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Hilsa (*Clupeidae*: *Tenualosa ilisha*) predators in the marine and riverine ecosystems of Bangladesh

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ABSTRACT: The predators of hilsa shad (*Tenualosa ilisha*) in the marine and riverine ecosystems of Bangladesh were identified. Data on the availability of hilsa shad in the stomach contents of top carnivore fishes were collected from 324 individuals with diversified occupations and hilsa-dominated geographical locations. Data analysis revealed that 15 predatory fishes preyed on hilsa, of which tuna, mackerel, shark, Indian threadfin, red snapper and fourfinger threadfin are dominant predators of adult hilsa in the Bay of Bengal, while freshwater shark, giant catfish, river catfish, humped featherback, stripped snakehead and giant snakehead are the main predators of juvenile hilsa in the Padma-Meghna river systems of Bangladesh. Further research leading to predation observations in controlled experiments can provide novel and robust information on predator-prey interactions in the context of ecosystem-based fisheries management and conservation initiatives.

KEYWORDS: *Tenualosa ilisha*, hilsa fish, predator, Bangladesh, Bay of Bengal, Meghna river, Padma river

INTRODUCTION

Bangladesh is a major fish-producing nation, where fish production contributed 4.4 percent of the country's national GDP, 2.5 percent of foreign exchange earnings, 11% of employment, and 60% of all consumed animal protein[1]. The anadromous hilsa shad (*Tenualosa ilisha*) is the most abundant and largest single-species fishery in the Bay of Bengal region, primarily in Bangladesh[2]. Annual hilsa catch in Bangladesh at nearly 500 000 tons contributes $2 billion to the economy and provides livelihoods to 0.5 million fishermen and 2.5 million people in the value chain and distribution[3,4]. Availability of hilsa in the right place at the right time in its lifetime is an important conservation and management challenge in Bangladesh. However, changes in water temperature, precipitation and oceanographic variables, such as wind velocity, wave action and sea level rise, can bring about significant ecological and biological changes to marine and fresh water ecosystems and their resident fish populations, including predator-prey relationships[5]. Hilsa fishing was largely restricted to the rivers but the activity has been expanded to wider areas of the northern Bay of Bengal, leading to a significant increase of marine catch in recent decades[6,7] (Table 1). Hilsa is planktivorous, i.e., feed mainly on phytoplankton, zooplankton, ichthyoplankton, protozoa, small crustacean and mollusc. However, predators of hilsa have not been reported and thus to fill this information gap, the present initiative investigates predators of hilsa in the marine and riverine ecosystems of Bangladesh.

Table 1 Hilsa catch in Bangladesh[7].

Year	Catch quantity (MT)			Increase
	River water	Marine water	Total	(%)
1984–85	73 388	71 050	144 438	–
1990–91	66 809	115 358	182 167	26
1994–95	84 420	129 115	213 535	17
2000–01	75 060	154 654	229 714	8
2004–05	77 499	198 363	275 862	20
2010–11	114 520	225 325	339 845	23
2014–15	135 396	251 815	387 211	14
2015–16	137 456	257 495	394 951	2
2016–17	217 469	278 948	496 417	26
2017–18	232 698	284 500	517 198	4

MATERIALS AND METHODS

Focus group discussions and semi-structured interviews[8,9] were conducted among 215 profes-

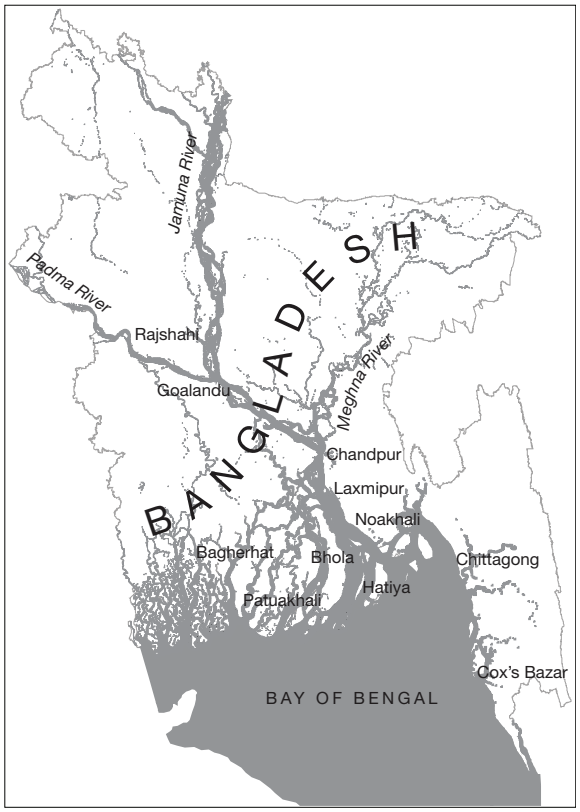

Fig. 1 Major hilsa landing locations in the coastal and riverine areas of Bangladesh, the grey areas indicate aquatic ecosystems (riverine, estuarine and marine)[2].

sional fishermen with >20 years' experience, 22 fish traders and 56 fish dressers with >10 years' experience in fishing villages, fish landing centres and local fish markets of Bhola, Hatiya, Lakshmipur, Chandpur, Noakhali, Patuakhali, Bagherhat, Rajshahi, Goalandu, Chittagong, and Cox's Bazar (Fig. 1) for the collection of data on the availability of hilsa in the stomach of top carnivore fishes. Correspondingly, 6 marine fish dressers (where marine trawl fishes are landed and gutted at the point of processing or marketing) were interviewed to share their experience of detecting hilsa during degutting large fishes. Interviews were conducted in the local language and centred on stakeholders' eyewitness account of hilsa predators that were observed during their professional duties (e.g., fishing, dressing, and processing), as well as associated phenomena (e.g., size of predators, seasonal change, quantity of hilsa in the stomach, life stage of prey hilsa). Additionally, interactions with 25 fisheries museum curators, instructors, researchers and academics have confirmed the information on hilsa predators.

Table 2 The respondent-identified predators of hilsa from marine and riverine ecosystems (n = 324).

Species	Weight† (kg)	Habitat‡	Prey (hilsa) life-stages
Shark	10–15	M	Adult
King mackerel	6–8	M	Adult
Yellowfin tuna	6–10	M	Adult
Indian threadfin	8–10	M	Adult
Fourfinger threadfin	4–6	M	Adult
Seabass	3–5, 8–12	R, M	Juvenile
Red snapper	4–8	M	Juvenile
Giant grouper	4–5	M	Juvenile
Bombay duck	0.2–0.3	E, M	Juvenile
Giant catfish	4–8	R	Juvenile
River catfish	3–5	R	Juvenile
Freshwater shark	3–4	R	Juvenile
Humped featherback	3–5	R	Juvenile
Stripped snakehead	2–4	R	Juvenile
Giant snakehead	3–5	R	Juvenile

† Common body weight.
‡ M=marine (Bay of Bengal), E=estuary (Meghna river estuary), R=river (Meghna and Padma rivers).

The data collection process involved 324 individuals from diversified occupations and different geographical locations of Bangladesh. Participatory appraisal evolved through a series of qualitative multidisciplinary approaches to learn about local-level conditions and local peoples' perspectives[10]. However, collection of predator species for analysing the stomach content was out of the scope of the present investigation. Collected data were analysed by using MS EXCEL, where respondent-wise predator data were used to develop cluster column diagram with an exponential trendline for the average data series.

RESULTS

Respondents from ancestral occupations (e.g., fishing, dressing, processing and trading), having hands-on experiences and indigenous knowledge, are invaluable to fisheries management for food and nutritional security. The respondents mentioned that the dominant predators of hilsa in the Bay of Bengal include shark (*Scoliodon sorrakowah*), mackerel (*Scomberomorus commerson*), tuna (*Thunnus albacares*), Indian threadfin (*Leptomelanosoma indicum*), fourfinger threadfin (*Eleutheronema tetradactylum*), and red snapper (*Lutjanus gibbus*). On the contrary, predators of the Padma-Meghna river system are represented by catfish (*Rita rita*), freshwater shark (*Wallago*

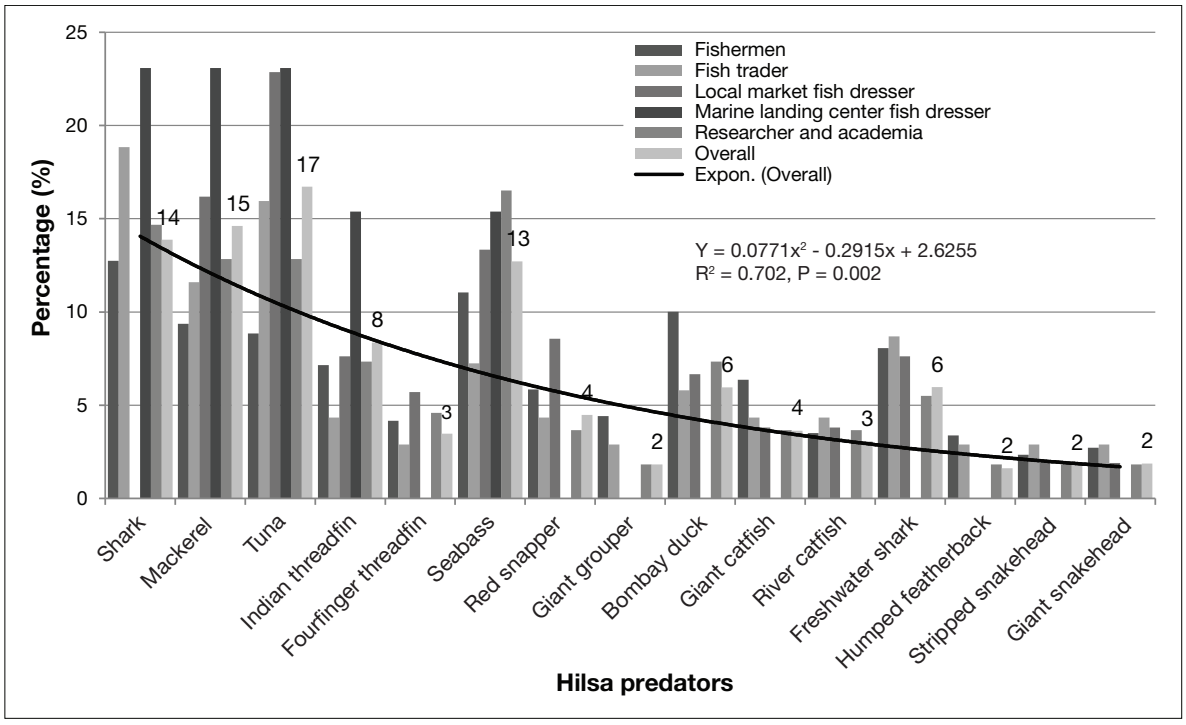

Fig. 2 Hilsa predators with relative importance in the marine and riverine ecosystems of Bangladesh.

auttu), giant catfish (*Pangasius pangasius*), river catfish (*Rita rita*), humped featherback (*Chitala chitala*), stripped snakehead (*Channa straitus*), and giant snakehead (*Channa marulius*). The respondents have identified fifteen predators, which prey on hilsa in the Bay of Bengal and Padma-Meghna river systems of Bangladesh (Table 2). In particular, tuna, mackerel, shark, Indian threadfin, red snapper and fourfinger threadfin are dominant predators of adult hilsa in the marine habitat representing 17, 15, 14, 8, 4, and 3% of responses, respectively (Fig. 2). These predators prefer hunting school-forming hilsa. In the Padma-Meghna river system, freshwater shark, giant catfish, river catfish, humped featherback, stripped snakehead and giant snakehead are the main predators of juvenile hilsa representing 6, 4, 3, 2, 2, and 2% of responses, respectively. Seabass (*Lates calcarifer*), being a euryhaline species, is a predator of juvenile hilsa both in rivers and coastal waters confirmed by 13% respondents. In addition, Bombay ducks (*Harpadon nehereus*) in the coastal and estuarine region are occasionally found with juvenile hilsa hanging out of their mouths and demonstrating 6%, while giant grouper (*Epinephelus lanceolatus*) represents only 2% respondents. The cluster column diagram showed predator-wise data from various respondents, including the average value. Additionally, the average data are also represented by the exponential trendline (Fig. 2).

DISCUSSION

The predator-prey relationships are complex, where predators can influence the dynamics of prey populations and prey can equally control predator populations. Mustafa[11] reported that a large portion of total fish biomass in the Bay of Bengal comprises of small demersal, medium demersal, medium pelagic and small pelagic groups. Accordingly, crustaceans, cephalopods, penaeidae, small mesopelagics and demersal group face high predation mortality by sharks in the oceanic ecosystem[12]. Specifically, Rohit et al[13] and Perera et al[14] found *Sardinella* spp. in the stomach of yellowfin tuna (*Thunnus albacares*) from the Indian Ocean. Food preferences of bullet tuna (*Auxis rochei*) are composed of anchovies, sardines and mackerel[15], whereas the dominance of clupeid fish is reported in the diet of Atlantic bluefin tuna (*Thunnus thynnus*)[16]. Similarly, Bakhoum[17] and Vahabnezhad et al[18] reported the presence of *Sardinella* spp. in the diet of king mackerel (*Scomberomorus commerson*) from the Egyptian Mediterranean coast and Persian Gulf, respectively. Bachok et al[19] reported the occurrence of anchovy,

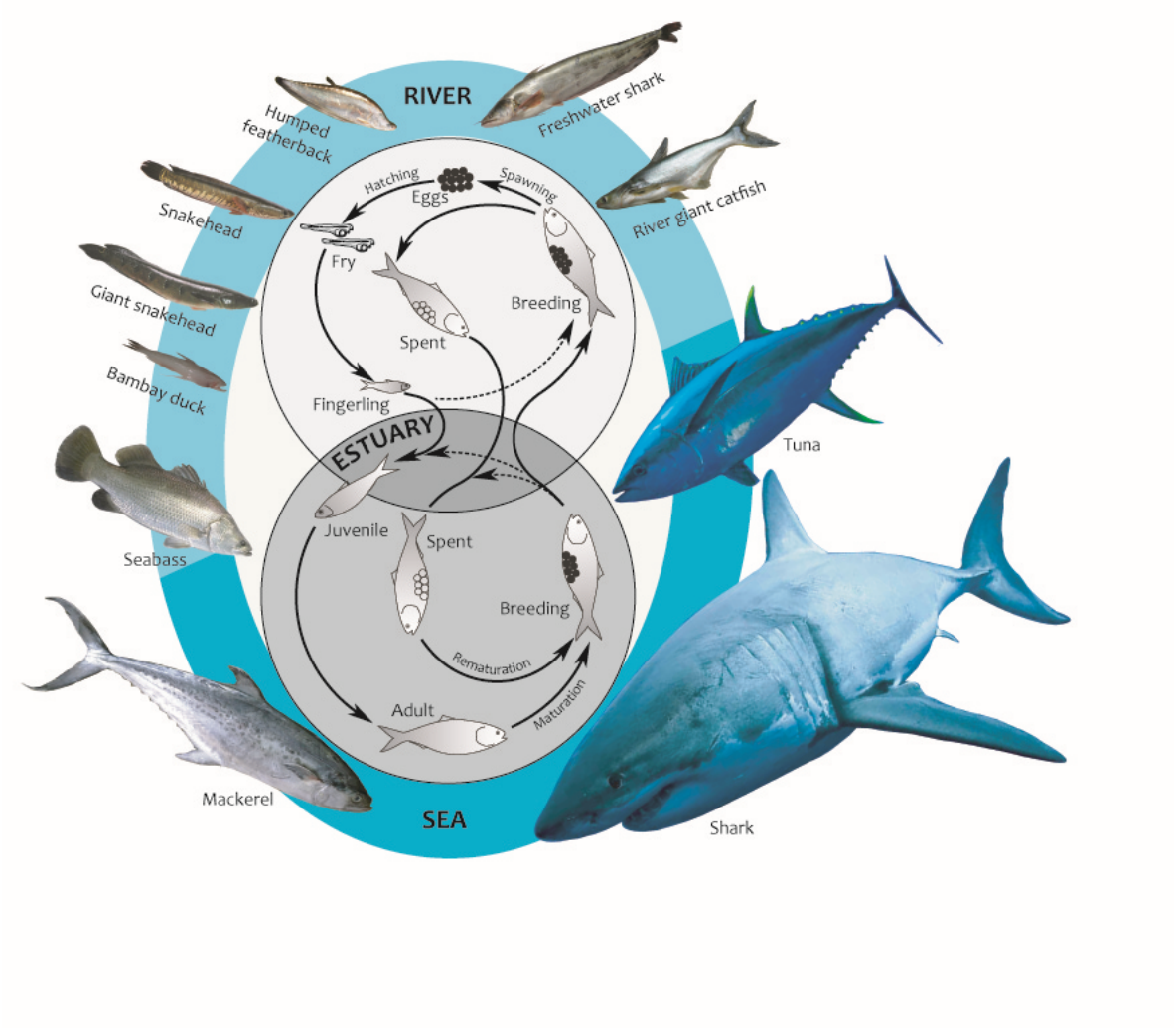

Fig. 3 A schematic representation of hilsa predators in the marine and riverine ecosystems of Bangladesh.

sardine and scad in the dietary compositions of tuna and mackerel from the Malaysian peninsular sea. The wide mouth gape and the presence of jaws with fine and re-curved teeth facilitate Bombay ducks in catching large sized preys including hilsa juveniles[20]. Freshwater shark, river catfish, humped featherback, stripped snakehead and giant snakehead are the dominant predators in freshwater bodies, including the Padma-Meghna river system. These predators mostly prey on small indigenous species of sprat, carplet, barb, minnow, perch, and gourami as well as juveniles of hilsa and carps. Reconciling the above facts, it is logical to illustrate major predators of hilsa in the marine and riverine ecosystems (Fig. 3).

It is necessary to identify priority areas of hilsa research and scaling-up science-based policy formulation[4]. However, ecosystem-based fisheries management (EBFM) in a designated geographical area can contribute to the resilience and sustainability of the ecosystem and recognizes the physical, biological, economic and social interactions[21]. In this connection, stock assessment of prey and predators with their abundance and geo-spatial distribution in the marine and riverine ecosystems are necessary.

CONCLUSION

Hilsa is the powerhouse of fisher's resilience in the coastal and riverine villages of Bangladesh. Juvenile hilsa was found to serve as key forage resources to riverine predators, whereas adult hilsa has served as a significant food source for generalist marine predators. However, predator's abundance and distribution can provide useful information for the

creation of management plans for hilsa fishery with potential conservation efforts. Further research leading to: (a) collection and analysis of gut content of potentially important piscivorous fish species and (b) predation observation in controlled experiment (e.g. in aquaria) can provide novel and robust information on predator-prey interactions in the context of the ecosystem based hilsa fisheries management.

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