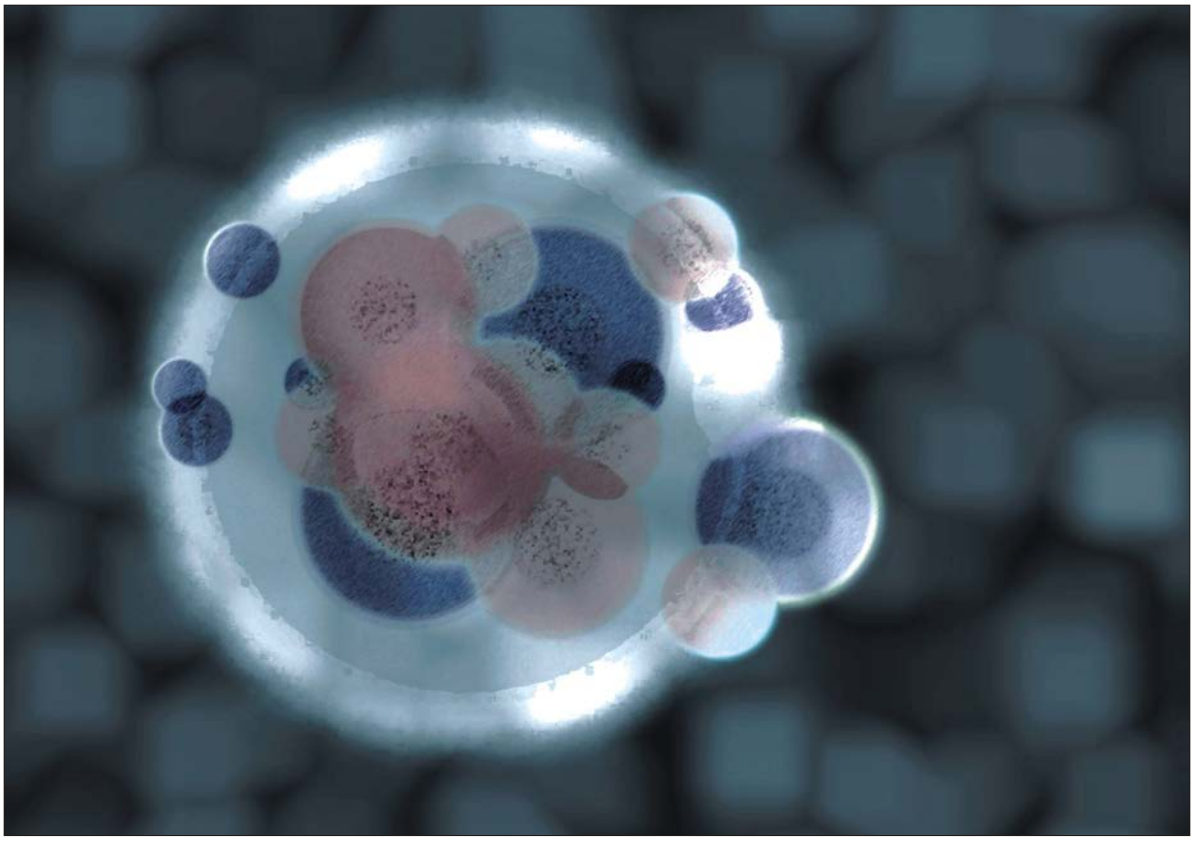

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Eco-biology of Freshwater Gobi, *Glossogobius giuris* (Hamilton) of the River Padma in Relation to its Fishery: A Review

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Abstract: The freshwater gobi, *Glossogobius giuris* (Hamilton) is widely distributed in freshwater bodies of Bangladesh. The investigation covers a comprehensive survey of literature on *G. giuris* in relation to its biology, ecology and fishery at home and abroad. It is aimed, at furnishing as much information as possible on various aspects, e.g. feeding habit and patterns among the different age groups, cannibalism, reproductive cycles and periodicity, size at reproduction and onset of reproduction, fecundity and gonadal development, catching methods and marketing; nutrients value and commercial importance of the gobi and others relevant fish species.

Key words: Eco-biology, *Glossogobius giuris,* fishery

INTRODUCTION

Food is the most important basic need for the survival of the living beings on the face of the earth. Whenever it is not available in sufficient quantities, there arise the problem of competition. It is a well-known fact that the population of the world is increasing in geometrical proportion whereas the food production in arithmetic proportion. This leads to the shortage of the food materials, which could be overcome either by controlling the population explosion or by the increasing the food production. The first one could not be done effectively and hence to adapt the alternative there was a lot of struggle to find out the ways and means to increase the food production. As a result, Bangladesh authorities had taken up the green revolution during early seventies just after the liberation, through which they exploited most of the terrestrial and aquatic resources to the maximum possible and improved the gross agricultural production to a remarkable extent.

Bangladesh is highly rich in fishery potentialities. There are thousands of ponds, tanks, beels, haors, baors, canals and rivers all over the country. The total area of perennial inland waters is estimated as 1.58 million ha and the inundated paddy fields including low lying areas which retain monsoon waters for about six months allowing seasonal fish culture is estimated as 2.83 million ha[1]. Bangladesh is the drainage outlet for a vast river basin complex made up of the Ganges-Brahmaputra-Meghna river system. The inland water areas of the country comprise 1.03 million ha of rivers, canals and estuaries; 1,14,161 ha of natural depressions such as the 'beels' and 'haors'; 1,61,943 ha of ponds and tanks; 5,488 ha of ox-bow lakes; 68,800 ha of Karnafuli reservoir; 2.8 million ha of flood plains and 87,300 ha of brackish water aquafirms[2]. In 1979, UNDP conducted a massive survey and reported that there are 1,54,082 acres of beels and haors, 89,000 acres of ponds and tanks, 4,28,800 acres of rivers and canals in Rajshahi Division.

Above all, it is observed that the protein content of the average Bangladesh food is far below the minimum requirement. Despite this vital importance of fish in the diet of the people, it is disquieting to note that the per capita consumption has shown a drastic decline over the years 1975-1976 to 1984-1985 as 22.2 g/person/day to 20.1 g/person/day. A recent study made by the DoF[3], Ministry of Fisheries and Livestock (2000-2001) indicates that the situation has developed and the per capita consumption increased (32 g/person/day) due to increase of culture and capture fisheries in Bangladesh. Even this was found to be not sufficient enough to satisfy the present day demand. That is why, the concentration of the scientists has been diverted towards strengthening the food material in terms of protein contents. Consequently it has been realised that among the animal protein, fish proteins are comparatively cheap and also abundant. Thus most of the agriculturists are becoming aquaculturists to grow more fish and supply the cheap proteins to the maximum possible and to meet the

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requirement of the people of the country. The government is also coming forward and very much encouraging the aquaculturists. The present decade in fact can be called as a decade of 'aquaplosion' keeping in view of the vast publicity for expansion of aquaculture.

Geographical position and physical features of the study area: The geographical position and effects of environmental parameters greatly influence the nature and pattern of population of a locality. The importance of such information is immense in studying the biological aspects of any fisheries species.

The Padma is a perennial river, taking its origin as 'Ganga' from 'Gangotri' in the snow-bound Himalayas. The Ganges or the Padma enters the country at the western extremity of the Rajshahi district after crossing 3 Indian states and flows in south easterly direction till it drains in the Bay of Bengal[2]. The river first touches Rajshahi at a place near Shibganj (now under the district of Nawabganj). It passes through the plains of Rajshahi and joins the Jamuna river at Goalanda, then with the Meghna river at Chandpur and then ultimately falls into the Bay of Bengal. The name Padma is given to that part of the Ganges, which lies between the point where the Bhagirathi branches off and the point where the Ganges meets the mighty Meghna[4]. At present the Ganges on entering Bangladesh takes its name as the Padma river and continues up to the point where it meets the Meghna river.

Rahshahi is situated in the latitudes between 24°6′ and 25°13′ North and the longitudes between 88°2′ and 89°21′ east on the north bank of the river Padma. The river Padma flows close to the Rajshahi City and continues in a south-easterly directions. The main city is located on the bank of the river Padma and the city experiences a single monsoon, i.e., June to August but likely to September. The relative humidity is the maximum during the month of June to August. The temperature fluctuates in summer around 30-42°C and in the winter 6-20°C (Source: Rajshahi Meteorological Station, 1998-2002).

The sampling area has a great seasonal fluctuation in temperatures, turbidity, water current, rate of water flows and other environmental factors. During the month of June to September the water level of the Padma rises up with the increased flow of water and heavy rainfall and over floods the adjacent areas. In the winter season, the rate of water flows decreases and during summer especially in the month of mid March to mid May the flow is very less, thereby large islands with in the rivers, called 'Chars' (sandy islands) are also formed. The river becomes narrow and it breaks up into a number of small pools, locally called as 'Damosh'. The turbidity also decreases in the winter and the bottom of the river is almost sandy to sandy loam which easily gives way to the strong current of the river during the rainy season. But the bank of the river consists of stiff clay soil or rarely muddy which yields little to the erosive action of the water. The Farakka Barrage made in the Indian portion of the Ganges has drastically affected the water level in the lean season, which has affected the fish population as well.

Selection of *Glossogobius giuris* as a model species: The selection of appropriate species for use as test organisms in biological assessments needs to be based on careful consideration of a number of factors. Hellawell[5] has suggested several characteristics which an "ideal" biological indicator species should posses. Indicator species need to have a wide distribution and be abundant enough for its use to have wide potential application. Sampling and handling of the selected species should preferably be simple, allowing easy collection of adequate sample and processing of the biological materials. Selected test species, which are easy to identify, reduces potential taxonomic error and enable non-specialist to use techniques based on such organisms. Careful thought was given to the selection of test species for use in this study. In addition to the above considerations, the aim was to select the species, *Glossogobius giuris* (Hamilton) that could be easily collected from the river Padma.

There are of course, some publications regarding the ecology and biology of the species from different geographical regions but no one has so far attempted to present a comprehensive and comparative account of this species. The majority of the gobi fishes, being small in size, do not constitute an important fishery anywhere in Bangladesh but *G. giuris* which attains about a foot in length, is notable, as it forms a fishery of some magnitude in the southern part of the country[6]. Siddiqui[7] reported that in Bangladesh about 80% population is poor and they mainly depend on small size fish for their daily supply of animal protein as they are available at a reasonable price. The freshwater gobi, *G. giuris* is tastier and nutritive, has drawn very little attention of the fishery scientists. The species, *G. giuris* is very important food fish, especially to the low-middle class and poor people, because of being comparatively cheaper but some times very expensive to them. The present study deals with the ecology, biology, biochemical composition, fishing and marketing of this species.

Identification and taxonomic position: Valid name: *Glossogobius giuris* (Hamilton); Local name: baila, baillya, bele, bailla, belia, bhalia[2,8].

Kingdom	: Animalia
Sub-Kingdom	: Metazoa
Phylum	: Chordata
Sub-Phylum	: Vertebrata
Super-Class	: Pisces
Division	: Gnathostomata
Class	: Osteichthyes
Sub-Class	: Actinopterygii
Super-Order	: Teleostei
Order	: Perciformes
Sub-Order	: Gobioidei
Family	: Gobiidae
Sub-Family	: Gobiinae
Genus	: *Glossogobius*
Species	: *Glossogobius giuris*

Synonyms: Gobius giuris (original combination) Hamilton[9], Fishes of the Ganges. p. 51; *Euctenogobius striatus* (original combination), *Gobius giuris* Day[10], Fishes of India. p. 294

Glossogobius giuris[9] (new combination); Herre[11], Gobies of the Philippines and China Sea. Monogr. Bur. Sci. Manila. 23:1-352; Shaw and Shebbeare[12], Fishes of Northern Bengal. p. 114; Ahmed[13], Fish fauna of East Pakistan. Pakistan J. Zool. 1: 18-24; Nichols[14], The freshwater fishes of China. Natural History of Central Asia, Vol. IX. p. 322; Herre[15], Checklist of Philippines fishes. Res. Rep. U.S. Fish Wild. Serv., 20:977; Koumans[16], Fishes of the Indo-Australian Archipelago. 10:165; Munro[17], Marine and Freshwater fishes of Ceylon. p. 239; Inger and Kong[18], Fishes from North Borneo. p. 183; Bhuiyan[8], Fishes of Dacca. The Asiatic Soc. of Pak. Publication No. 13; Srivastava[19], Fishes of Eastern Uttar Pradesh, India. p. 142; Doha[20], Fishes of the district Mymensing and Tangail. Bangladesh J Zool. 1(1):1-10; Rahman[21], A check list of the freshwater bony fishes of Bangladesh. Riverine Fisheries Research Station, Chandpur. Bul. No. 1; Mohsin and Ambak[22], Freshwater fishes of Peninsular Malaysia. p. 284; Mauge[23], Gobiidae. pp. 358-388; Hoese[24], *Gobiidae*. pp. 774-807; Rahman[2], Freshwater fishes of Bangladesh. Published by Zoological Society of Bangladesh. p. 364; Kailola[25], The fishes of Papua New Guinea. vol. III. p. 153; Bhuiyan, *et al.*[26], A checklist of the fishes of Rajshahi. The Rajshahi University Studies, Part-B, Vol. XX. pp. 287-306; Devi[27], Gobioids of Ennore estuary and its vicinity. *Rec. Zool. Surv. India*. 90:161-189; Talwar and Jhingran[28], Inland fishes of India and adjacent countries. Vol. 2. p. 592; Skelton[29], A complete guide to the freshwater fishes of southern Africa. p. 388; Stiassny and Raminosoa[30], The fishes of the inland waters of Madagascar. pp. 133-148; Rao[31], Pisces. In "The fauna of Chilka Lake". p. 673; Rainboth[32], Fishes of the Cambodian Mekong. FAO[33], Species identification field guides for fishery purposes. p. 262.

Diagnostic characters of *G. giuris* (external morphology): Body elongated, anteriorly cylindrical, posteriorly compressed. Head pointed depressed, lower jaw longer. Maxilla extends to bellow anterior part of eye. Lips thick, teeth villiform in jaws, outer and inner rows enlarged caninoid in front in both jaws. Tongue bilobate. Some longitudinal mucous canals on cheek. Head 3.0-3.4 in standard, 3.8-4.2 in total length. Height 5.0-6.2 in standard, 6.3-7.6 in total length. Eyes 4.5-9.0 in head; snout 1.5-3.0; inter-orbital 0.5-2.0. Eyes larger in younger specimens[24].

Scales on upper part of head, upper parts of cheek, breast and belly ctenoid. 31-34 along lateral line, 25-30 rows before base of dorsal. Dorsal fins close together. First dorsal fin lowers than body. Second dorsal and anal pointed posteriorly. Pectoral fin as long as or longer than head excluding snout. Pelvics united forming a sucking disc. Caudal pointed or somewhat rounded.

Colour olive green to blackish green above, lighter below. Body with 2 alternating rows of 4-6 dark blotches. Fins yellowish green, spotted with dark edges. In estuaries and freshwater throughout Bangladesh said to attain up to 350 mm in length in Bangladesh but in the present collection it is only 285 mm in total length. Maximum length recorded by several authors are 450 mm[10]; 300 mm[8], 292 mm[2].

Habitat and distribution of *G. giuris*: The *Glossogobius giuris* (Hamilton) is widely distributed in the freshwater and estuaries of Bangladesh, India, Pakistan, Burma and Fareast[8,19]. In Bangladesh it is commonly found in the rivers, estuaries, haors, baors, beels, ponds and swamps[6]. It has a very wide distribution throughout the world. In central Australia it is only found in the Georgina River where it appears to be common[34,35]. It is found mainly in freshwater and estuaries, but it also enters the sea[28]; occurs in clear to turbid streams with rock, gravel or sand bottoms[32,36]. This species is probably found in all types of freshwater, occurring in a very wide variety of freshwater habitats from lowland ponds to torrential mountain streams[32]. This wide spread distribution is also found from Africa to Oceania: Red Sea and East Africa and most inland freshwater bodies over the Indian Ocean and western Pacific[37-39] and it is not found in IUCN Red list[40].

Food and feeding habit: Like all organisms, fishes require energy to fuel their body machinery and processes,

including growth, metabolism and reproduction[41]. The regularity must suit the fish ability to find and ingest food and to store energy. For some, feeding is almost continuous, for ones feeding is in seasonal; but for most animals feeding is the dominant activities of their lives because their need is constant and their food is usually scarce[42]. As a consequence, information about the nutritional requirements of fish species is far from complete and there are few species for which the requirement has been defined for all life history stages[43].

Fishes can be classified broadly on the basis of their feeding habits as detritivorous, herbivorous, carnivorous and omnivorous. A majority of fishes are euryphagous and carnivorous having a mixed diet[41]. The feeding behaviour of fishes is as diverse as their morphology, which more often reflects their general method of feeding. However, while most fishes are specialized in their feeding to a greater or lesser degree, their actual diet at any given time depends on the availability of both typical and atypical food items, as well as on the presence of potentially competing fish species. Often the feeding mode and food types are associated with the body forms and digestive apparatus. For example, longer guts with greater surface are as typify species that feed on detritus and algae and take in a high percentage of indigestible materials such as sand, mud or cellulose. In contrast, carnivorous species tend to have shorter gut lengths. Das and Moitra[44] stated to infer the general nature of food of a fish of its functional morphology of alimentary system among the Indian fishes of the Uttar Pradesh as herbivorous, carnivorous and omnivorous. Kramer and Bryant[45] examined the diets and measured the gut lengths of 21 fish species from the forest streams of Panama. Some works are available on the relationship between dietary habits and gut length-body length of fishes[46-52]. But very little information is available on dietary habit in relation to the morphological variation.

Food and feeding habits of fishes vary from species to species even within the species in different stages of its life cycle. Mookerjee *et al.*[53] reported on the food and its percentage composition of the common adult food fishes of Bengal. Hynes[46] pointed out different methods of food analysis for fishes and stated that if a large number of guts are analysed for food study, results obtained by occurrence, dominance and points methods are approximately the same. Pillay[47] made a critical review of different methods of food analysis of fishes. He stated that the best way of examination for food and feeding habit of fish is gut contents. In certain fishes, the food of the juveniles may be very much different from that of the adults. Alikunhi *et al.*[54] found that the main food of the adult *G. giuris* was fish and that of the juveniles, aquatic insects and their larvae. Bhowmick[55] reported that crustaceans formed the major food of the juveniles while the most preferred food of the adult gobi was fish. Marquez[56] also reported the same from Laguna de Bay. Doha[6] gave an information on food and feeding habit of freshwater gobi and stated that young, juvenile and adults are different in feeding habit.

Obviously, the feeding behavior of fishes is influenced by many factors, including characteristics of the environment, the predators and the prey[41]. David and Rajagopal[57] described the food and feeding habits of different commercial fishes and stated that during rainy season submerged vegetation offers masses of decaying food of the fishes. Grasses and their seeds and the terrestrial insects formed important food items of several fishes. Dewan and Saha[58] studied the seasonal pattern of feeding habit of *Tilapia nilotica* and found the seasonal variation in feeding activity. The feeding activity was higher in summer than in winter. Mustafa *et al.*[59] observed the same in *Colisa fasciata*. Kurian and Inasu[60] described the variation of food and feeding habit of *Horabagrus brachysoma* from ponds, paddy fields and the rivers. Some observations are available on food and feeding habit of different species from the river Padma[52,61-65].

Cannibalism I. e. feeding of an animal on its own individuals is a frequent occurrence among carnivorous fishes. Cannibalistic habit has been shown in different fishes such as *Anabas testudimeus, Heteropneustes fossilis, Clarias batrachus, Notopterus chitala, Wallago attu* etc.[66]; *Channa punctatus*[67]. Cannibalism has frequently been observed in the freshwater gobi *Glossogobius giuris* when the young ones were abundant[6,68,69]. Alikunhi *et al.*[54], Bhowmick[55] and Doha[6] reported the cannibalistic habit of adult *G. giuris* but they did not show any relationship of cannibalism in relation to its size and sex.

Reproductive biology: Fishes have a fascinating array of reproductive behaviour patterns. Not surprisingly, such behaviour is highly adaptive and is strongly correlated with the overall ecology of each species and with its morphological adaptations. Environmental parameters i.e. day length, temperature, turbidity, availability and nature of food, inter-specific and intra-specific social relations may influence the nature and patterns of reproduction and developmental behaviour[70]. It is thus possible to construct a classification of fishes based on their methods of reproduction and the means by which fish protect their developing embryos and young[71,72]. In this system, Moyle and Cech[41] categorised fishes as (i) Non-guarders (ii) Guarders and (iii) Bearers based on spawning habits.

According to Stephenson[73] the habitants of the tropical fishes can be classified as, (i) continuous breeder (ii) discontinuous breeder (iii) annual breeder and (iv) breeders-which breed more than once a year.

General pattern of reproduction in fishes: The reproductive strategies of fishes are often reflected in the anatomical differences between the sexes. Internally, of course, the sexes of most fishes can be easily distinguished by examination of the gonads, at least during the spawning season. While the internal differences between the sexes are generally obvious in mature fish, it is frequently difficult to distinguish the sexes externally. Indeed, many fishes show virtually no sexual dimorphism or dichromatism[41] but in most fishes with sexual differences in size, it is the female that is larger or at least achieves a larger size. Among the live-bearing fishes, females are larger than males. Doha[6] observed sexual dimorphism in *G. giuris* and the fish showed sexual dimorphism after attaining a total length of 60mm. The males had straight, thin and pointed and females short, fleshy and circular genital papilla. The pelvic fins of the maturing and gravid females were darker in colour than those of the males during the breeding season.

Spawning mode and behaviour: The capacity of any given species to produce gametes is indicated by reproductive characteristics of that species, particularly the modes of gamete development and maturation[74]. These will determine the quantity of gametes that individuals of a species can produce. Spawning mode may also be of relevance if harvest requires, or utilizes, natural fertilization[75]. Maturation of gametes in the majority of teleosts is naturally followed by release of gametes to the water for fertilization via the behavioural act of spawning or in the much smaller number of internal fertilizing species by copulation. Spawning behaviour is cued by physical environmental factors, social interactions and in many species, sexual pheromones[76-79]. There are several broad patterns of spawning behaviour found in different fishes in different habitats, i.e. group spawning and pair spawning. A variation occurs in Pacific herring *Clupea harengus*, where group spawning occurs in large aggregations without pair formation but eggs are deposited onto macro-algae[80]. In species, which show pair spawning, spawning behaviour is characterized by some degree of mate selection and behavioural interaction (courtship and sexual display) before spawning. Pair spawning may be promiscuous, with a single fish spawning with more than one mate during a spawning episode. But each spawning action involves at least transitory pair interactions, i.e. single female-multiple male spawning of salmonids[81] and single male-multiple female spawning by some damsel fishes[82,83]. Alternatively, pair formation may be permanent (at least in terms of the current reproductive season)-a pattern shown by some Chichlids[84]. The above brief review highlights the variety of spawning modes and behaviour shown by the fish that is important both for identifying the essential requirements for spawning in the wild and on generating a facsimile of these essential features in the husbandry environment. In case of freshwater gobi, very little is known of its spawning mode and behaviour that means it is less important both in the capture and culture fishery[6,24,85].

Environment and age on reproduction: The activity of the endocrine system is cued by environmental variable to ensure that reproductive development, ovulation and spawning occur at the most appropriate time. Important physical cues are photoperiod and temperature which in temperate species, generally control overall reproductive development and final gamete maturation[86-88]. Changes in temperature and photoperiod may also operate to synchronize reproductive cycles in tropical species. Tropical and sub-tropical damsel-fishes show some reproductive seasonality in relation to day length[89] and short-term changes in temperature stimulate spawning episodes[90]. Water flow or level may be important in tropical freshwater species, particularly in areas where juvenile nursery areas are dependant on seasonal inundation[41]. Specific substratum may also be required for gamete maturation, ovulation and/or spawning to occur, ranging from aquatic vegetation in cyprinids[76] to rock surfaces in various cichlids[84,91].

The age of onset of reproduction is another factor that varies with sex, male typically mature at smaller sizes and younger ages than females. For both sexes, the age at first reproduction depends in good part on the nature of the environment in which the population of concern lives, as well as on the nature of the population itself. Where the environment is favourable for growth and favours high adult survival, fish will tend to delay reproduction; but if conditions are unfavourable, so that growth and adult survivable are low, reproduction tends to take place at a younger age[41,92]. A similar result has been reported by Alm[93] on the brown trout. Alikunhi *et al.*[54], Marquez[56], Bhowmick[55] and Doha[6] reported on sexual maturity of *G. giuris* but not clearly mentioned in relation to the age and environmental impact on this species. In a less predictable environment, natural selection favours females that reproduce as quickly as possible, because

the probability of survival from one year to the next is low. A similar pattern has been found for the number of young produced in different environments by live-bearing fish[94].

Reproductive periodicity: Several patterns of life cycle can be distinguished in the freshwater fishes of the Temperate Zone. The most common in annual life cycle with complete replacement of generations and breeding in early summer to early monsoon and most commonly occur in April to August. A large number of literatures are available on the biological works of fishes but very little on *G. giuris*. Thus, some of the allied references are mentioned below with particular season and pattern of life cycle. Alikunhi[95] made observations on the sexual maturity, fecundity, larval development and early growth of *Labeo bata*. Afroze and Hossain[96] studied the sexual maturity and spawning season of *Amblypharyngodon mola* and they observed that the breeding season of the fish extends from May and continue till October and August is the peak breeding season of *A. mola*. Parween *et al.*[97] observed that the *Esomus danricus* breeds from March to July with a peak in the month of May. Fatema *et al.*[98] observed the breeding periodicity of *Oxygaster bacaila* and suggested that *O. bacaila* breeds from April to August with peak in June and July. In case of *G. giuris*, the adult females contained mature eggs in their ovaries from March to June and November[6]. Hora[99] reported that *G. giuris* migrates to the sea for spawning, whereas, Alikunhi *et al.*[54] observed that it breeds both in impounded and running, fresh and salt waters. Willey[100] reported that the fish breeds during May to July in Ceylon (Sri Lanka). It perhaps, breeds throughout the year as adult females with mature eggs in their ovaries. *G. giuris* has a prolonged breeding season or probably breeds twice in a year after short gap of the two seasons. This is followed by Harry[101], Desai[102], Das [103], Mustafa *et al.*[104], Bhuiyan and Islam[105], Hossain *et al.*[106], Haque and Hossain[107], Bhuiyan *et al.*[108].

Fecundity and sex ratios: Fecundity is one of the most common measure of reproductive potential in fishes, because it is a relatively easy measurement to make. It is the number of eggs in the ovaries of a female fish. In general, fecundity increase with the size of the female, with the relationship, F= aLb, where, F= fecundity, L= fish length and 'a' and 'b' are constants derived from the data[109]. With this relationship, larger fishes produce considerably more eggs than smaller fishes, both absolutely and relative to body size. There are many factors that complicate the interpretation of fecundity data, especially in relation to the investment of energy. Some of these complications are the relationship between fecundity and (i) fertility (ii) frequency of spawning (iii) parental care (iv) egg size (v) population density and (vi) environmental factors[109]. Rounsefell[110] found that with in the Salmonidae, river spawners produce larger eggs than lake spawners and in anadromous form, species with the longest freshwater stages produce the largest eggs, demonstration fine evolutionary "tuning" to the environment. Although the evolutionary adjustment of fecundity to environmental conditions (such as food supply) is important, equally important is the ability of fishes to adjust egg production on an annual basis in relation to environmental variation. When food is plentiful, there is plenty of energy available for investment in reproduction. As a result, well-fed fishes produce more and frequently larger eggs. Wooten[111] found that three-spine sticklebacks (*Gasterosteus aculeatus*) were exceptionally fecund in food-rich environments. Williams[112] argues that highly fecund fishes are capable of rapidly adjusting their populations to environmental changes.

The variations of fecundity is very common in fishes and the number of eggs produced by an individual female is dependant on various factors, like size, age, types of species of the samples and their ecological habitats including food availability[41,113]. A thorough knowledge of the fecundity of a fish is essential for evaluating the commercial potentialities of its stock, life history, practical culture and actual management of the fishery[75,114,115]. A large number of published literature are available on the fecundity of fishes but practically no work has been done on the fecundity of *G. giuris* in relation to its habitat. Bhowmick[55] and Doha[6] stated on the fecundity of *G. giuris*, which ranged from 10,760 to 29,580. It seems to be highly fecund freshwater fish. Other notable works on the breeding habit, reproductive periodicity, fecundity etc. of different fishes include those of Alikunhi[95], Thompson[116], Harry[101], Desai[102], Blake[117], Das[103], Bhuiyan and Rahman[118,119], Afroze and Hossain[120], Islam and Hossain [121]Banu *et al.* ,[122] Bhuiyan and Islam[105], Islam and Hossain[123], Bhuiyan *et al.*[124], Haque and Hossain[107], Alam *et al.* [125], Bhuiyan and Afrose[126] etc.

Biochemical composition and edible flesh contents: Fish is a high-grade foodstuff and constitutes an important part of an average Bangladesh diet. It is particularly valuable for providing proteins of high quality comparable to those of meat, milk and eggs. In our country, 80% of animal protein comes from fish[127] because meat, milk and eggs are not easily available to the people. Next to meat

fish is the only protein that contains all the essential amino acid in about right proportion called as complete protein. It is quite evident that the frequency of changes in the composition of biochemical constituents of biota varies not only with the environmental changes, but also with seasons[128-132]. Moreover, the changes of biochemical constituents have also been attributed to various physiological and other factors such as maturation, spawning, feeding etc[133,134].

Fish flesh contains four basic ingredients in varying proportions, such as water, protein, fat and ash; and other important nutrients substances like minerals and vitamins[135]. Generally, fish protein tends to be higher in lysine and lower in trytophan contents than meat. McCance and Widdowson[136] compared the essential amino-acid composition of egg, milk, meat and fish. Guha[137] worked on fish nutrients as human food and fish, which supply high-class protein compare to the other animal sources. The proximate composition of the flesh contents for the edible portion of the different fishes show a wide range of variation[135]. He has reported this variation as moisture 28-90%; protein 6-28%; fat 0.2-64% and ash, 0.4-1.5%.

Fish oil has generally more unsaturated fatty acids than animal fats. Since poly unsaturated fatty acids are beneficial in keeping down the cholesterol level of blood. Fish and fish oils are likely to be particularly useful in this regard[137]. On the basis of fat contents, Hardy and Keay[138] classified fishes into lean fish (less than 0.5% fat), semi-fatty fish (less than 2% fat) and fatty fish (more than 2% fat). Stansby[135] also categorized fishes in five groups on the basis of their fat and protein contents; these are low fat-high protein; medium fat-high protein; high fat-low protein; low fat-very high protein and low fat-low protein. Another type of variation in proximate composition occurs in the same species of fish, e.g. from the head to the tail or dorsal to the ventral or it may be a variation in composition of various types of tissue like light muscle and dark muscle or depute of fat areas. Stansby[135] revealed the causes of variation in proximate composition.

The importance of fats and oils are recorded both commercially and industrially all over the world, which is increasing day by day in a very long magnitude for both medicinal, dietary and other uses. The main constituent of fats and lipids are the fatty acids and glycerol. Fats and lipids are very wide spread in nature, being found in all vegetables and animal where they form as an essential part of the colloidal complex. They act as heat insulators and as reserve suppliers of energy in the animal body[138]. Krause and Mahan[139] has demonstrated the fat, oils and fat-like substances. They are insoluble in water but soluble in solvents, ether, chloroform, benzene and acetone. Fats are composed of carbon, hydrogen and oxygen but in proportions that greatly increase their energy value. Most of the natural lipids are composed of about 98 to 99% triglycerides and the vast majority of these are long chain triglycerides, one or two percent remaining include trace of mono and diglycerides, free fatty acids, phospholipids and unsaponifiable matter containing sterols.

Lipids such as the fats and oils represent the chief form in which excess nutrients are stored in the animal body. They serve as a concentrated source of energy and heat insulators. One gram of lipid supplies 9 calories, which is more than twice the amount of energy supplied by each gram of carbohydrate. Milroy[140] investigated the function of fat during the reproductive period of herrings. McCartney[141] tried to explain the attainment of sexual maturity in fish by analysing the differences of chemical composition of body muscles, blood and gonads. Johnstone[142] also worked out on the same species and determined the fat values in their body muscles. Jacobs[143] described the process of fat deposit in fish flesh. Borgstrom[144], Adhikari and Noor[145], Rubbi *et al.*[146] and Soldevilla[147] determined the differences of fat elements in different fishes in different season.

The assessment of the proximate moisture contents of the fish is not only important to know its nutritive value but also for its better processing and preservation. Lovern and Wood[148] measured the amount of moisture from the flesh of herrings and described its necessity. Thurston[149] determined the relationship between moisture-fat and moisture-protein of the Alaskan pink salmon. Malek *et al.*[150], Hardy and Keay[138], Gopalan *et al.*[151] and Soldevilla[147] worked out on the same and detected the fluctuation range due to some environmental, ecological and biological factors. Hellawell[5] indicated the water quality and ecological-environmental effects, which change the nutrient quality of an aquatic organism in several ways.

Fish is also a fairly good source of calcium and phosphorus, particularly small fishes which are eaten with bones are also a source of iron, trace elements like copper and a fair proportion of vitamins which is important for human beings[136]. Desnosier[152] published a brief report on the biochemical composition and food value of some fishes. Zafri and Ahmed[153] investigated the nature of vitamins of some fishes and Banu *et al.*[154] compared the mineral contents of edible portion of 19 freshwater fish species of Bangladesh.

Fishing methods and marketing of *G. giuris*: Bangladesh is blessed with water resources. There are four categories

of major fisheries resources in Bangladesh, these are i) inland open water (4.92 million ha); ii) inland closed water (0.36 million ha); iii) brakish water (0.141 million ha) and iv) marine water (16.61 million ha). Inland fisheries comprise rivers, estuaries, beels, floodplains, polders, ponds, ox-bow lakes, brakish water etc. In early sixties inland fisheries contributed about 90% of total fish production of the country. Fish production from aquaculture has increased to a great extent but inland open water fish production is in slow progress. Now only about 42% of total fish production comes from inland open water[3].

The UNDP conducted a massive survey in 1979 and reported that there are 1,54,082 acres of beels and haors, 89,000 acres of ponds and tanks, 4,28,800 acres of rivers and canals in Rajshahi division. The river Padma is one of the major inland open water resources in this division as well as the major natural resources for the capture fisheries in Bangladesh. The freshwater gobi, *G. giuris* occurs more frequently but it is of less economic importance due to of its smaller size. Doha[6] reported that the majority of the gobi fishes, being small in size, do not constitute an important fishery anywhere in Bangladesh. Of these, *G. giuris*, which attains about a foot in length, is notable, as it forms a fishery of some magnitude in the southern part of the country. Little attention has been paid to this fish in this country in the past because nobody catches it for paying special attention or particular intention.

Fishes are caught using a variety of gears and traps from the inland open water resources in our country. Some crafts are also essential to assure a good and effective fishing[155]. The fishing gears along with vessels, auxiliary equipment and fishers constitute the 'fishing unit'. Fishing gears used in Bangladesh are many and varied depends on tradition, nature of the water bodies, expected species and low cost but maximum exploitation with minimum efficiency of the gears[156]. A number of workers have studied the different aspects of fishing gears in several countries including the Indo-Pak sub continent. Willey[100] noted on the freshwater fishing of Ceylon; Ahmed[157] carried out a synopsis on fishing gears of East Pakistan; Van Brandt[158] worked on modern fishing gears of the world; Bhanot[159] investigated the common fishing methods in India; Rout *et al.*[160] studied on efficiency of gears for sampling and harvesting of bottom dwelling fish. Casselman *et al.*[161] and MacLennan[162] have reported the gear selectivity and fish sampling for monitoring fish assemblages in large riverine fishes; and more recently, Shrestha[163] investigated on the freshwater fishing implements and methods of Nepal. But there is no work on the fishing methods of riverine fishes in terms of a particular species (except *Hilsa ilisha*) in Bangladesh.

Marketing is the process of planning and executing the conception, pricing, promotion and distribution of ideas, goods, services to create exchanges that satisfy individual and organizational goals[164]. Marketing is typically seen as the task of creating, promoting and delivering goods and services[165]. Traditionally, a 'market' is a physical place where buyers and sellers gather to exchange goods. Sellers and buyers are connected by 4 flows; the sellers send goods to the market; in return they receive money and information; an exchange of money for goods and services and an exchange of information[165].

A large number of workers such as Ahmed[157], Chowdhury[166], Dutta[155], Bhuiyan[167] and Rokeya *et al.*[168] etc. have worked on fish marketing of several species or a group of fishes in Bangladesh. Karim[1] reported on the landing of exportable commercial fishes in Chittagong, Kohls[169] analysed marketing margin of middleman in fish market, Bucksimiar[170] described the problems of transportation and marketing of the marine fisheries products and their remedy. Sharker[171], Sabur and Rahman[172] worked on the marine fish marketing and their existing problems in Bangladesh with special emphasis on marketing cost analysis. Parween and Hossain[173], Hossain[174] reported the marketing system of prawns and small indigenous fishes. In the river Padma, fishing is made throughout the year and maximum fishes are sold in the local market, but no record is available on the catch estimation, catching method, landing, marketing channel or customer price of any species including the freshwater gobi, *G. giuris* from the river Padma.

Economic importance: 'Gobi' or 'goby' is from Latin '*gobius*', i.e., a fish of small value; gudgeon and from Greek '*Kobios*'[24] (http://www.fishbase.org). The majority of gobi fishes, being small constitute a small fishery in Bangladesh but *G. giuris* which attains about a foot in length, is notable as it forms a fishery of some magnitude in the southern part of the country. It is distributed widely in freshwater ponds, swamps, beels, rivers and estuaries[6]. In Bangladesh about 80% population is poor and they depend on small size fish for their daily supply of animal protein, as they are available at reasonable price[7]. Fish is the main source of animal protein in the diet of the people of Bangladesh because more than 80% of the animal protein in our diet comes from fish alone[127]. Next to meat fish is the only protein that contains all the essential aminoacids in about the right proportion and such called "complete protein". Ahmed *et al.*[175] reported on the biochemical composition of gobi fishes and showed as high protein-low fat in the flesh of *G. giuris*. The species, *G. giuris* is very important food fish due to its reasonable price and contains all the nutrients. The freshwater gobi,

G. giuris is treated as a minor commercial species for capture fishery[24]. Costa *et al.* [176]described some significant roles of small fish capture fisheries from Rajdhala beel in Netrakona district of Bangladesh. *G. giuris* contributes 1.93% of the total capture from Rajdhala beel as capture fishery. Some records are available for the marine fishes but no record of this species from any river in Bangladesh. In the present investigation *G. giuris* was found as 1.09% in an average of the total capture from the river Padma[177].

Among the freshwater fishes, next to carps, catfishes and snakeheads and *G. giuris* are widely used as food. *G. giuris* is semi-commercially important and very much abundant in the river Padma, Bangladesh. Freshwater fishes are suffering in many ways, such as decreasing population or disrupted reproductive behaviour or showing different abnormalities in their normal life cycle. The present review was on the freshwater gobi to study its biology, ecology, biochemical composition, abundance, fishing methods and marketing system. The findings will help the fishery scientists exploit and also to contribute to the future improvement of the present population stock of the fish through culture in the ponds and other small water bodies.

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