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COLOSSAL LOSS OF FISH BIODIVERSITY DURING FRY COLLECTION IN THE RUPSHA RIVER

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Abstract
A key challenge for sustainable fish production is the loss of fish biodiversity caused by the indiscriminate capture of non-target creatures, particularly in Bangladesh's inland and coastal regions. In addition to serving as a crucial navigational channel in Bangladesh's coastal regions, the Rupsha River in Khulna City is also home to over 15000 fishermen who harvest fish and shrimp fry. Therefore, a study was carried out to assess the existing fry collection scenarios, fish bycatch and its impact on the biodiversity to enhance the production and biodiversity of the Rupsha River. Between May 2022 and July 2023, information was gathered from stakeholders through a combination of personal observation, focus groups, and cross-check interviews. In this study, *Macrobrachium rosenbergii* and *Penaeus monodon* fry were collected from wild sources by fixed blue net (FBN) and drag net (DN) as target species. For FBN compared to DN, efficiency and survival rate were both higher. FBN and DN caught 20 different bycatch species, including one highly endangered (*Channa striata*), four vulnerable species, and four commercial species. During the study period, the mortality rates of bycatch was 50%. The assessed value of the commercial adult species lost during fry collection stands at 1,245 BDT (Bangladesh Taka) per person per day, whereas the earnings of the fry collectors' amount to 80 BDT per day. Hence, it is imperative to rigorously enforce a ban on larvae fishing through community participation and integrated coastal zone management to preserve aquatic biodiversity and protect the livelihoods of the coastal population.

Keywords: Post larvae, Biodiversity, Fixed blue net, Drag net

Introduction

Coastal aquaculture, particularly the cultivation of black tiger shrimp (*Penaeus monodon*) and giant freshwater prawn (*Macrobrachium rosenbergii*), significantly contributes to both rural and national economies, serving as a major source of export earnings and employment in the coastal regions. Shrimp and prawn constitute the second-highest foreign income generator after the ready-made garments industry in Bangladesh. According to the Department of Fisheries of Bangladesh, the combined production of shrimp and prawn was 0.16 million MT in 2003, and this figure increased to about 0.24 million MT in 2020 (DoF, 2020). While hatchery-produced post-larvae are now available in many countries across Asia and Latin America, wild fry still remains a significant source of seed in various regions (FAO, 2007).

In Bangladesh, shrimp farming heavily relies on wild-sourced post-larvae (PL) for both prawn and shrimp. Traditionally, prawn farmers have favored stocking their farms with wild PL rather than hatchery-produced fry due to limited availability and perceived lower quality of hatchery PL (Ahmed et al., 2005; Angell, 1992). Additionally, the survival rate of wild PL is reported to be much higher than that of hatchery-produced fry (Muir, 2003). It is estimated that approximately 2 billion shrimp fries are harvested annually from wild sources (Banks, 2003). Concerning freshwater prawn, more than 90% of the total PL is sourced from natural habitats, while for black tiger shrimp, over 50% is obtained from the wild (Banks, 2003). This reliance on wild sources represents one of the contributing factors to the depletion of fish biodiversity.

In Bangladesh, roughly 40% of the gathered seed dies before stocking in aquaculture facilities, primarily as a result of inadequate handling and transportation procedures. Furthermore, it has been noted that approximately 99

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finfish and other shrimp species fry are discarded in the process of collecting a single shrimp post-larva (Rashid, 2000). The collection of wild post-larvae for stocking in aquaculture facilities represents a pivotal aspect of shrimp farming (Páez-Osuna, 2001).

The Rupsha River sustains the livelihood and nutritional security of the communities residing alongside through diverse fisheries activities. Flowing alongside Khulna city, the river merges with the Pashur River at the Mongla channel before ultimately emptying into the Bay of Bengal. The river functions as a breeding and nursery ground for various freshwater and marine species (Hossain et al., 2016). Fishermen engage not only in fish harvesting but also in the collection of prawn fry (*M. rosenbergii*) and shrimp fry (*P. monodon*) from the Rupsha River (Khatun, 2022). Approximately 15,000 fishermen, including children, participate in the fry collection process. Various studies have been conducted on fry collection in Bangladesh, covering aspects such as the harvesting of wild shrimp larvae in different rivers (Ahmed et al., 1998; Azad et al., 2007) and the collection of prawn larvae in the Pashur River (Ahmed et al., 2005; Ahmed & Troell, 2010). However, the exploration of the scenario of fry collection in the Rupsha River and its impact on biodiversity is yet to be undertaken. This study is dedicated to examining the abundance of wild fry and bycatch in relation to gear type, season, and different sites within the Rupsha River, along with estimating the loss of fish diversity and its valuation.

Materials and Method

Study Area

The study was conducted in four selected upazilla of the Rusha River, Khulna (22°45'17.24" and 89°33'15.47") based on geography and availability of shrimp fry collectors from May 2022 to July 2023 (**Figure 1**). The sampling sites were Navy ghat, Rupsha ghat, Batiaghata bazar and Chalna ghat under Dighalia, Rupsha, Batiaghata and Dacop upazillas, respectively. The lower part of the Bhairab River near Peroli ghat under Dighalia upazilla is known as Rupsha River that runs by the side of Khulna city and connects to Moyuri River at Batiaghata, and Pashur River at Mongla channel before falling into the Bay of Bengal. Numerous facilities including fisheries, transport, business, dockyards and shipyards are located along its banks.

Data collection method

Secondary data were collected from *upazilla* fisheries office, project reports, books and journals. A primary questionnaire was prepared based on secondary data, and discussion with resource person. Then, it was reviewed by field work, and final questionnaire was prepared for data collection. A combination of the following participatory, qualitative methods was used for primary data collection.

Focus Group Discussion (FGD)

Twenty FGDs were conducted with members of fishing communities including larvae collectors, fry traders, hatchery owners, women, and children. Each FGD group consisted of 6-10 individuals. The FGD sessions were held at fish markets and riverbanks where participants felt comfortable answering the questions. The FGDs aimed to gain insight into various aspects of fry collection and biodiversity loss.

Questionnaire Interview (QI)

Before conducting QIs, semi-structured questionnaires were prepared based on secondary data. Fry collectors in the study areas were interviewed using the questionnaire. QIs were conducted at various locations including riverbanks, fishing sites and local gathering places. Each interview lasted approximately 30 minutes focusing on fry collection, daily income, catch amounts, bycatch amounts and the destructive effects of fry collection on biodiversity. Additionally, direct observations of fry collection activities were performed in all studies areas.

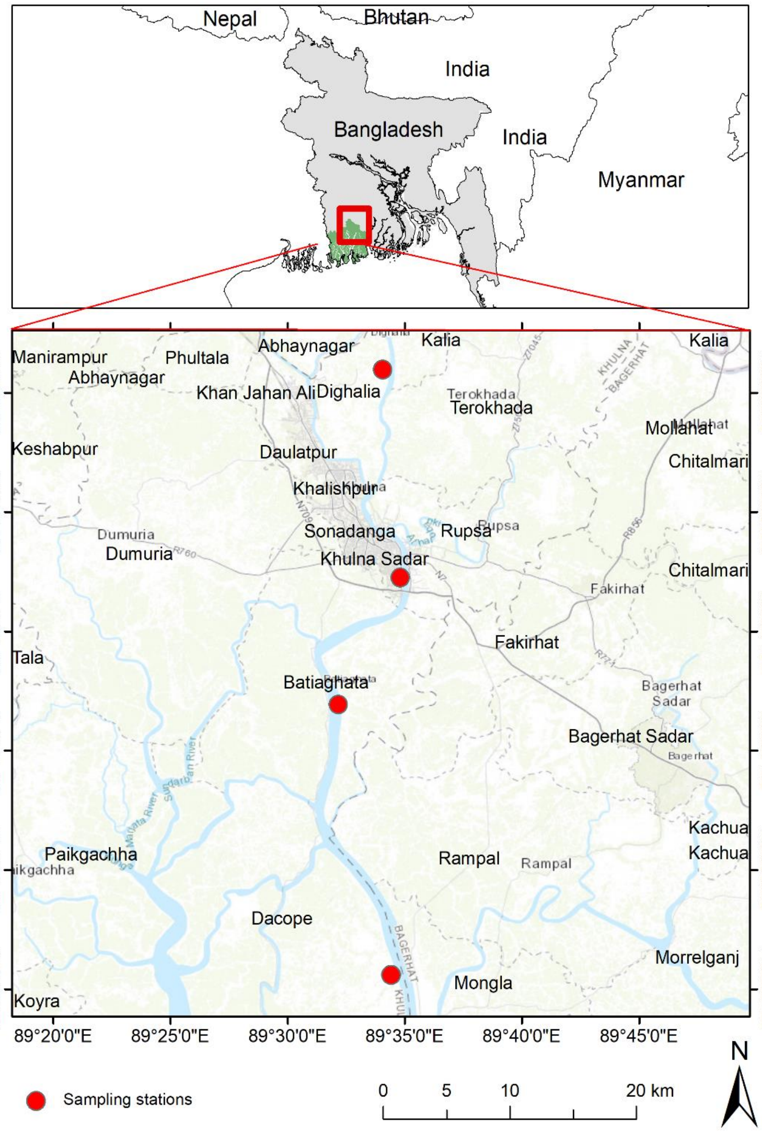

Figure 1. Map of the study sites prepared using ArcGIS version 10.

Key Informants Interview (KII)

28 KIIs were conducted with individuals who possessed substantial knowledge about fry collection and related activities. The cross-check interviews involved *upazilla* fisheries officers, university teachers, researchers of Fisheries Research Institute (FRI), local leaders, project staffs, non-governmental organization (NGO) staffs and others with expertise in the respective field.

Sample collection

Fry and bycatch samples were collected in an earthen pot during peak seasons according to local practices. The fry of shrimp and prawn were collected during high tide by Fixed Blue Nets (FBNs) and Drag Nets (DNs). The nets were operated two times a day. Each session lasts for 3-4 hours. After an interval of 25-30 minutes, the target species were collected. The discarded bycatch species were counted and preserved in 10% formalin for analysis. The fry collectors usually discard the bycatch mostly on the water, and occasionally in the river bank.

In each location, approximately five samples were collected for each type of gear in both morning and evening in each of the three seasons. These collected samples were then brought to the laboratory to determine the exact number of the bycatch and identified the species according to IUCN (2015). The bycatch species were categorized as critically endangered, vulnerable, near threatened and least concern. Bycatch species that have high market value and consumers' demand were considered as commercial species. Availability of fry during both lean and peak periods were measured to estimate yearly catch and monetary value.

Data analysis

Data from questionnaire interviews and direct observation were coded and analysed using Microsoft Excel (version 2013) and R programming language (R core Team, 2023). Pairwise comparisons were made using Mann-Whitney test. Percentage data were transformed into Arcsine and Shapiro-Wilk test was used for normality, then t-test and analysis of variance (ANOVA) were performed for comparison. All hypothesis tests were performed at 0.05 significance level.

Results

Fry collecting gear, operation and efficiency

Table 1 summarizes seasonal gear efficiency and colossal losses during fry collection in the study areas. Two popular nets: the FBN (locally called "nil jal" or set bag net) and the DN (locally called "tana jal") were used in the Rupsha River. The FBN is typically operated at a distanced place from the shoreline and required more than one person. The net had a triangular-shaped opening. Its location needed to be adjusted as the high tide gradually receded from the shoreline. In contrast, the DN is operated near the shoreline by a single person and has a rectangular-shaped opening. Fry collectors would use these nets on the riverbank to collect the target species as the tide began to recede. Long nylon rope, bamboo and floating weights were used to construct the net. The nylon rope and bamboo were essential for gear operation while floating weights were used with the FBN. The DN features a bamboo frame. The FBN costs 900-1200 BDT while the cost for a DN is 300-500 BDT. The collectors operated nets usually 4-6 hours, sometimes upto 8 hours (Table 1). The net was emptied at 20-30 minutes interval.

In this study, the target species were *M. rosenbergii* (palaemonid prawn) and *P. monodon* (penaeid shrimp). On an average, a fry collector collected 77, 100 and 217 target individuals per day during winter, summer and monsoon seasons, respectively by using the FBN. In contrast, when employing the DN, the fry collector collected 50, 57 and 137 target individuals per day during the corresponding seasons. In the study areas, a fry collector discarded 2,542, 2,626 and 1,334 bycatch individuals per day during winter, summer and monsoon seasons, respectively when the FBN was used. The catch of both target and bycatch species was significantly higher in FBN than DN during monsoon ($p < 0.05$, Figure 2).

Number of target species was the highest in monsoon followed by summer and winter ($p < 0.05$). However, the captured bycatch species was higher in monsoon than winter ($p < 0.05$), and the abundance in monsoon was not significantly differ from summer ($p > 0.05$). It was consistently observed that bycatch mortality was significantly higher when using DN compared to FBN ($p < 0.05$). In summer, bycatch mortality rate was the lowest followed by monsoon and summer ($p < 0.05$). In case of areas, fry collection was the highest in Dacop and the lowest was in Dighalia regardless of gear type and season ($p < 0.05$). Similarly, the lowest bycatch was achieved in Dighalia ($p < 0.05$), and no fry or bycatch collection occurred during the winter season (Table 1).

Table 1. Gear efficiency of larvae collection and bycatch.

Season	Sampling time	Area	Gear type	Fix/ Tow time*	Target sp.**	Bycatch**	Operation***	Bycatch mortality (%)
Winter	7:00-11:00 am 3:00-6:00 pm	Dacop	FBN	30	85	910	8	43
			DN	20	60	286	4.5	62
		Batiaghata	FBN	30	65	907	7	33
			DN	20	40	262	4	40
		Rupsha	FBN	30	80	725	7	42
			DN	20	50	360	4	57
		Dighalia	FBN	-	-	-	-	-
			DN	-	-	-	-	-
Summer	6:00-10:00 am 4:00-6:00 pm	Dacop	FBN	30	100	902	6	22
			DN	20	50	732	4	31
		Batiaghata	FBN	30	120	936	6	21
			DN	20	80	768	5	29
		Rupsha	FBN	30	85	574	5	23
			DN	20	40	598	4	32
		Dighalia	FBN	30	30	214	4	40
			DN	-	-	-	-	-
Monsoon	5:10-8:30 am 4:00-6:30 pm	Dacop	FBN	30	220	854	5	34
			DN	20	130	665	4	41
		Batiaghata	FBN	30	250	1222	6	27
			DN	20	180	1008	5	29
		Rupsha	FBN	30	180	850	6	32
			DN	20	100	723	5	38
		Dighalia	FBN	30	50	372	5	27
			DN	20	35	334	4	44
Overall				**25**	**97**	**676**	**5**	**36**

**minute, **individuals/person/day, ***hr/day*

Bycatch species

Although it's difficult to identify the small larvae by eyes or compound microscope, there were 20 types of bycatch species identified from the study area (Figure 3; Table 2). Typically, these bycatch species were discarded into water or on the river bank. Among the collected species, one was noticed as critically endangered species (*Channa striata*), while four as vulnerable species (*Wallago attu*, *Sperata aor*, *Microphis cuncalus* and *Microphis deocata*), one as near threatened species (*Macrobrachium lancesteri*), and fourteen as least concern species. Overall, two (*Palaemon styliferus* and *Macrobrachium lancesteri*) were found as adult stage. In addition to targeted shrimp fry, bycatch like *Metapenaeus monoceros, Scylla olivacea, Sperata aor,* and *Liza parsia* have also market value in adult stage.

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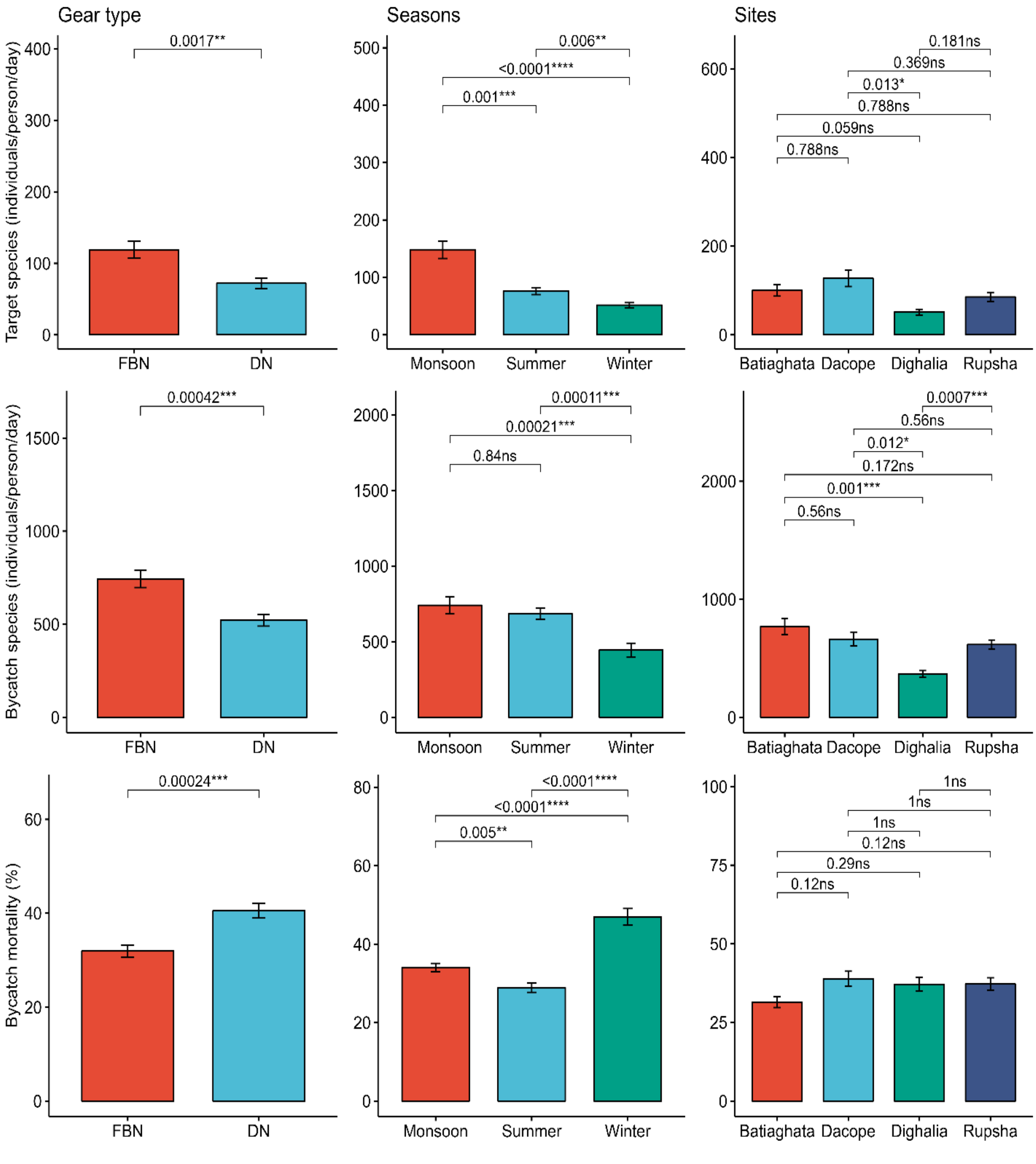

Figure 2. Abundance of target and bycatch species, and bycatch mortality in different gears, seasons and sites in Rupsha River. The asterisks (*) indicate significance levels; ns = not significant.

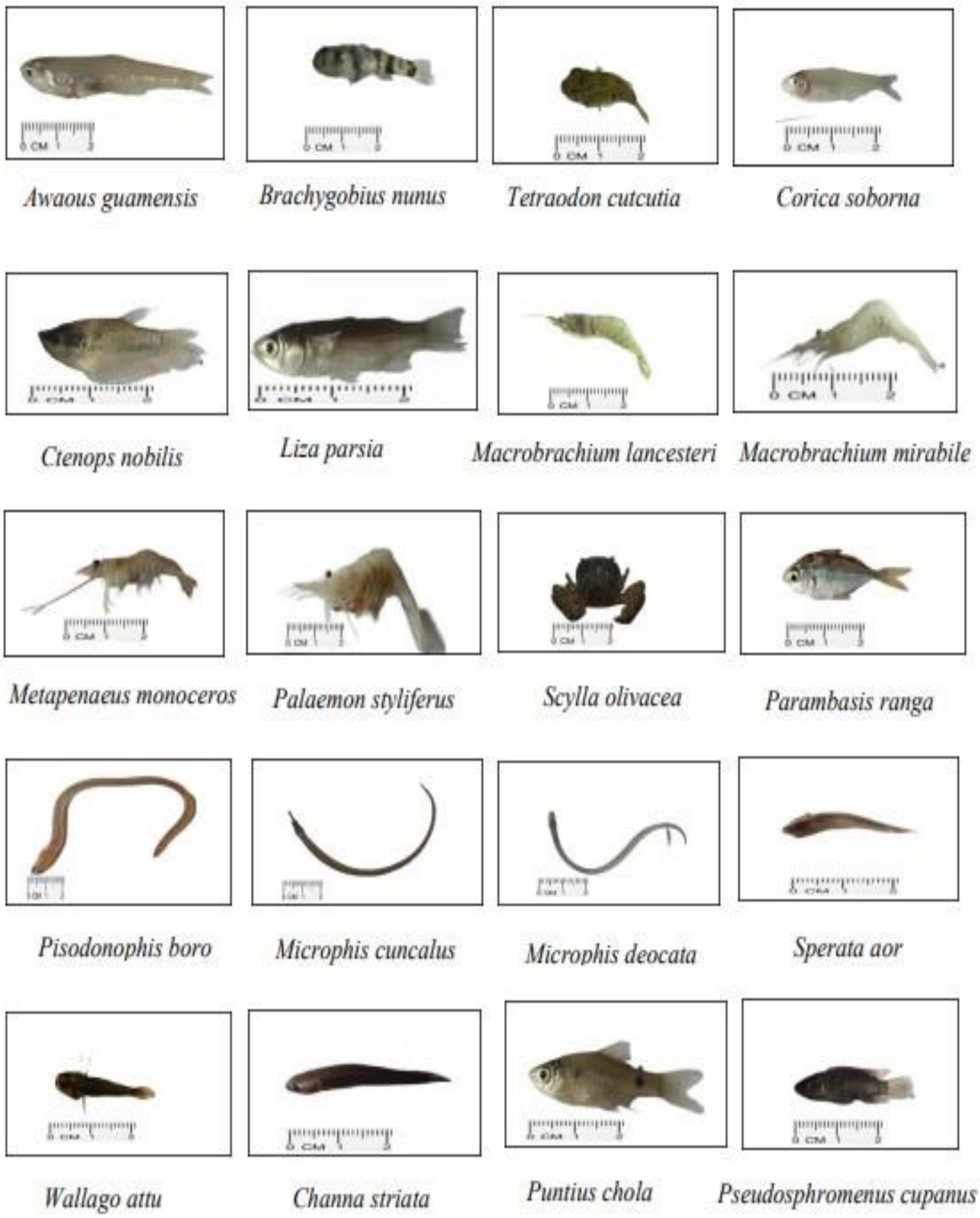

Figure 3. Photographs of non-targeted fish (bycatch) species in the studied areas.

Table 2. Detailed taxonomic classification of bycatch species.

Sl.	Order	Family	Scientific name	English name	Local Name	Status*
1	Anabantiformes	Channidae	*Channa striata*	Snakehead murrel	Shol	CR
2	Siluriformes	Siluridae	*Wallago attu*	Freshwater shark	Boal	VU
3	Clupeiformes	Clupeidae	*Corica soborna*	Ganges River-sprat	Subarna, Kharika	LC
4	Siluriformes	Bagridae	*Sperata aor*	Long whiskered Catfish	Ayer	VU
5	Anguilliformes	Opichthidae	*Pisodonophis boro*	Rice-paddy Eel, Snake Eel	Kecho Baim, Nol Baim	LC
6	Cypriniformes	Cyprinidae	*Puntius chola*	Chola Barb	Chola Punti	LC
7	Perciformes	Gobiidae	*Brachygobius nunus*	Short Goby, Buzz Goby	Nuna Bailla	LC
8	Perciformes	Osphronemidae	*Pseudosphromenus cupanus*	Spiketail Paradisefish	Koi Bandi	LC
9	Perciformes	Osphronemidae	*Ctenops nobilis*	Indian Paradise Fish, Indian Gourami.	Napit Khaiisha, Napit khayra	LC
10	Tetraodontiformes	Tetraodontidae	*Tetraodon cutcutia*	Ocellated blowfish	Tepa, Potka	LC
11	Perciformes	Gobiidae	*Awaous guamensis*	River Goby	Shil Baila	LC
12	Mugiliformes	Mugilidae	*Liza parsia*	Grey Mullet	Parse, Parse Bata	LC
13	Perciformes	Ambassidae	*Parambasis ranga*	Indian Glassy Fish	Chanda, Chandu, Tek Chanda	LC
14	Syngnathiformes	Syngnathidae	*Microphis cuncalus*	Crocodile tooth pipefish	Kumirer khil	VU
15	Syngnathiformes	Syngnathidae	*Microphis deocata*	Deocata pipefish	Kumirer khil	VU
16	Decapoda	Portunidae	*Scylla olivacea*	Mud crab	Kakra	LC
17	Decapoda	Penaeidae	*Metapenaeus monoceros*	Speckled/ Ginger shrimp	Harina/ Kharkharia chingri	LC
18	Decapoda	Palaemonidae	*Macrobrachium lancesteri*	Rice land prawn	Dhanua chingri	NT
19	Decapoda	Palaemonidae	*Macrobrachium mirabile*	Shortleg river prawn	Latiya icha	LC
20	Decapoda	Palaemonidae	*Palaemon styliferus*	Roshna prawn	Gara icha	LC

CR = Critically endangered, VU = Vulnerable, NT = Near threatened, LC = Least concern

Species composition in different season

The catch composition of different bycatch species and/or groups with three seasons are given in Table 3. Bycatch and target species number were varied with season. The major bycatch species- *M. monoceros* is under penaeid shrimp, and *M. lancesteri*, *M. mirabile* and *P. styliferus* are under palaemonid prawn which was also supported by key informants.

Table 3. Bycatch species composition in different season of the study areas.

Season	Net type	Bycatch (individuals/person/day)					Ratio (Target: Bycatch)
		Crablet	Penaeid shrimp	Palaemonid prawn	Finfish	Total	
Winter	FBN	255	157	324	107	843	1:9
	DN	81	43	89	72	285	
	Average	168	100	206	90	564	
Summer	FBN	149	175	262	70	656	1:7
	DN	94	155	220	55	524	
	Average	122	165	241	63	590	
Monsoon	FBN	57	256	349	162	824	1:4
	DN	48	179	332	123	682	
	Average	52	217	340	142	753	
Overall		114	161	263	98	636	1:6

The number of crabs, penaeid shrimp, palaemonid prawn and finfish captured were higher in FBN than DN (**Table 3**). As bycatch amount, palaemonid prawn was the highest followed by penaeid shrimp, crablet, finfish for both gears. The highest number of crablet were captured in winter season by FBN than DN.

Among the bycatch, four species such as *S. aor*, *L. parsia*, *M. monoceros*, and *S. olivecia* were commercial. These species were captured as bycatch in significant quantities throughout the year and its market demand remains consistently high. *S. aor* (*Ayre*), mature harvest usually in October, is another commercial and vulnerable species and people willing to pay more due to delicious and nutritive. *M. monoceros* (*Harina chingri*) is highly popular as an export item after *P. monodon* and *M. rosenbergii*. The bycatch size captured in 2-2.3 cm. *S. olivacea* (*Kakra*) is a popular species in our country. Adult female crabs go offshore to spawn (Bir et al., 2020). When the crablets are in the megalopa stage, they return to inshore water. The smallest size (megalopa) was observed in winter and monsoon, the carapace length was 1.5 cm. Another species, *L. parsia* (*Parshe*) is abundant in the Khulna region. It is typically harvested in November and December. The fry was captured in 2.5-3 cm length.

An estimation of yearly monetary value of commercial bycatch species are shown in Table 4. The table displays the possible economic benefits might be obtained after complete implementation of the ban on harvesting fry collection. The financial valuation from dead species was estimated based on a 10% survival rate in the natural environment, and 50% mortality of commercial bycatch species during fry collection. The analysis excludes off-season (October and November) and includes both peak and lean season. The yearly monetary value of *S. aor*, *L. parsia*, *M. monoceros*, and *S. olivecia* captured by a fisherman during fry collection in Rupsha River were 137,000, 68,400, 305,025 and 247,050 BDT, respectively. A fisherman may earn 152,512 BDT/year from dead crablets if 9,804 crablets will not be destroyed through fry collection. Similarly, it was 68,250 BDT/year for *S. aor,* 34,200 BDT/year for *L. parsia,* and 123,525 BDT/year for *M. monoceros* from adults that were destroyed during fry collection.

Table 4. Yearly monetary value of commercial bycatch species.

Species	Criteria	Catch*	Yearly catch**	Survived number	Average weight ***	Market price****	Yearly value (BDT)	Yearly value (USD)
S. aor	I	6	1368	137	1.00	1000	137,000	1245
	II	3	684	68	-	-	68,250	620
L. parsia	I	15	3420	342	.250	800	68,400	622
	II	8	1710	171	-	-	34,200	311
S. olivacea	I	86	19608	1961	.220	700	305,025	2773
	II	42	9,804	980	-	-	152,512	1386
M. monoceros	I	121	27588	2759	.150	600	247,050	2246
	II	61	13,794	1379	-	-	123,525	1123
	I	171	51,984				756,975	6882
	II			25,992			378,487	3441

**individuals/ person/ day; **individuals/person/year; ***individual/ kg, ****BDT/ kg, I = Overall, II = Mortality by fry collection, 1 USD = 110 BDT.*

Scenarios of fry harvesting in Rupsha River are summarized in Table 5 which includes observations in both peak and lean seasons. Approximately 15,000 fry collectors collect fry in Rupsha River (personal communication with key informants). A fry collector collects fry 10 months in a year. October and November are the off-season. A larvae fisher usually captured 80 targets and 478 bycatch individuals per day. Therefore, one target individual costs six bycatch individuals and the overall bycatch mortality rate was 36%. The fry collectors earned 80 BDT/day. If they were to stop their activities, these species could reach their maximum size and weight. This would allow the collection of larger fish resulting in significant profits. The fry collector may earn 1,245 BDT/day from commercial species that are discriminately destroyed during fry collection. Similarly, they may earn 7,56,975 BDT/year from commercial bycatch species whereas 24,320 BDT/year from target species.

Table 5. Scenario of fry collection in Rupsha River, Bangladesh.

Criteria	Remark
Target species availability (individuals/person/day)	35-250; average 80
Target species availability in FBN (individuals/person/day)	30-250; average 140
Target species availability in DN (individuals/person/day)	35-180; average 108
Target species yearly catch (individuals/person/year)	24,320
Daily income (BDT/person/day)	80
Yearly income (BDT/person/day)	24,320
Number of bycatch species (CR=1, VU=4, NT=1, LC=14)	20
Daily bycatch captured (individuals/person/day)	478
Yearly bycatch captured (individuals/person/year)	1,45,312
Target: Bycatch	1:6
Overall bycatch mortality (FBN = 31%, DN = 40%)	36%
Commercial bycatch mortality	50%
Number of commercial species of bycatch	4
Daily commercial species of bycatch captured (individuals/person/day)	171
Yearly commercial species of bycatch captured (individuals/person/year)	51,984
Bycatch mortality of commercial species (individuals/person/year)	25,992
Monetary value of commercial bycatch species (BDT/person/day)	2,490
Monetary value of commercial bycatch species (BDT/person/year)	7,56,975
Monetary value of dead commercial bycatch species (BDT/person/day)	1,245
Monetary value of dead commercial bycatch species (BDT/person/year)	3,78,487

FBN = Fixed blue net, DN = Drag net, CR = Critically endangered, VU = Vulnerable, NT = Near threatened, LC = Least concern

Discussion

Fry collecting gear, operation and efficiency

FBN is more comfortable to operate than DN. FBN captured 131 target individuals/day and DN captured 81 target individuals/day. As a result, above 61% catch were collected by FBN in the Rupsha River. Similarly, 60-70% of the overall catch is operated by FBN in the Pashur River (Ahmed & Troell, 2010) and on the shoreline of the Bay of Bengal (Azad et al., 2007). The hauling time that was observed in the Rupsha River is similar to neighboring areas (Ahmed & Troell, 2010; Ahmed et al., 1998; Banik, 2022; Vass et al., 1978). The nets were generally operated twice a day during high tide for about five hours which is less than in other coastal areas of Bangladesh (Ahmed & Troell, 2010; Banik, 2022; Islam et al., 2015). The larvae fishers poured target individuals into an earthen jar with debris to keep them alive in the Rupsha River like the southwestern coast of Bangladesh (Ahmed et al., 1998). However, less mortality (15%) is noticed by Azad et al. (2007) in Patuakhali and Barguna districts with similar gear. It was also found that DN created more bycatch mortality than FBN. Moreover, DN created more destruction to the benthic flora and fauna (Ahamed et al., 2012).

Bycatch species

About 20 bycatch species (crab, shrimp, prawn, and finfish) were identified in the study areas. Among these species, *C. striata* is critically endangered, and *W. attu*, *S. aor*, *M. cuncalus* and *M. deocata* are vulnerable species. Palaemonid prawn was captured in the highest number in all seasons. In contrast to the Rupsha River, 14 bycatch species are available in the Pashur River (Ahmed & Troell, 2010). Both target species and three bycatch species such as *M. monoceros*, *P. styliferus*, and *M. mirabile* are found in Pashur River. The bycatch in Rupsha River also consisted of four commercial species such as *S. aor*, *L. parsia*, *M. monoceros*, and *S. olivecia* which are not reported in Pashur River. Moreover, five available commercial bycatch species, *M. malcolmsonii*, *P. indicus*, *T. ilisha*, *P. pangasius* and *L. calcarifer* in Pashur River are absent in the Rupsha River. These differences in bycatch diversity between the two rivers could be attributed to differences in geographical location and salinity. Pashur River surrounded by the Sundarbans is more saline than the Rupsha River and an intervening zone between freshwater and seawater (Hoq, 2007; Islam, 2003) that serves as a nursery ground and seasonal habitat for many freshwater and marine water species.

Species composition in different seasons

The fry collector collected fry throughout the year except in October and November. February-March was the peak season for shrimp and June-August was the peak season for prawn fry collection. Azad et al. (2007) mentioned the same peak season of prawn fry collection in Dacop. The peak season of shrimp fry collection is also the same in Cox's Bazar, Indian Sundarbans, Rampal and Mongla (Banik, 2022; Chakraborty et al., 2021; Dutta, 2019; Karim, 1986). Both shrimp and prawn species were found in the Rupsha River in winter and summer seasons while only prawn fry was captured in monsoon. Rupsha River is a distributary of the Ganges and Ganges is the only source of freshwater in the greater Khulna district. Since a huge freshwater intrusion happened in the Rupsha River in monsoon, only prawn fry was captured. *P. monodon* fry was abundant from October to February and associated with moderate salinity. The fry collectors captured 80 target individuals/person/day and 478 bycatch individuals/person/day in inshore areas of the study sites. The larvae and juveniles of *P. monodon* need an outer/inner littoral zone to survive (Motoh, 1985). The abundance of both target and bycatch species was higher in monsoon than summer and winter seasons. However, the bycatch mortality rate was higher in winter than in other seasons, which might be due to the thermal shock of the bycatch species during winter season.

Impacts on biodiversity, ecosystem and coastal livelihood

Because of substantial negative impacts on aquatic fish stocks and ecosystems, wild fry collection is illegal in Bangladesh. The fry collectors selected target species and discarded low or zero-valued larvae and juveniles of many non-target fish and shellfish species into water or river banks. Moreover, the high mortality of bycatch species was observed during the study period. The excessive removal of target and bycatch species may lead to serious brood stock scarcity that may create problems for long-term fisheries development in Rupsha River and its surrounding areas. The actual stock recruitment of shrimp-prawn or other important species is dependent on the survival of the larvae. The practice of dragging the net along the shore creates a severe physical disturbance on the bottom and uproots the mangrove seedlings. Both of the nets damage feeding, breeding and nursery grounds of many species who utilize this area during part of their life cycle (Saikat, 1992). The fry collectors mentioned the decline of the catch of larvae over the last few years which was also supported by key informants and many fisheries experts. The study showed an overall low larva catch rate, an average of 80 individuals/person/day throughout the year except the ban period. The ratio of target and bycatch was 1:6 in the present study was much lower than previous reports (Ahmed & Troell, 2010). The low target and bycatch ratio in our study might be due to differences in mesh size of the gears and data collection procedures, for example direct observation with fry collectors and interviews with them, which sometimes exaggerated the information during field visit. In Bangladesh, the highest number of bycatch captured is 1,666 individuals (Hoq et al., 2001) and the lowest was 80 individuals (Deb, 1998) for only one target individual. The loss of a wide range of larvae and juvenile fish and shellfish of many aquatic resources of commercial, ecological and biomedical values could be a big threat to biodiversity and ecosystem services. Therefore, larvae fishing threatens the livelihoods of the very fisher flocks depending on these resources. A fry collector earned 24,320 BDT/year by selling target species while the monetary value from 4 commercial species was 756,975 BDT/person/year and from only dead commercial species was 378,487 BDT/person/year. Fry collection became a barrier to ecological conservation and sustainable resource-use practices.

Conclusion

Harvesting wild fry is a common practice in aquaculture and the global shrimp-prawn farming industry. Relying on wild fry as the preferred seed source for extensive systems has detrimental effects on both aquatic biodiversity and coastal ecosystems. The substantial monetary losses incurred from commercial bycatch species must not be overlooked. During the capture of *P. monodon* and *M. rosenbergii* fry in the Rupsha River, the fry collector encountered approximately 20 bycatch species using FBN and DN. The composition of both target and bycatch species captured varied based on gear types, sites, and seasons. Despite operational disparities, both methods significantly contributed to biodiversity loss and habitat degradation. The availability of wild prawn and shrimp post-larvae, along with the accompanying bycatch species, has steadily declined in recent years. Although larvae fishing generates short-term economic benefits for the rural impoverished population, it poses long-term threats to the health of aquatic ecosystems and jeopardizes the livelihoods of coastal communities. In the Rupsha River, the fry collector was responsible for the destruction of 25,992 bycatch species per person annually, with a mature stage monetary value estimated at 378,487 BDT per person per year. To address this issue, the Department of Fisheries (DoF) imposed a ban on wild post-larvae fishing and implemented seasonal restrictions on fish harvesting. The DoF also conducted training sessions to raise awareness about the impacts of wild post-larvae fishing and implemented penalties, occasionally confiscating fry collecting nets. However, the main obstacles to enforcing these regulations are the lack of alternative livelihood opportunities and the scarcity of high-quality post-larvae from hatcheries. Therefore, the DoF and non-governmental organizations (NGOs) should promote a sustainable approach that conserves aquatic biodiversity while simultaneously protecting the livelihoods of fry collectors. Strict monitoring and the implementation of a licensing system for collecting mature fish and shellfish among fry collectors could help alleviate the pressure on larvae fishing and safeguard biodiversity.

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Conflict of Interests
The authors declare no conflict of interest.

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