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Original Article

Diversity and conservation status of fish in the Nijhum Dweep National Park, Bangladesh

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Abstract
Nijhum Dweep National Park lacks a detailed inventory of aquatic fauna including fish. This study reported the diversity and abundance of fish along with their conservation status from the surrounding waters of the national park to fill the knowledge gap. Fish samples were collected randomly from 16 spots of surrounding water of the park between October 2017 and March 2018. There were 47 fish species recorded belonging to 10 orders, 27 families and 44 genera. *Odontamblyopus rubicundus* was the dominant fish species that comprised 20.24% of the total catch, followed by *Rhinomugil corsula* (15.54%), *Mystus gulio* (12.03%) and *Eleutheronema tetradactylum* (9.92%). One nationally Endangered fish species (*Clupisoma garua*) and three Vulnerable fish species (*Gudusia chapra*, *Sicamugil cascasia* and *Wallago attu*) were recorded. Fish diversity of the park was rich but exceeding extraction rate, huge disposal of by catch, and presence of exotic omnivorous fish species was disconcerting that require monitoring and further studies.

Keywords: Bay of Bengal; coastal fisheries; fish checklist; Marine Protected Area; Meghna Estuary

1 | INTRODUCTION

Nijhum Dweep National Park (NDNP), located in the south-central coast of Bangladesh, is a biodiversity rich area that includes diverse, globally threatened terrestrial and aquatic species (Iftekhar and Takama 2008; MoEF-BFD 2014). It is a destination for thousands of migratory birds and a part of Ganges-Brahmaputra-Meghna delta which has been recognised internationally as an Important Bird and Biodiversity Area (IBA) by Birdlife International (Das *et al.* 2020a). Government of Bangladesh has declared it as a protected area under the National Park category in 2001 for its floral and faunal richness (Iftekhar and Takama 2008) and declared a vast area of surrounding water as a Marine Protected Area (MPA) in 2019 for marine megafauna and fish resources (Bangladesh Gazette 2019). This area represents exclusive assemblage of freshwater, brackish and marine ecosystems with mangrove succession and therefore, produces a large natural stock of fisheries resources including molluscs, crabs and shrimps (Hossain *et al.* 2013; Saha *et al.* 2014).

People inhabit in this area are heavily dependent on fishing for their livelihoods. Especially being a spawning ground of commercially important and the national fish of Bangladesh i.e. *Tenualosa ilisha* (Hossain *et al.* 2016), Nijhum Dweep plays an important role in the local and national economy (MoEF-BFD 2014). A number of other commercially important fish and aquatic species such as barramundi, snapper, eel, goby, mullet, ribbon fish, crab, shrimp etc. along with non-commercials are also being harvested frequently from this site (MoEF-BFD 2014; Mustafa *et al.* 2018). Two local landing stations (Namar

Bazar and Mokhtaria) export on average 3615 tonnes fish each year (BBS 2011; Rahman *et al.* 2012; MoEF-BFD 2014). This extensive fishing along with the use of inappropriate gear and bycatch destruction are disrupting ecosystem balance, depleting fisheries stock of both target and non-target species, and eventually diminishing diversity (Molina and Cooke 2012; Kumar *et al.* 2019). Continuation of unsustainable fishing practices for a prolonged period will result in reduced ecosystem services which in turn will affect livelihoods of local people, people involved in the market chain and national economy (Cámara and Santero-Sánchez 2019). Nonetheless, information on a detailed inventory of aquatic fauna including fish, stock size of fisheries resources including commercially important species, extraction and depletion rate of these resources in Nijhum Dweep National Park (NDNP) are lacking (MoEF-BFD 2014). However, a list of fish species, based on landing centre data, is available (Mustafa *et al.* 2018) but conservation aspect remains unknown. Generally, in landing stations, the chance of mixing of wild catches with locally cultured ones covers a shed top of the actual scenario. To fill this knowledge gap with a straight forward checklist and conservation status at most possible details, here we report the diversity, abundance and conservation status of fish from the surrounding waters of NDNP.

2 | METHODOLOGY

2.1 Study area

Area of Nijhum Dweep National Park (22°03′51.4″N, 91°00′03.4″E) is 16352 ha and is located in the Meghna Estuary of the south-central coast of Bangladesh under Hatiya Upazila of Noakhali District (Figure 1). It is delimited in the east by Meghna River, in the north by Mokhtaria Channel, in the west by Shahabaj River and in the south by the Bay of Bengal. The area is inundated by tidal actions twice a day and is dynamic in nature where sediment accretion and erosion regularly takes place (Hossain *et al.* 2017; Das *et al.* 2020a) which affects the species composition (Coleman 1969; Milliman 1991; Uddin *et al.* 2015). This area is an important site for many globally threatened species proclaimed by International Union for Conservation of Nature and Natural Resources (IUCN) including Critically Endangered (*Calidris pygmaea*, *Orcaella brevirostris* and *Sphyrna lewini*), Endangered (*Tringa guttifer*, *Calidris tenuirostris* and *Urogymnus polylepis*) and Vulnerable (*Rhyncops albicollis*, *Prionailurus viverrinus*, *Lutrogale perspicillata*, *Susa chinensis*, *Neophocaena phocaenoides* and *Lepidochelys olivacea*) species (Islam and Khan 2005; Li *et al.* 2009; MoEF-BFD 2014; Bangladesh Gazette 2019; Mundkar *et al.* 2017; Das *et al.* 2020b). Around 20000 people live within NDNP and population density is 800 km^{-2} (MoEF-BFD 2014).

2.2 Sampling

Fish samples were collected randomly from 16 spots of surrounding water of the park between October 2017 and March 2018. As the fishing was dependent on tidal effect and availability of 'on spot fishermen', the sampling frequency varied from one to six per month at each site. In total, 3279 individuals of different fish specimens were collected. Majority of fish were bought from fishermen on spot, some were collected from the nearby landing station as well as by casting nets on the spot.

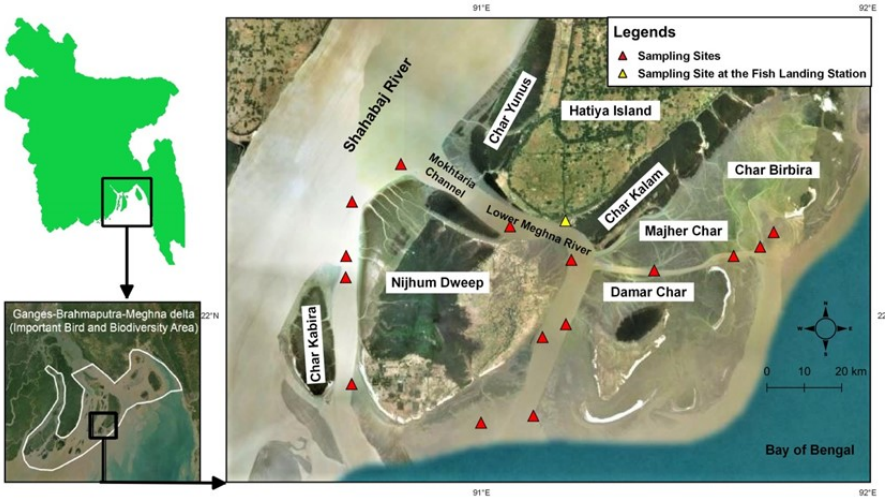

FIGURE 1 Nijhum Dweep National Park showing 16 field sites and one landing station for fish sampling.

Common fishing gears included fixed purse net (locally known as Bata jal and Behundi jal), gill net (Chandi jal and Poa jal) and cast net (Jhaki jal) were seen mostly as fishing gears. Moreover, in shoreline fishing especially for bentho-pelagic fishes, drag net (Thela jal) was also seen to be used frequently. Descriptions of the fishing gears are available in Table 1. A survey boat was operated for 240 hours during the study period. Collected fish specimens were preserved in an icebox, carried to the fisheries laboratory of the Department of Zoology, Jagannath University, Dhaka where it was stored in a freezer for further taxonomic assessments. Collected fish individuals were identified using morphometric and meristic characteristics (after Rahman 2005; Siddiqui *et al.* 2007; Rahman *et*

al. 2009). However, conservation status is based on IUCN red list of Bangladesh (IUCN Bangladesh 2015) and IUCN red list of threatened species (IUCN 2020). Moreover post fishing practices were examined during the study period to trace any threat to the ecosystem of NDNP. In addition, as a part of an opportunistic study, during three days back and forth of full moon, we have counted the volume of marketable and overthrown fishery products especially for the *Odontamblyopus* spp. from more than fifty mechanized boats.

TABLE 1 Commonly used fishing gears in the waters of Nijhum Dweep National Park.

Category	Name of gears	Shape	Total length (m)	Mesh size (inch)	
				Present study	Azam *et al.* (2014)
Fixed purse net	Bata jal	Conical	100	0.75	1.5 – 2 and 0.2 – 0.5
	Behundi jal	Conical	15	0.5 – 1	2 – 2.5 and 0.2 – 0.5
Gill net	Poa jal	Rectangular	200	1.5	3.5 – 4
	Chandi jal	Rectangular	2300	3.5	4 – 4.5
Cast net	Jhaki jal	Conical	NA	NA	0.25 – 0.5
Drag net	Thela jal	Triangular	2.5	0.25	0.1 – 0.2

2.3 Data analysis

Results were analysed through a tabular technique where simple statistic were used (e.g. average and percentage) using MS Excel. Month-wise data were compiled and arranged to understand the diversity of fishes in each month of the study area. Species diversity, richness and evenness indices were also calculated. The Shannon-Weaver diversity (*H*), Margalef's richness (*D*) and Pielou's evenness (*e*) indices were calculated using the following formulas:

Shannon- Weaver diversity index $H = -\Sigma\, Pi \ln Pi$ (Shannon and Weaver 1949).

Here, *H* is the diversity index and *Pi* is the relative abundance (s/N). *s* is the number of individual for each species and *N* is the total number of individuals.

Margalef's richness index $D = (s-1)/\ln N$ (Margalef 1968)

Here, *s* is the number of individual for each species, *N* is the total number of individuals and *D* is the richness index.

Pielou's evenness index $E = H/\ln S$ (Pielou 1966).

Here, *S* is the total number of species, *E* is the similarity or evenness index, *ln* is the natural logarithm and *H* is the diversity index.

3 | RESULTS AND DISCUSSION

3.1 Fish diversity

We recorded 47 fish species that belonged to 10 orders, 27 families and 44 genera during the study period (Table 2). *Odontamblyopus rubicundus* was the dominant fish species that comprised 20.24% of the total catch, followed by *Rhinomugil corsula*, *Mystus gulio* and *Eleutheronema tetradactylum* comprising 15.54%, 12.03% and 9.92% respectively (Table 2). Mustafa *et al.* (2018) reported 42 fish species from the landing stations of Nijhum Dweep of which only nine were common with our findings. Landing station-based sampling method could invite the difference. Fish in landing stations may arrive from a distance source that usually includes both open water captured and closed-water cultured fishes. We recorded an exotic fish *Oreochromis* spp. (tilapia). The early maturation, excessive fecundity and growth rate of tilapia can create pressure on the carrying capacity of local habitat, hybridisation with local fish disrupts genetic diversity, predating and outcompeting indigenous fish fauna and reduce indigenous species diversity and population (Canonico *et al.* 2005; Martin *et al.* 2010; Imteazzaman and Galib 2013). Both intensive and opportunistic aquaculture of tilapia by local people might be a potential source for seed or juvenile intrusion to the surrounding water body.

Perciformes was the most dominant order, comprised of 23 species belonging to 23 genera and 13 families (Table 2). Eight fish species belonging to 7 genera and 3 families under order Clupeiformes, 4 species belonging to 3 genera and 3 families under order Siluriformes and 2 species belonging to 2 genera and 2 families under order Beloniformes were also recorded (Table 2). Hanif *et al.* (2015) also reported Perciformes as dominant from coastal waters of Bangladesh. The family Gobiidae was the most diversified among 27 families represented by 8 species belonging to 8 genera accounting for 17% of the total fish species and 18% of total genera (Table 2). Other major families were Clupeidae (11% genera and 11% species), Mugilidae (9% genera and 9% species), Sciaenidae (7% genera and 6% species) and Polynemidae (5% genera and 4% species). The study area was an ideal habitat for fish species of Gobiidae family because they dwell in shallow coastal water, rivers (Allen 1991) and estuaries (Talwar and Jhingran 1991). Rahman (2005) enlisted 18 species of fish under the 15 genera of the Gobiidae family in Bangladesh. Of them, 44% species was recorded in NDNP.

3.2 Biodiversity indices

The average value of Shannon-Weaver diversity index (*H*) was 2.44. This suggests a satisfactory fish diversity condition around the water of NDNP (Figure 3). In coastal wa-

ter of Bangladesh Shannon- Weaver diversity index ranges from 1.5 – 3.5 (Hanif *et. al.* 2015). However, higher *H* value depends on the increase of both species number and evenness in a population. Index value 2.0 – 3.0 indicated light pollution level in the aquatic ecosystem (Biligrami 1988). In coastal habitats of Bangladesh, *H* value was ranged between 2.6 and 3.7 (in Naaf River, Chowdhury *et al.* 2011; southern coastal water, Hanif *et al.* 2015). The average value of *D* was recorded 4.00 with the highest (4.43) in February 2018 (Figure 3). Rahman *et al.* (2016) recorded *D* values between 4.72 and 5.24 in a coastal river of Bangladesh whereas Mustafa *et al.* (2018) recorded a mean *D* value of 4.45 in Nijhum Dwip. However, *D* value is influenced by sample size, changes in water depth, lack of rainfall, increased fishing rate, seasons and so on (Nair *et al.* 1989; Galib *et al.* 2013). The average value of *E* was 0.76 with the maximum (0.82) in October 2017 and the minimum (0.68) in March 2018. The *E* value, close to 1 means, the individuals are equally distributed (Sheldon 1969). Hence, the evenness value of October 17 indicates the most uniform distribution of individuals.

TABLE 2 Checklist of fish with their conservation status and percentage of total catch recorded in Nijhum Dweep National Park, Hatiya, Bangladesh from October 2017 to March 2018. DD, Data Deficient; EN, Endangered; LC, Least Concern; NT, Near Threatened; VU, Vulnerable; –, no data available in the red list.

Order and family	Scientific name	Common name (local name)	IUCN Bangladesh (Global) status	% of total catch
Clupeiformes (17% of the total species)				
Clupeidae	*Tenualosa ilisha*	Hilsa shad (Ilish)	LC (LC)	1.04
	Gudusia chapra	Indian river shad (Chapila)	VU (LC)	0.12
	Gonialosa manmina	Ganges river gizzard shad (Chapila)	LC (LC)	0.64
	Anodontostoma chacunda	Chacunda gizzard shad (Chacunda)	LC (LC)	0.04
	Sardinella longiceps	Indian oil sardine	– (LC)	0.08
Pristigasteridae	*Pellona ditchela*	Indian pellona (Choukka)	LC (LC)	0.08
Engraulidae	*Setipinna taty*	Scaly hairfin anchovy (Teli phasa)	LC (LC)	0.40
	Setipinna phasa	Gangetic hairfin anchovy (Phasa)	LC (LC)	0.08
Perciformes (49% of the total species)				
Gobiidae	*Glossogobius giuris*	Tank goby (Bailla)	LC (LC)	3.39
	Boleophthalmus boddarti	Boddart's goggle-eyed goby (Dahuk)	LC (LC)	1.20
	Taenioides buchanani	Burmese gobyeel (Raja chewa)	LC (DD)	1.91
	Trypauchen vagina	Burrowing goby (Sada chewa)	LC (LC)	0.24
	Odontamblyopus rubicundus	Rubicundus eelgoby (Lal chewa)	LC (LC)	20.24
	Apocryptes bato	Gobi (Chewa bele)	LC (LC)	0.44
	Pseudapocryptes elongatus	(Chewa)	LC (LC)	0.04
	Awaous guamensis	Scribbled goby (Bailla)	LC (LC)	0.04
Polynemidae	*Polynemous paradiseus*	Paradise threadfin (Tapasi)	LC (LC)	1.35
	Eleutheronema tetradactylum	Four finger threadfin (Tailla)	–	9.92
Sillaginidae	*Sillaginopsis panijus*	Flathead sillago (Tular dandi)	LC (–)	1.27
Sciaenidae	*Panna microdon*	Panna croaker (Chita lambu)	– (LC)	1.43
	Johnius coitor	Coitor croaker (Koitor)	LC (LC)	0.52
	Pterotolithus maculatus	Spotted croaker (Gutipoa)	– (LC)	0.04
Trichiuridae	*Lepturacanthus savala*	Smallhead Hairtail (Churi)	–	1.04
Terapontidae	*Terapon jarbua*	Tiger Perch (Borguni)	– (LC)	0.36
Scombridae	*Rastrelliger kanagurta*	Indian Mackerel (–)	– (DD)	0.04
Sparidae	*Acanthopagrus latus*	Yellowfin seabream (Datina)	– (DD)	0.88
Cichlidae	*Oreochromis* sp.	Nile tilapia (Tilapia)	– (VU)	0.04
Leiognathidae	*Gazza minuta*	Toothpony (Deto Chanda)	– (LC)	0.28
Latidae	*Lates calcarifer*	Barramundi (Bhekti)	– (LC)	0.20
Lutjanidae	*Lutjanus argentimaculatus*	Creek red bream (–)	– (LC)	0.12
Ambassidae	*Chanda nama*	Elongate glass-perchlet (Chanda)	LC (LC)	1.12
Mugiliformes (9% of the total species)				
Mugilidae	*Liza parsia*	Gold spot mullet (Bata)	LC (LC)	4.66
	Rhinomugil corsula	Corsula Mullet (Khorsula)	LC (LC)	15.54
	Mugil cephalus	Flathead mullet (Bhangan bata)	LC (LC)	3.31
	Sicamugil cascasia	Yellow-tail mullet (Kachki)	VU (LC)	0.20

TABLE 2 Continued.

Pleuronectiformes (4% of the total species)				
Cynoglossidae	*Cynoglossus arel*	Largesale tongue sole (Kukur jeeb)	LC (–)	6.18
	Cynoglossus lingua	Long tongue sole (Kukur jeeb)	LC (LC)	3.59
Tetraodontiformes (2% of the total species)				
Tetraodontidae	*Chelonodon patoca*	Milk spotted puffer (Potka)	DD (LC)	0.04
Beloniformes (4% of the total species)				
Hemiramphidae	*Hyporhamphus limbatus*	Congaturi halfbeak (Ek Thota)	LC (LC)	0.08
Belonidae	*Xenentodon cancila*	Asian needlefish (Kakila)	LC (LC)	0.32
Aulopiformes (2% of the total species)				
Synodontidae	*Harpodon nehereus*	Bankagduel (Loitta)	–	4.06
Siluriformes (9% of the total species)				
Bagridae	*Mystus gulio*	Long whiskers cat fish (Nuna-tengra)	NT (LC)	12.03
	Mystus cavasius	Gangatic mystus (Golsha)	NT (LC)	0.28
Schilbeidae	*Clupisoma garua*	Garua bacha (Ghaura)	EN (LC)	0.08
Siluridae	*Wallago attu*	Freshwater shark (Boal)	VU (VU)	0.04
Scorpaeniformes (2% of the total species)				
Platycephalidae	*Platycephalus indicus*	Gobi (Mur bailla)	LC (DD)	0.44
Cypriniformes (2% of the total species)				
Cyprinidae	*Ambylpharyngodon mola*	Carplet (Mola)	LC (–)	0.60

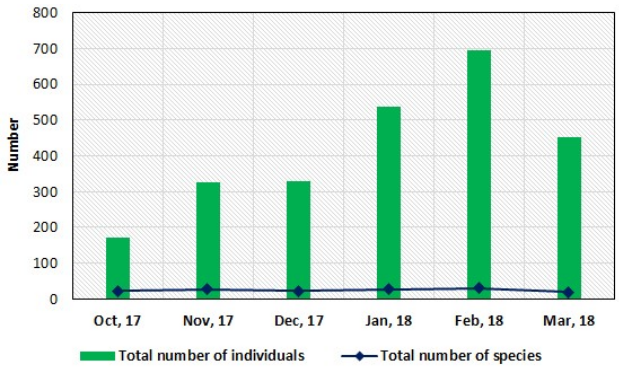

FIGURE 2 Number of fish species and specimens collected between October 2017 and March 2018 from the Nijhum Dweep National Park, Hatiya, Bangladesh.

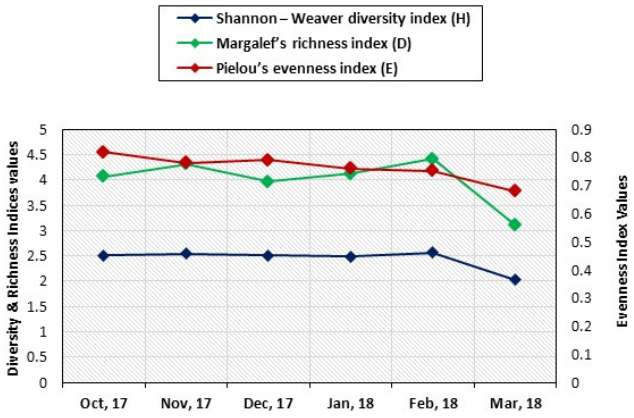

FIGURE 3 Diversity, richness and evenness indices of fish in Nijhum Dweep National Park, Hatiya, Bangladesh.

3.3 Conservation status

Out of 47 recorded species, conservation status of 34 fish species have been reported by IUCN Bangladesh (IUCN Bangladesh 2015) (Table 2). Of these, there were four Threatened, two Near Threatened, one Data Deficient and 27 Least Concerned species. Threatened species comprised of one Endangered (*Clupisoma garua*) and three Vulnerable (*Gudusia chapra*, *Sicamugil cascasia and Wallago attu*). Hanif *et al.* (2015) recorded 26.53% Locally Threatened, 11.22% Vulnerable, 10.20% Endangered and 5.10% Critically Endangered species out of 98 fish species from the southern coastal waters of Bangladesh.

3.4 Threats

Human population density of NDNP is high, 800 individuals km^{-2} (MoEF-BFD 2014) and they are dependent on fish and fisheries resources for their livelihood. This resulted in exceeding pressure on the natural resources of the park. For example, we had recorded a rough tally and did an empirical calculation for 6 days (3 days back and forth of full moon) around 20 metric tons of *Odontamblyopus rubicundus* had been captured daily during the peak time of which more than 50% were smaller than marketable size (20 – 25 cm; Hossain 2013). These were then dried for poultry feed and some were thrown into the water. Large amount of bycatch of bentho-pelagic fishes like *Cynoglossus lingua* and *Cynoglossus arel* were recorded. They were discarded because these species have no commercial importance in the study area. However, they certainly have functional role in the ecosystem and huge disposal of these species can cause ecosystem imbalance. Likewise, usage of fishing nets (i.e. gill net, set bag net and bottom trawling nets) with different mesh size to maximize the capture of target species results in increased bycatch of juveniles of target and non-target species. These indiscriminate harvesting might cause a detrimental effect on aquatic inhabitants and the ecosystem

of NDNP. Fisheries management plan (MoEF–BFD 2014) yet to highlight threats as unsustainable fishing practices were prevailing. Therefore, local fishermen were not aware of their legitimate fishing practices. We recommend further study, adopting strategies to mitigate threats in the management plan and awareness programme among fishermen.

4 | CONCLUSIONS

The present investigation documented fish diversity and abundance using different biodiversity indices in Nijhum Dweep National Park as well as annotated their local and global conservation status. Though it requires iteration, during this biannual period of study, current investigation recorded 47 fish species indicating a rich diversity around Nijhum Dweep. However ungoverned extraction rate, disposal of bycatch, and presence of exotic omnivorous fish species are disconcerting and requires proper and regular monitoring at this site. We recommend further studies on the detailed inventory of aquatic fauna, annual fish diversity and abundance, stock size of fish and other fisheries resources with the extraction and depletion rate. Monitoring the extraction of fish resources including threatened species and sustainable fishing practices are required to sustain a healthy ecosystem and to receive ecosystem services in the future.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTION

KKS conceptualisation, fieldwork, data analysis and manuscript (MS) preparation; **MSB** conceptualisation, data analysis and MS preparation; **IS** fieldwork and MS preparation; **NK** fieldwork and MS preparation; **SI** fieldwork; **MAB** MS review and editing; **DKD** conceptualisation, supervision, fieldwork and MS review and editing.

DATA AVAILABILITY STATEMENT

All voucher specimens are preserved in Fisheries Research Laboratory, Department of Zoology, Jagannath University, Dhaka 1100, Bangladesh. Additional clarification may be obtained from the corresponding author.

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