thirty-one (21%) major commercially important fish species were identified as very high risk of extinction (Endangered, EN), 39 (27%) species as high risk of extinction (Vulnerable, VU), 22 (15%) species as Lower Risk (LR), and 31 species (22%) as least concern (LC) (Fig. 1.3). Tables 1.2, 1.3, 1.4, 1.5, 1.6, and 1.7 present a list of freshwater ISF fish species status.

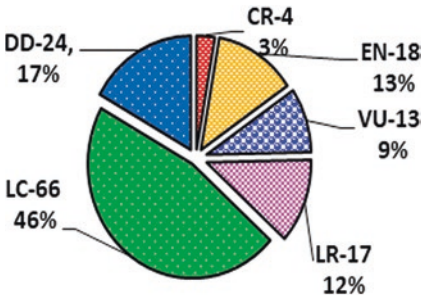

Fig. 1.3 IUCN biodiversity status of freshwater fishes in Bangladesh

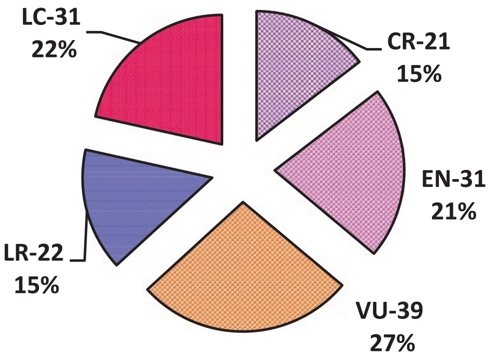

Fig. 1.4 Present biodiversity status of freshwater fishes in Bangladesh

Table 1.2 Critically endangered (CR) ISF fish species followed by IUCN 2000 and present status

Sl. No	Order	Family	Scientific name	Common name	Plate	Present status
1	Cypriniformes	Cyprinidae	*Labeo boga* (Hamilton 1822)	Bhangan Bata		CR
2	Channiformes	Channidae	*Channa barca* (Hamilton 1822)	Pipla/Tila shol		CR
3	Siluriformes	Sisoridae	*Sisor rabdophorus* (Hamilton 1822)	Chenua		CR
4	Siluriformes	Olyridae	Olyra longicaudata (McClelland 1842)	Bot Shinghi		CR

Table 1.3 A List of endangered (EN) ISF fish species of Bangladesh followed by IUCN 2000 and present status

Sl. No	Order	Family	Scientific name	Common name	Plate	Present status
1	Cypriniformes	Balitoridae	*Schistura scaturigina* (McClelland 1839)	Dari		CR
2	Cypriniformes	Cyprinidae	*Opsarius barna* (Hamilton 1822)	Barna Baril/Koksa		CR
3	Cypriniformes	Cyprinidae	*Opsarius bendelisis* (Hamilton 1807)	Baril		CR
4	Cypriniformes	Cyprinidae	*Barilius vagra* (Hamilton 1822)	Koksa/Vagra		CR
5	Cypriniformes	Cobitidae	*Botia dario* (Hamilton 1822)	Bengal loach/Bou mach		CR
6	Cypriniformes	Cobitidae	Botia dayi (Hora 1932)	Hora loach/		CR
7	Cypriniformes	Cobitidae	*Neoeucirrhichthys maydelli* (Bănărescu and Nalbant 1968)	Goalpara loach		EN
8	Cypriniformes	Cobitidae	*Botia lohachata* (Chaudhuri 1912)	Reticulate loach/Bou mach		CR
9	Cypriniformes	Cyprinidae	*Crossocheilus latius* (Hamilton 1822)	Stone roller/Kola Bata		EN

(continued)

Table 1.3 (continued)

Sl. No	Order	Family	Scientific name	Common name	Plate	Present status
10	Cypriniformes	Cyprinidae	*Devario anomalus* (Conway, Mayden and Tang 2009)	Anomalus zebra		EN
11	Cypriniformes	Cyprinidae	*Garra annandalei* (Hora, 1921)	Ghor poa		CR
12	Cypriniformes	Cyprinidae	*Garra gotyla* (Gray 1832)	Sucker head/Ghar poia		EN
13	Cypriniformes	Cyprinidae	*Megarasbora elanga* (Hamilton 1822)	Elong/Elanga		EN
14	Cypriniformes	Cyprinidae	*Oreichthys cosuatis* (Hamilton 1822)	Kosuati		CR
15	Siluriformes	Bagridae	*Batasio tengana* (Hamilton 1822)	Tengra		EN
16	Siluriformes	Schilbeidae	*Clupisoma garua* (Hamilton 1822)	Garua bachcha/ Muribacha		EN
17	Siluriformes	Siluridae	*Ompok bimaculatus* (Bloch 1797)	Butter catfish/Kani pabda		EN
18	Siluriformes	Siluridae	*Ompok pabda* (Hamilton 1822)	Pabdah catfish/ Madhu pabda		EN

Table 1.4 A List of ISF Vulnerable (VU) ISF fish species of Bangladesh followed IUCN 2000 and present status

Sl. No	Order	Family	Scientific name	Common name	Plate	Present status
1	Clupeiformes	Clupeidae	*Gudusia chapra* (Hamilton 1822)	Indian river shad/Chapila		VU
2	Cypriniformes	Cobitidae	*Lepidocephalichthys annandalei* (Chaudhuri 1912)	Annandale loach/Gutum		VU
3	Cypriniformes	Cobitidae	*Lepidocephalichthys irrorata* (Hora 1921)	Loktak loach/Puia		EN
4	Cypriniformes	Cyprinidae	*Cabdio morar* (Hamilton 1822)	Aspidopara/ Morar		EN
5	Cypriniformes	Cyprinidae	*Chagunius chagunio* (Hamilton 1822)	Chaguni/Utii		EN
6	Cypriniformes	Cyprinidae	*Chela cachius* (Hamilton 1822)	Chep chela		EN
7	Cypriniformes	Cyprinidae	*Danio dangila* (Hamilton 1822)	Dangila danio/Nipati		VU
8	Cypriniformes	Cyprinidae	*Pethia ticto* (Hamilton 1822)	Tit punti/Ticto barb		VU
9	Mugiliformes	Mugilidae	*Sicamugil cascasia* (Hamilton 1822)	Bata/Kachki/Kachki Bata		VU