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Original Article

A study on the diversity, marketing and conservation status of different aquatic food fauna in Kokrajhar, Assam, India

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Abstract
Kokrajhar district of Assam in North-eastern India has several natural water resources that harness a variety of aquatic fauna. Understanding the aquatic biodiversity is vital for the sustainable development of fisheries and aquaculture expansion. The present study aims to record the diversity and marketing of aquatic food faunal resources in Kokrajhar, Assam. Surveys were conducted in three village markets and two town markets of Kokrajhar. Altogether, 64 finfish, 6 shellfish and 4 aquatic insect species were recorded. The abundant presence of diverse small indigenous fish species indicates the potential for the aquaculture expansion of these species in the region. Majority of the species (77%) were found to be Least Concern, whereas, 5, 3 and 1 species were Near Threatened, Vulnerable and Endangered respectively as per IUCN Redlist database. A higher demand and market price were observed for all locally captured species. This study has highlighted the rich aquatic food faunal biodiversity of Kokrajhar and the socio-economic condition of the local fishers. The information from this study may be useful in the sustainable development of fisheries and aquaculture in the region.

Keywords: aquatic insects; freshwater finfish; Kokrajhar; shellfish; *Tor putitora*

1 | INTRODUCTION

Freshwater aquatic biodiversity consists of phytoplankton, zooplankton, aquatic plants, insects, fish, birds, mammals and others (Kumbhar and Mhaske 2020; Verma and Prakash 2020). Biodiversity is ecologically very important since it ensures the ecological balance necessary for survival of all living organisms, sustainable development (Ashok 2019; Verma 2021) and its conservation is thus is a useful tool for managing clean up water and environment (Sirsat 2022). India, with its four global biodiversity hotspots, contributes a significant share to the world's biological resources. According to the National Bureau of Fish Genetic Resources (NBFGR), the country is home for rich diversity of 2508 indigenous finfish species which accounts for 7.8% of the global fin fish diversity. Apart from the finfish resources, 2934 species of crustaceans and 5070 molluscs also contribute to the rich aquatic germplasm resource of India (Jeena and Gopalakrishnan 2012). Many of these species are important source of nutrition and livelihood for the local population in and around the freshwater resources. Fisheries play important role by providing protein, nutrition, food security and various socio-economic opportunities (FAO 2020). Many shellfish species and aquatic insects form an essential part of traditional cuisines and ethnozoology in various cultures worldwide. Aquatic insects also play ecologically important roles as primary consumers, detritivores, predators and pollinators and hence regarded as bioindicators (Dijkstra *et al.* 2014). However, anthropogenic activities such as pollution, urbanisation, construc-

tion of dams etc. have induced severe stress on freshwater fish diversity (Verma 2016; Parvez *et al.* 2023) which may result in substantial losses of fish species diversity (Galib *et al.* 2018; Chakraborty *et al.* 2021; Prakash 2021). Hence, proper knowledge of species diversity may be vital for their conservation and sustainable development (Ghosh *et al.* 2002; Galib 2015). However, regional diversity and availability of fish may be reflected in local fish markets (Ullah *et al.* 2016) and could be important in places where direct sampling from the aquatic habitat is difficult. Therefore, studies on the fish markets are useful for understanding the availability of different fish species in various the seasons (Gomra *et al.* 2020).

Assam, with an area of 78438 km square, has rich water resources which includes 5.49 lakh hectares of beels (wetlands), rivers, ponds and low-lying water bodies and 5050 km of rivers including Brahmaputra, Barak and their tributaries (Das 2012; Gogoi *et al.* 2015). In Assam, the fishery sector provides employment to several people either directly by practising fish farming or indirectly by getting involved in associated activities such as marketing (Yadav *et al.* 2020). Not surprisingly about 90% of the population of Assam consumes fish (Yadav *et al.* 2020) which indicates the tremendous potential of this sector. The abundance of water resources in the region is one of the primary reasons for the rich diversity of fish species reported in the region. The state is one of the topmost producers of fish among the North-eastern states of India and during 2017–18, total fish production and import of the Kokrajhar district alone were estimated to be 6438 and 80 tonnes respectively (Debnath *et al.* 2020).

There are some reports on the diversity of ichthyofaunal resources of the beels and rivers of Assam (e.g. Deka and Dutta 2013; Bordoloi 2014; Chakraborty *et al.* 2016; Rahman *et al.* 2016; Nag *et al.* 2017; Talukdar and Rajbongshi 2018), but very few are available from Kokrajhar region of lower Assam (Chakraborty *et al.* 2016). Through an extensive literature survey, it was observed that no study is available on the availability and marketing aspects of the locally available aquatic food faunal resources of Kokrajhar district. Kokrajhar district of lower Assam is a region gifted with several beels like the Diplai, Dheer, and rivers like Gaurang, Ultapani, Samoka, Gongia, Swrmanga, Sankosh and Champabati which supports for a variety of aquatic food faunal species. Fish and fisheries play an important part in the culture, tradition, and indigenous food habit of the people of this region. Small scale fisheries play an important role in solving the issues of poverty, food security, and pro-poor growth (Bene 2006). The fishing activity in rural areas, apart from providing affordable nutrition also serves as a means for raising the socioeconomic status of the poor people to strengthen their livelihood. For sustainable utilisation of these resources and to devise appropriate planning for its conservation, it is essential to understand the species diversity and their conservation status. Therefore, this paper is an attempt to study the diversity, marketing and the conservation status of aquatic food fauna in the local markets of Kokrajhar, Assam.

2 | METHODOLOGY

2.1 Study area

The study was conducted in five markets located in and around the main town area of Kokrajhar district (Figure 1). Kokrajhar is the headquarter of Bodoland Territorial Region (BTR), Assam, and is located between 89°46′E and 90°38′E longitude and 26°19′N to 26°54′N latitude with an area of about 3169.22 square kilometres. The region is surrounded by the river Brahmaputra along the south, Bhutan on the north and West Bengal in the west. Kokrajhar is surrounded by stretches of lush green forest with several rivers such as Gaurang, Champawati, Gongia, Samoka and Swrmanga draining the region. It also has some popular beels like Diplai beel and Dheer beel which serves both as a natural source of aquatic food products for the local people, and also as a tourist site. Also known as a global centre of Bodo culture, the district is inhabited by several communities such as Bodo, Garo, Rajbongshi, Rabha, Bengali, Nepali and Santhali with the Bodos as the major group (Narzary *et al.* 2016). The total population was reported to be 886999 with 452965 males and 434034 females with a sex ratio of 958 females per 1000 males as per Government of India Census, 2011. Agriculture and allied activities remain the major economic activity in the region with 80% of the population directly engaged in agricultural activities.

2.2 Survey sites

Five local fish markets in the Kokrajhar area were selected for the study (Figure 1). These were Boro Bazaar (26°33.984′N, 90°16.193′E) and Maldangpara Bazaar (26°24.846′N, 90°16.579′E) in the Kokrajhar town area, and three markets in the village areas *viz.* Lahoti Bazaar (26°35.444′N, 90°21.846′E), Kangkhila Bada Bazaar (26°30.113′N, 90°19.056′E) and Bishmuri Bazaar (26°33.585′N, 90°17.558′E). Boro Bazaar and Maldangpara Bazaar were surveyed in the morning between 0700 to 1100 hours, whereas Lahoti Bazaar, Kangkhila Bada Bazaar and Bishmuri Bazaar were surveyed in the afternoon between 1600 and 1800 hours. The survey timings were selected based on the market timings and maximum availability of fish sellers and retailers in these respective markets.

2.3 Sample survey and data collection

The sampling survey was conducted twice per month from July 2021 to January 2022. The different types of finfish, shellfish and insect species observed in the different markets were recorded and photographed (Salim *et al.* 2021). Information on the common local name was

also recorded for use in identification later. Sample specimens of species were also preserved in 10% formalin to confirm their identity using standard references (Vishwanath 2017; Chanda *et al.* 2018; Froese and Pauly 2022). Data regarding the cost price, availability, sources and marketing method of all the recorded aquatic food faunal resources were also recorded from the fish sellers and retailers through personal interviews involving structured and unstructured questionnaires. The respondents were asked to give information on the source or origin of the species (from local areas or from outside the study area). The IUCN conservation status of all the species recorded were determined from the IUCN red list data (IUCN 2022). All the species were grouped under six categories *viz.*, LC = least concerned; VU = Vulnerable; DD = Data deficient; NE = Not Evaluated; NT = Near threatened and EN = Endangered, according to the information provided by the IUCN Red List data.

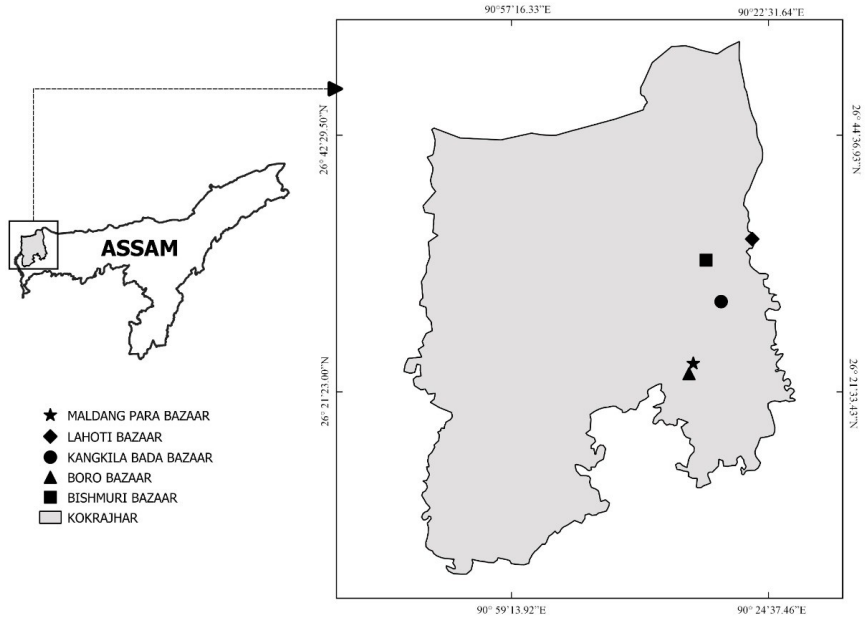

FIGURE 1 Map showing the study area and location of the five markets in Kokrajhar, Assam, India.

2.4 Demographic socio-economic data

The respondent's demographical data such as age, sex, education, family size, community and income were collected from the local fish retailers and sellers in all the markets following standard methods (Islam *et al.* 2013; Verma *et al.* 2015; Roy *et al.* 2017). Before participation, the respondents were informed about the study and the use of their data, and all of them gave their consent for participation and use of the data generated from the study. All the data collected were organised, tabulated, analysed and presented in tables and graphs using the Microsoft Office Excel 2007.

3 | RESULTS

3.1 Aquatic food faunal species

A total of 74 species of aquatic fauna (64 finfish, 6 shellfish and 4 insect species) were recorded in the study from the five different markets. Table 1 depicts the scientific name, local vernacular name (Bodo), order, family and IUCN conservation status of the different species recorded in the study. It was observed that the local beels like the Diplai and Dheer beels were the main source of most of the aquatic food fauna in all the markets. The other sources include rivers like the Sangkosh and Brahmaputra, small local wetlands, and local ponds of Kokrajhar and nearby districts such as Barpeta and Bilashipara.

3.1.1 Fish species

Among all the recorded species, maximum diversity was recorded for fish (64 species, 24 families in 12 different orders) indicating the rich diversity of fish in the region. Order Cypriniformes represented the maximum diversity of fish species with 32 species including 28, 3 and 1 species belonging to Cyprinidae, Cobitidae and Botidae respectively. Orders Siluriformes and Perciformes accounted for 10 and 8 species respectively. Four species were recorded from order Synbranchiformes followed by Anabantiformes and Osteoglossiformes having two species each. Single species were recorded from each of the orders Characiformes (*Piaractus brachypomus*), Clupeiformes (*Hilsa ilisha*), Gobiformes (*Glossogobius giuris*), Anguilliformes (*Anguilla bengalensis*) and Tetraodontiformes (*Leiodon cutcutia*).

The list of fish includes common species like the major carps (*Cyprinus carpio*, *Labeo rohita*, *Cirrhinus cirrhosus*), minor carps and small indigenous fish species (SIFs) like *Botia dario*, *Lepidocephalichthys guntea*, *Amblypharyngodon mola*, *Danio rerio*, *Esomus dandrica*, *Channa gachua* and *Channa punctatus*. Both endemic and exotic fish species were found in all the markets surveyed, but the village markets were observed to have more endemic species, mostly the SIFs. Some cold-water indigenous carps like the *Tor putitora*, *Garra lamta* etc. were

also recorded in the study. Order Siluriformes recorded ten species belonging to seven families showing the presence of different types of catfish in the region. The different catfish species recorded were *Wallago attu* and *Ompok pabda* (Siluridae), *Clarius batrachus* (Claridae), *Mystus tengara*, *Mystus vittatus*, *Amblyceps apangi* and *Sperata seenghala* (Bagridae), *Heteropneustes fossilis* (Heteropnuestidae), *Chaca chaca* (Chacadae) and *Pangasius pangasius* (Pangasiidae). All of the recorded fish species were reported to be obtained from local resources like beels, rivers, wetlands and local culture ponds from Kokrajhar except *H. ilisha* and *P. pangasius* which is reported to be imported from nearby states and also from Uzan Bazaar Landing Centre, Guwahati, Assam located at the bank of river Brahmaputra.

TABLE 1 List of different food fish, shellfish and aquatic insect species recorded in the five different markets of Kokrajhar, Assam, India.

Order	Family	Species	Local Name	IUCN status
Finfish				
Cypriniformes	Cobitidae	*Lepidocephalichthys thermalis*	Bwtia	LC
		Canthophyrs gongota	Goget	LC
		Lepidocephalichthys guntea	Bwtia	LC
	Botidae	*Botia dario*	Agor bwtia	LC
	Cyprinidae	*Esomus danrica*	Maowa	LC
		Rasbora daniconius	Maowa	LC
		Pethia ticto	Pitikri	LC
		Pethia conchonius	Pitikri	LC
		Puntius sophore	Pitikri	LC
		Systomus sarana	Kwti	LC
		Danio rerio	Agor maowa	LC
		Catla catla	Catla	LC
		Cirrhinus cirrhosus	Mirka	VU
		Hypophthalmichthys nobilis	Big head	DD
		Amblypharyngodon mola	Moha	LC
		Cyprinus carpio	Common carp	VU
		Hypophthalmichthys molitrix	Silver	NT
		Labeo rohita	Rohu	LC
		Labeo bata	Bata	LC
		Ctenopharyngodon idella	Grass carp	NE
		Opsarius barna	Na gwlao	LC
		Labeo boga	Lengsa	LC
		Tor putitora	Kantashi	EN
		Garra annandalei	Na kanda	LC
		Garra lamta	Soltoka	LC
		Psilarhynchus homaloptera	Ontaibajab	LC
		Danio devario	Eleng	LC
		Labeo calbasu	Bouse	LC
		Labeo gonius	Kuria	LC
		Chagunius chagunio	Purkaita	LC
		Bangana dero	Bengana	LC
		Raiamas bola	Na daoka	LC
Siluriformes	Claridae	*Clarius batrachus*	Magur	LC
	Bagridae	*Mystus tengara*	Tengwna	LC
		Mystus vitatus	Tengwna	LC
		Amblyceps apangi	Taraigazli	LC
		Sperata seenghala	Ari	LC
	Siluridae	*Wallago attu*	Barli	VU
		Ompok pabda	Pabda	NT
	Heteropneustidae	*Heteropneustes fossilis*	Sengi	LC
	Chacadae	*Chaca chaca*	Gandagageb	LC

TABLE 1 Continued.

Order	Family	Species	Local Name	IUCN status
Siluriformes	Pangasiidae	*Pangasius pangasius*	Fangkas	LC
Perciformes	Channidae	*Channa punctatus*	Gwri	LC
		Channa gachua	Nisla	LC
		Channa marulius	Sal	LC
	Anabantidae	*Anabas testudineus*	Khaoi	LC
	Nandidae	*Nandus nandus*	Tota	LC
	Ambassidae	*Chanda nama*	Chandanga	LC
		Parambassis lala	Chandanga	NT
	Badidae	*Badis badis*	Dusumai	LC
Synbranchioformes	Mastacembelidae	*Macrognathus pancalus*	Turi	LC
		Macrognathus aral	Turi	LC
		Mastacembelus armatus	Bami	LC
	Synbranchidae	*Monopterus cuchia*	Kusia	LC
Beloniformes	Belonidae	*Xenentodon cancila*	Khangkila	LC
Osteoglossiformes	Notopteridae	*Notopterus notopterus*	Pwila	LC
		Chitala chitala	Chital	NT
Characiformes	Characidae	*Piaractus brachypomus*	Rupchanda	NE
Clupeiformes	Clupeidae	*Hilsa ilisha*	Elish	LC
Gobiformes	Gobiidae	*Glossogobius giuris*	Hasumutra	LC
Anguilliformes	Anguillidae	*Anguilla bengalensis*	Nangdor	NT
Anabantiformes	Osphronemidae	*Trichogaster lalius*	Pwrlagor	LC
		Trichogaster fasciata	Bengshi	LC
Tetradontiformes	Tetraodontidae	*Leiodon cutcutia*	Gangatopa	LC
Shellfish				
Decapoda	Palemonidae	*Macrobrachium rosenbergii*	Natur	LC
	Penaeidae	*Penaeus indicus*	Natur	NE
	Gecarcinucidae	*Sartoriana trilobata*	Kangkrai	DD
Gastropoda	Ampullaridae	*Pila globosa*	Samo ladai	LC
	Viviparidae	*Bellamya bengalensis*	Samo dahwnai	LC
	Pachychilidae	*Brotia costula*	Samo gwlao	LC
Aquatic insects				
Hemiptera	Belostomatidae	*Lethocerus indicus*	Gangjema	LC
Coleoptera	Hydrophilidae	*Hydrophilus triangularis*	Singkaori	NE
		Hydrophilus ovatus	Singkaori	NE
	Dytiscidae	*Cybister tripunctatus*	Singkaori	NE

LC, Least Concern; VU, Vulnerable; DD, Data Deficient; NE, Not Evaluated; NT, Near Threatened; EN, Endangered.

3.1.2 Shellfish species

Six different species of freshwater shellfish belonging to two different orders were recorded in our study. These were reported to be procured from local aquatic bodies such as wetlands, beels, small streams and rivers except for *Macrobrachium rosenbergii* which is reported to be imported from commercial culturing ponds of nearby district Nalbari, Nagaon, and also from neighbouring states. Two species were recorded from order Decapoda viz., *Penaeus indicus*, *Sartoriana trilobata* (Decapoda), whereas *Pila globosa*, *Bellamya bengalensis* and *Brotia costula* were from order Gastropoda.

3.1.3 Aquatic insects species

Four aquatic insect species belonging to three families under two different orders were recorded during the survey. These were *Lethocerus indicus* (Hemiptera), *Hydrophilus triangularis*, *Hydrophilus ovatus* and *Cybister tripunctatus* (Coleoptera). All the aquatic insects were reported to be obtained from local aquatic bodies like beels, ponds, waterlogged paddy fields, small streams and rivers.

3.2 IUCN conservation status

The IUCN conservation status of the recorded species was

also evaluated (Table 1). It was observed that 57 species belonged to Least Concern, while 6, 5 and 3 and were found to be in the Not Evaluated, Near Threatened and Vulnerable categories respectively. Only one species (*T. putitora*) was recorded as Endangered, while two species was recorded as Data Deficient. It was observed that 77.1% of all the recorded species belong to Least Concern and 8.1% to Not Evaluated category. However, 6.7, 4.1, 2.7 and 1.3% of all the species were found to belong to Near Threatened, Vulnerable, Data Deficient and Endangered category respectively.

3.3 Market price and availability

The market price in all the surveyed market was found to vary with factors such as demand, condition of the fish and seasonal availability. It was observed that *A. bengalensis* (Anguillidae) was the most expensive fish with a price range of Indian Rupees (INR) 600 – 720 kg^{-1} followed by *C. batrachus* priced at INR 480 – 600 kg^{-1} and *M. cuchia* (Synbranchidae) and *H. fossilis* (Heteropneustidae) with a price range of INR 440 – 520 kg^{-1} (Table 2). The lowest market price was recorded for *E. danrica*, *P. ticto* and *L. rohita* (Cyprinidae), *P. pangasius* (Pangasiidae) and *Piaractus brachypomus* (Garacidae) which were all sold for INR 200 – 240 kg^{-1}. The decapods *M. rosenbergii* and *P. indicus* were sold for INR 400 – 480 kg^{-1} and INR 360 – 400 kg^{-1} respectively. Locally available *S. trilobata* were priced in the range INR 100 – 160 kg^{-1}. Edible gastropods *B. bengalensis* and *B. costula* were priced at INR 20 – 60 kg^{-1} whereas *P. globose* (shells removed) were sold by local women retailers for the price of INR 240 – 400 kg^{-1}. Three out of the four aquatic insects (*L. indicus*, *H. triangularis* and *H. ovatus*) recorded in village markets, were found to be priced at INR 200 – 500 kg^{-1}, whereas *C. tripunctatus* was found to be priced at INR 240 – 500 kg^{-1}.

Maldangpara Bazaar in comparison to other markets had the highest market price for all the available aquatic food faunal species (Table 2). Three species of shellfish belonging to Gastropoda *viz. P. globosa* (shells removed), *B. bengalensis* (with and without shell) and *B. costula* (with and without shell) were exclusively available in the village markets only. Very few retailers were observed selling imported fish in all the village markets, and they were mostly seen selling species such as *L. rohita*, *P. brachypomus* and *P. pangasius*, which were ice-preserved.

Throughout the survey, it was found that the maximum catch of majority fish species was obtained during the December to April. The fluctuation in the market price of all the species was between a minimum of INR 10 and a maximum of INR 200 across all species during the study period. Customer demand for most of the species was recorded to be high except for some locally available species such as *E. danrica*, *P. ticto*, *P. conchonius*, *Parambassis lala*, *A. mola*, *C. nama*, *D. rerio*, *Badis badis*, *L. cutcutia* and *T. lalius*. The respondents also reported a lower demand for the fish species that are cold stored/preserved for longer periods. Maldangpara Bazaar in comparison to other markets had the highest market price for all the available aquatic species.

3.4 Demographic data of respondents

The total number of respondents that participated in the survey was 86 out of which 28, 10, 14, 17 and 17 participated from Boro Bazaar, Maldangpara Bazaar, Lahoti Bazaar, Kangkhila Bada Bazaar and Bishmuri Bazaar respectively (Table 3). Among all the markets surveyed, Boro Bazaar showed maximum number of male fish retailers, belonging to different religions and age groups. Equal numbers of male and female retailers were observed in Maldangpara Bazaar, whereas Lahoti Bazaar, Khangkilabada Bazaar and Bishmuri Bazaar showed a higher number of female retailers selling locally captured fishes and shellfish. In the village markets, the majority of fish retailers belonged to Bodo and Santhali communities (33.3 and 66.6% respectively). However, in the markets of Kokrajhar town area, the majority of the retailer belonged to the Bengali community (63.2%) followed by Bodo and Assamese (28.9 and 7.9% respectively). No retailers belonging to Santhal community were observed in the town markets. The Bengali Muslim community was observed as the largest group of fish retailers in the Boro Bazaar. It was observed that in the town markets, Bengali retailers were mostly associated with the business of those fish that were procured from outside states. Whereas, those captured from local beels and rivers were sold by the Muslim retailers.

In all the markets it was observed that all the respondents were educated at least up to the primary school level. However, the majority were found to have attended upper primary or high school education (53.4%). Only 9.4% of respondents were graduates or of higher qualification, majority of which were encountered in main town markets. A majority (58.1%) of the respondent had five or lesser children whereas, 30.2% and 11.6% of respondents reported having 6 – 10 and above 10 children respectively. Most of the retailers (79.1%) were found to sell up to 10 kg of fish and shellfish per day, while another 20.9% reported selling above 10 kg day^{-1}. This trend was similar in all the markets surveyed. The income generated varied from INR 200 – 1000 day^{-1}. Overall, it was observed that 40.7 and 34.9% of the respondents reported an income generation of about INR 200 – 500 and above INR 500 day^{-1} respectively.

Participation of women retailers in all the surveyed markets was noticeable with an overall representation of 44.2% of all the respondents in the study which indicates almost equal involvement of female retailers in all the markets except Boro Bazaar. Records from all the village markets surveyed *viz.* Lahoti Bazaar, Khangkilabada Ba-

zaar and Bishmuri Bazaar revealed a maximum number of female retailers (57 – 71%) selling locally captured fishes and shellfish. A unique feature of the village markets was that three species of shellfish belonging to Gastropoda *viz. P. globosa* (without shell), *B. bengalensis* (with and without shell) and *B. costula* (with and without shell) were sold exclusively by the women retailers only.

TABLE 2 The variation in the market price of the different species recorded at different markets in the study.

Species	Consumer demand	Most catch	Market-wise price per kg (in INR)				
			LH	KB	BMB	MB	BB
Lepidocephalichthys thermalis	H	Dec- Apr	280	280	280	400	280
Canthophyrs gongota	H	Dec- Apr	400	400	400	-	-
Lepidocephalichthys guntea	H	Dec- Apr	280	280	280	400	280
Botia dario	H	Dec- Apr	280	280	280	-	280
Esomus danrica	L	Apr-Aug	240	240	240	280	200
Rasbora daniconius	L	Apr- Aug	240	240	240	280	200
Pethia ticto	L	Dec-Apr	240	240	240	280	200
Pethia conchonius	L	Dec-Apr	240	240	240	280	200
Puntius sophore	M	Dec-Apr	240	240	240	280	240
Systomus sarana	H	Dec-Apr	400	400	400	550	-
Danio rerio	L	Apr-Aug	200	200	200	280	200
Catla catla	H	Dec-Apr	320	320	320	360	320
Cirrhinus cirrhosus	M	Dec-Apr	280	280	280	280	240
Hypopthalmichthys nobilis	M	Dec-Apr	320	320	320	320	280
Amblypharyngodon mola	L	Apr-Aug	200	240	240	280	200
Cyprinus carpio	H	Dec-Apr	320	320	320	320	280
Hypophthalmichthys molitrix	M	Dec-Apr	320	320	400	320	280
Labeo rohita	M	Dec-Apr	240	240	240	240	200
Labeo bata	M	Dec-Apr	240	240	240	240	200
Ctenopharyngodon idella	H	Dec-Apr	320	320	320	320	280
Opsarius barna	H	Dec-Apr	400	400	400	-	-
Labeo boga	H	Dec-Apr	400	400	400	-	-
Tor putitora	H	Dec-Apr	400	400	400	-	-
Garra annandalei	H	Dec-Apr	400	400	400	-	-
Garra lamta	H	Dec-Apr	400	400	400	-	-
Psilarhynchus homaloptera	H	Dec-Apr	400	400	400	-	-
Danio devario	L	Dec-Apr	240	240	240	-	-
Labeo calbasu	H	Dec-Apr	400	400	400	-	-
Labeo gonius	M	Dec-Apr	400	400	400	-	-
Chagunius chagunio	M	Dec-Apr	400	400	400	500	-
Bangana dero	M	Dec-Apr	400	400	400	500	-
Raiamas bola	H	Dec-Apr	400	400	400	550	-
Wallago attu	H	Dec-Apr	400	400	400	480	320
Clarius batrachus	H	Dec-Apr	480	480	480	600	480
Mystus tengara	M	Aug-Nov	320	360	360	400	280
Mystus vitatus	M	Aug-Nov	-	-	-	400	280
Amblyceps apangi	H	Dec-Apr	280	280	280	-	-
Sperata seenghala	M	Dec-Apr	-	-	-	400	320
Ompok pabda	M	Dec-Apr	-	-	-	520	440
Heteropneustes fossilis	H	Dec-Apr	440	480	480	520	440
Chaca chaca	H	Dec-Apr	400	400	400	400	320
Pangasius pangasius	M	Dec-Apr	240	240	240	240	200
Channa punctatus	M	Aug- Nov	280	320	320	400	240
Chana gachua	M	Aug-Nov	280	320	320	400	240
Channa marulius	M	Aug-Nov	400	480	480	520	400
Anabas testudineus	H	Dec-Apr	360	400	400	480	320

TABLE 2 Continued.

Nandus nandus	H	Apr-Aug	240	360	360	480	280
Chanda nama	L	Apr-Aug	240	280	280	320	200
Parambassis lala	L	Apr-Aug	240	280	280	320	200
Badis badis	L	Apr-Aug	200	200	200	280	200
Macrognathus pancalus	H	Aug-Nov	320	360	360	480	320
Macrognathus aral	H	Dec-Apr	400	400	400	460	360
Mastacembelus armatus	H	Dec-Apr	400	400	400	460	360
Monopterus cuchia	H	Dec-Apr	400	480	480	520	400
Xenentodon cancila	H	Apr-Aug	280	320	320	400	240
Notopterus notopterus	H	Dec-Apr	-	-	-	320	280
Chitala chitala	H	Dec- Apr	-	-	-	-	400
Piratus brachypomus	M	Dec-Apr	240	240	240	240	200
Hilsa ilisha	M	Dec-Apr	-	-	-	-	480
Glossogobius giuris	M	Dec-Apr	280	280	280	320	280
Anguilla bengalensis	H	Dec-Apr	640	640	640	720	600
Trichogaster lalius	H	Dec-Apr	280	320	320	320	360
Trichogaster fasciata	H	Dec-Apr	280	320	320	320	360
Leiodon cutcutia	L	Apr-Aug	-	-	-	-	240
Shellfishes							
Macrobrachium rosenbergii	M	Dec-Apr	-	-	-	480	400
Fenneropenaeus indicus	M	Dec-Apr	-	-	-	400	360
Sartoriana trilobata	M	Apr-Aug	100	100	100	160	-
Pila globosa (without shell)	H	Apr-Oct	240	240	240	400	400
Bellamaya bengalensis	M	Apr-Oct	20	20	20	60	60
Brotia costula	M	Apr-Oct	20	20	20	60	60
Insects							
Hydrophilus ovatus	H	Dec-Apr	200	200	200	500	-
Cybister tripunctatus	H	Dec-Apr	200	200	200	500	-
Hydrophilus triangularis	H	Dec-Apr	200	200	200	500	-
Lethocerus indicus	H	Dec-Apr	240	240	240	500	-

LH = Lahoti Bazaar, KB = Khangkilabada Bazaar, BMB = Bishmur Bazaari, MB = Maldangpara Bazaar, BB = Boro Bazaar. L = Low demand; H = High demand; M = Medium demand. INR = Indian Rupees, 1 USD (US Dollar) = 82.33 INR (as on 18 Jan 2023).

4 | DISCUSSION

4.1. Finfish species diversity

Northeast India which falls under the eastern Himalayan region is globally considered one of the hotspots for freshwater biodiversity (Borah and Das 2020). Local fish and vegetable markets are considered to represent the rich biodiversity of flora and fauna of a region. The present study on the five local markets of the Kokrajhar region has highlighted the important aquatic fauna of the region which are available in these markets for consumption. Similar studies on market surveys to assess the diversity of fish and shellfish species have been reported in many studies earlier. Salim *et al.* (2021) studied the fish species diversity by surveying 21 fish markets of Andhra Pradesh and 7 fish markets of Telengana and found that 25 species were traded in the selected markets of Telengana and 22 species from Andhra Pradesh. Similarly, Gomra *et al.* (2020) also studied fish diversity and availability in different parts of Northern India (Gummat fish market, Jammu Division; Bilaspur fish market, Himachal Pradesh; Amritsar fish market, Punjab) by surveying markets in the study area. This study has revealed the diversity of finfish in the region as 64 species of fish were available in the markets surveyed. This agrees with some earlier reports where the diversity of fish in the region was reported (Chakraborty *et al.* 2016; Singha *et al.* 2017). All the markets under the present study showed a diversity of fish species, and maximum diversity was observed in order Cypriniformes. Order Cypriniformes is one of the most diverse fish species (Chakraborty *et al.* 2016) and many studies have recorded similar high diversity of the order in India (Deka and Dutta 2013; Bordoloi 2014; Bordoloi and Hazarika 2015; Nag *et al.* 2017; Borah and Das 2020) and abroad (Chaki *et al.* 2014; Altaf *et al.* 2015; Muhammad *et al.* 2017). In the present study, it was observed that the family Cyprinidae recorded the highest number of species (30) covering 52.63% of the total recorded fish species. This is in agreement with reports from earlier works in different parts of Assam (Deka and Dutta 2013; Rahman *et al.* 2016; Singha *et al.* 2017). The availa-

bility of indigenous fish species such as *C. batrachus*, *H. fossilis*, *M. cuchia*, *A. testudineus*, *C. gachua* and *C. punctata* in the local markets of Kokrajhar in our study indicates the availability, preference and thus potential for aquaculture expansion of these species in the region. These species are of good economic value as they are also considered to contain medicinal properties to combat physical weakness or anaemia and are prescribed as a diet during convalescence (Narzary *et al.* 2019; Roy *et al.* 2022).

TABLE 3 Demographic socio-financial records of all the respondents in the study.

Parameters		No. of respondents					Total
		Town Markets		Village Market			
		BB	MB	LB	KB	BMB	
Sex	Male	25	5	6	5	7	48
	Female	3	5	8	12	10	38
Community	Bodo	3	8	4	4	8	27
	Bengali	22	2	0	0	0	24
	Assamese	3	0	0	0	0	3
	Santhal	0	0	10	13	9	32
Age group	20-25	2	1	3	6	5	17
	26-35	10	4	4	8	8	34
	36-50	11	5	6	3	2	27
	Above 51	5	0	1	0	2	8
Educational qualification	Class I-IV	10	2	8	7	5	32
	Class VI-X	12	7	6	9	12	46
	Class XI-Graduation	6	1	0	1	0	8
Size of family	0-5	10	8	8	12	12	50
	6-10	12	2	4	4	4	26
	Above 10	6	0	2	1	1	10
Quantity sold (kg day^{-1})	Up to 10	18	8	11	15	16	68
	Above 10	10	2	3	2	1	18
Income (INR day^{-1})	Up to 200	3	3	4	5	6	21
	201-500	4	4	8	10	9	35
	Above 500	21	3	2	2	2	30

LH = Lahoti Bazaar, KB = Khangkilabada Bazaar, BMB = Bishmur Bazaari, MB = Maldangpara Bazaar, BB = Boro Bazaar.
INR = Indian Rupees, 1USD (US Dollar) = 82.33 INR (as on 18 Jan 2023).

Beels, most notably the Diplai Beel of Kokrajhar and other natural sources like rivers, beels and local wetlands in the Kokrajhar region was found to be the primary source of fish. Similar observations were made by Singha *et al.* (2017), where Diplai Beel was found to be the most important source of fish in Kokrajhar. This indicated the importance of these natural water bodies as a natural habitat for all these species. Attention may be given for the proper management of these resources for full potential utilization in a sustainable manner. However, certain species such as *H. ilisha*, *P. pangasius* and *M. rosenbergii* were exclusively procured from fish auction sources outside the region, mainly imported from neighbouring states like Bihar, West Bengal, Andhra Pradesh and Uttar Pradesh mostly cold-preserved. Debnath *et al.* (2020) also reported the import of fish from neighbouring states (West Bengal, Andhra Pradesh and Bihar) and nearby districts (Nagaon and Nalbari) to meet the demand of Kokrajhar. *Hilsa ilisha* and *M. rosenbergii* was also reported to be supplied from Uzan Bazaar Landing Centre, Guwahati, Assam which is the largest fish landing site located at the bank of river Brahmaputra. However, the diversity of species was more pronounced in the locally procured species.

Among the locally procured fish species, small indigenous fish species (SIFs) occupied an important share of the market contributing about 60% of all the species recorded in the present study. The SIFs are an important group of fish with immense potential for culture both as food and ornamental fish and grows up to the size of 25 – 30 cm in adult stage. In India, about 58.8% (450 species) of all fish species are recognised as SIFs, and their maximum diversity is recorded in the Northeast region (Lakra *et al.* 2010). The SIFs are a high source of macro and micronutrients, vitamins and minerals (Das *et al.* 2013) Local indigenous fish species are good candidates for aquaculture diversification and expansion as they are nutrient-rich and readily accepted by the people. Some of the important SIFs recorded in the present study were *L. thermalis*, *L. guntea*, *B. dario*, *E. danrica*, *R. daniconius*, *P. ticto*, *P. conchonius*, *P. sophore*, *D. rerio*, *D. devario*, *A. mola*, *C. chagunio*, *B. dero*, *R. bola*, *M. tengara*, *M. vita-*

tus, *A. apangi*, *C. chaca*, *C. nama*, *P. lala*, *M. pancalus*, *M. aral*, *M. armatus*, *X. cancila*, *N. notopterus*, *G. giuris*, *T. lalius*, *T. fasciata* and *L. cutcutia*. The presence of these diverse species indicated the rich ichthyofaunal diversity, especially the SIFs, of the Kokrajhar region. Some of these species are recognised to be potential candidates for expansion of aquaculture especially ornamental culture (Goswami and Zade 2015; Kaushik *et al.* 2017) which indicates the potential for development and expansion of ornamental fishery and aquaculture in the region.

4.2 Shellfish and aquatic insect species

Indian tribal communities from the coastal, central and north-eastern regions are known to consume wild populations of freshwater molluscs (snails and clams) as a cheap source of protein, while some communities also believe that they possess medicinal value (Jadhav *et al.* 2020). Shellfish and aquatic insects have always been an integral part of the traditional cuisines and food habits of many communities including the Bodos of Assam. A variety of shellfish in different parts of Assam has been documented in some earlier studies (Roy and Gupta 2010; Sonowal *et al.* 2021) indicating a rich diversity. The nutritional and food value of many shellfish and aquatic insects have been documented by many authors (Devi *et al.* 2018; Thangjam *et al.* 2020). Moreover, some species are consumed for their traditional medicinal value. For example, in Manipur, snails are believed to enhance or help maintain good eyesight (Jadhav *et al.* 2020). Nargis *et al.* (2011) also reported that *Pila globosa* has been used as medicine for the cure of several diseases such as controlling blood pressure, rheumatism, cardiac diseases, asthma, giddiness and nervousness.

The presence of six shellfish species in the markets of Kokrajhar indicates their value and significance in the traditional food habit of the local people. Unlike the finfish resources, all the shellfish (except *M. rosenbergii* and *Penaeus indicus*) and the aquatic insects were found to be obtained exclusively from local freshwater bodies. All the six shellfish and four aquatic insects were found to belong to the Least Concern (LC) or Not Evaluated (NE) category except the decapod *Sartoriana trilobata* locally known as Kangkrai, which were described as Vulnerable (VU) as per IUCN. A number of studies have been reported for aquatic food insects in Assam and other regions (Das 2019; Thangjam *et al.* 2020; Zhao *et al.* 2021). Aquatic insects are also rich in nutrients such as proteins, fat, carbohydrates, minerals and vitamins and have been part of food habits for many communities worldwide (Devi *et al.* 2018). However, a relatively lesser number of shellfish and aquatic insect species were recorded compared to finfish species in our study. This may not necessarily be an accurate estimate of the total available shellfish and aquatic insect diversity of the region as only those species were included in our study which were edible, available in the markets and in high consumer demand. Also, our survey was restricted only to a limited number of local markets, and during a limited time period. Hence, extensive studies, including those in the natural habitats, may be suggested for determining the total species diversity of aquatic shellfish and insects in the region. Notwithstanding these limitations, some other probable reasons for the diminishing availability and diversity of these species may be attributed to their declining population because of over-harvesting (Jadhav *et al.* 2020) and use of insecticides in agriculture.

4.3. IUCN Conservation status

The IUCN categories of conservation status help us in understanding the threat levels and assessment of the likelihood of extinction under the current circumstances (Rahman 1989). With respect to the conservation status, most of the species were found to be categorised under Least Concern (77%) or Not Evaluated (8.1%) as per the latest IUCN red list data. However, few species like *H. molitrix*, *O. pabda*, *P. lala*, *C. chitala* and *A. bengalensis* were in the category of NT while species like *C. cirrhosus*, *C. carpio* and *W. attu* were recorded as VU. Only *T. putitora* was found to be in the EN category. This indicates that species such as *T. putitora* and *O. pabda* for which there are few known techniques for culture, may require special attention as uncontrolled exploitation in the wild may lead to their extinction. Similar observations were made for *C. chitala*, *H. molitrix*, *W. attu* and *O. pabda* (reported as NT) and *C. carpio* (reported as VU) species in Assam (Rahman *et al.* 2016; Singha *et al.* 2017; Talukdar and Rajbongshi 2018).

4.4. Socio-economic status of fish retailers

The status of women has been described as relatively better in North East India in comparison to the other states (Brahmachary and Brahmachary 2018). This observation was also reflected in our study where local women fish farmers and retailers constituted about 44.2% of all the fish sellers and retailers participating in the business of selling fish in all the local markets surveyed in the study. A similar report of women vendors presenting freshwater molluscs was reported by Jadhav *et al.* (2020). It was also observed that most of the village-based small-scale capture fishery was performed primarily by the womenfolk using traditional fishing gears or by utilising makeshift gears such as mosquito nets as a fishing net. Roy *et al.* (2017) also reported similar practice among the women folk in the Sundarbans, where women performed a major role in fresh and dry fish marketing in Sunderbans. In the present study, women retailers in village markets were mainly seen selling mostly SIFs such as *D. rerio*, *P. ticto*, *L. thermalis*, *P. sophore*, *B. badis* and *C. nama*, which are easy to catch using traditional gears like dragnets and the Jekai. Fishing was reported to be per-

formed either in a group (usually for catching fish) or as scattered individuals (for catching shellfish) and continued till sufficient catch was obtained to generate enough daily income for the family. Throughout the process attempts are made to keep the catch alive and fresh as the selling price, the customer demand and preference is higher for the fresh and live samples. A similar case of price variation according to the freshness of fish was reported in Dinajpur, Bangladesh (Hossain *et al.* 2015).

Village fish sellers were observed selling their catch in a unique way by wrapping the fish or shellfish in the broad leaves of *Curcuma caesia*. Shell fishes such as *P. globosa*, *B. bengalensis* and *B. costula* were sold with the shells intact or removed. Edible aquatic insects such as *Lethocerus indicus*, *Cybister tripunctatus*, *Hydrophilus ovatus* and *Hydrophilus triangularis* were also sold exclusively by the women only. Male retailers were mostly seen selling species such as *M. armatus*, *M. aral*, *M. cuchia*, *R. bola*, *C. chagunio*, *B. dero* and *S. sarana*, which require significant efforts to catch, and also have high consumer demand. Most of the local retailers in the town markets were found to procure their fish from the local villagers in large quantities and sold them in the town markets at a relatively higher price. Cold storage in ice or keeping alive in water tanks (for species such as *C. batrachus* and *M. cuchia*) was common practice by these town retailers.

In the present study, it was observed that there was a higher demand for locally caught fish compared to those fish procured from outside the region which were mostly cold-stored. Freshness, diversity, and being preservative-free were the main reasons cited for the preference of the locally procured species. The effect of this trend was noticeably observed in the market price as the locally caught fresh fish were sold at a higher price than those imported. High variation of price was observed during the periods of high catches, and the variation of price was lower during the period of low catch season. The greater variation of price provides a higher economic benefit for the middle man and lower profit for the poor local village fishers. Similar observations were also reported in the wholesale and retail market of Dinajpur, Bangladesh (Hossain *et al.* 2015) and in Kerala and Gujarat (Gopal *et al.* 2001).

There is a general observation in most places of India that compared to the achievements in fish production, the fish marketing system remains poor and inefficient (Kumar *et al.* 2008; Das *et al.* 2013), and an urgent requirement exist for the fish market development in the rural part of India (Rajput *et al.* 2017). A similar observation was also made in our study where a properly organised marketing system was lacking for the locally caught fisheries resources in the region. Individual fishers were solely responsible for the procurement, transport, storage or marketing of their catch. High cost of cold storage facilities and transportation, poor presentation and handling of fish and unhygienic conditions are some of the challenges in the production and marketing system even today (Kumar *et al.* 2008; Shobiya *et al.* 2020). Most of the local fishers were financially and educationally poor and relied on traditional gears. Similar constraints such as low socio-economic and educational status, and lack of training facility were also reported by Kumar and Pandey (2013) in Uttar Pradesh. Due to a lack of proper storage facility, the village fishers are compelled to sell their catch to the middle man who finally sells them at the market at a higher price. Such issues were also reported in Orissa, Uttar Pradesh and Bangladesh (Hossain *et al.* 2015; Verma *et al.* 2015; Panda *et al.* 2022). Providing training, aids and technical know-how may result in better, sustainable and profitable fisheries in the region. Proper assessment of the marketing strategy would help the district become self-sufficient in the production of aquatic food faunal resources.

The present study has highlighted the rich diversity of food fish, shellfish and aquatic insect species, their marketing and fishery in Kokrajhar. Altogether 74 different edible aquatic faunal species including 64 finfish, 6 shellfish and 4 aquatic insect species were recorded in the different markets of Kokrajhar. Most of the species belonged to the least concerned category. A vast diversity of SIFs recorded in the study indicated the preference and potential for the aquaculture expansion of these species. Results of our study indicated the rich diversity of finfish in the water resources of the district. This study has also established the current status of fish retailers and the marketing system in the local markets of Kokrajhar. The information from this study may be useful in planning and management of fisheries in the region for achieving sustainable development of fisheries and aquaculture in the region.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHORS' CONTRIBUTION

BM and BD performed the survey, collected the data, analysed the data and prepared the manuscript. BKK conceptualised the study, designed the study, supervised the work, interpreted the data, drafted, edited, enriched and finalised the manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on a reasonable request from the corresponding author.

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