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Bait specificity in Hook and line fishery of River Ganga and associated conservation issues

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Recent survey in lower 1,110 km stretch of River Ganga regarding 'hook and line' fishery revealed that fishers apply their inherited indigenous knowledge for selection of bait to harvest finfish and shellfish from river water. A total number of 26 different types of baits under 07 categories were recorded. Six varieties of fish species and four types of insects are found to be prevalent for catching carnivorous fishes. Five specially modified indigenous types of bait moulded with fish attractants were also documented. Bait-fish species association in hook and line fishery of river Ganga is discussed. Feeding habits of the target fishes was compared with the type of baits employed. Conservation issues associated with hook and line fishery is highlighted along with possible remedial measures. Different varieties of hook & line fishery which are in operation in river Ganga are briefly described. Indigenous Traditional Knowledge (ITK) associated with hook & line fishery needs to be properly documented and preserved for developing and encouraging 'sport fishery' in River Ganga.

Keywords: Bait-fish relationship, Conservation, Hook & line, ITK, River Ganga, Sport fishery
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The diverse nature of fish fauna in a large flowing river system like Ganga is best reflected through its fishing practices. As the river comes across varied topographical conditions, fishing exercises also vary notably. A number of fishing gears each having specific fishing techniques are put to use in river Ganga. However, such practices vary depending upon the landscape and availability of targeted fish species. Since the fishes belonging to upper trophic level of the aquatic ecosystem generally fetch higher economic return, therefore, attempts are mostly made to capture them through angling. Out of the several traditional fishing practices, hook and line fishing forms one of the most prevailing and feasible gears in terms of cost to exploit maximum of the pelagic, column and demersal fish species from the coastal waters[1]. Similar instances are met with the fishing activities of inland water bodies. Comprehensive work on fishing gears of inland waters of India - specifically of river Ganga was documented long back by several workers[2,3,4,5]. On the other hand, detailed documentation of non-selective fishing gears along with its sustainable measures from the lower stretch of river Ganga was put on record in recent past[6]. However, such documents lacked information related to specific hook & line fishery. Documentation of various fishing techniques of northeast India depicted four different types of hook & line fishing procedures[7]. However, being one of the popular fishing methods in the country operated in almost every water body, there is not much documentation regarding hook and line fishery techniques of the inland open waters especially of the major rivers like Ganga. In river Krishna, hook & line fishery is reported from almost entire stretch of the river[8]. This indigenous method of fishing is practiced both as a sport as well as means for livelihood producing substantial amount of catch from the open water bodies. The entire process of hook & line, being comparatively simpler as compared to other fishing practices, are found to be operated extensively in the entire middle and lower stretch of river Ganga. However, apart from different modes of hook & line fishing, variation of bait also plays a significant role. In this type of fishing techniques, the fishes are mainly encouraged or rather tempted towards gulping the bait. In a vast continuous flowing river system like Ganga, the type of hook and line arrangement is somewhat different (mostly multiple hook and line) in comparison

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to the one that is mostly operated in ponds, reservoirs and other lentic water bodies. This is mainly due to the fact that the fishers have their obligation to maximize their catch to earn bulk remuneration by operating multiple hooks from a single long line. The present paper is an attempt to document some unique bait-fish relationships under Hook and line fishery of river Ganga in the context of feeding habit of targeted fish species. Brief description of the existing practices of different forms of hook & line fishery in lower and estuarine stretch of the river were also given.

Methodology

The present investigation was carried out through quarterly sampling at selected stations extending from Buxar (Bihar) to Fraserganj (West Bengal) located in middle and lower stretch (1110 km out of total 2525 km) of river Ganga during the year 2016-2017. Three major fish landing stations in Bihar, viz., Buxar, Patna and Bhagalpur were covered in the lower middle segment of the river, while the lower and estuarine stretch was covered by nine sampling stations, viz., Farakka, Berhampore, Nabadwip, Tribeni, Barrackpore, Uttarpara, Godakhali, Diamond Harbour and Fraserganj (Indian Sunderban, river mouth) areas of West Bengal (Fig. 1 & Table 1). Collection of detailed information on hook & line fishery at each station and its related parameters like their mode of operations, baits used, and species caught, etc. was thoroughly documented and listed. Dimension of the hooks such as its thickness, gape and length were measured using Vernier calipers to the nearest 0.1 mm. Information was collected based on direct field observations as well as interactive interview sessions with the active fishermen using pre-scheduled questionnaire. Adjacent areas of targeted major stations were also explored to gather recent developments under this specific indigenous knowledge. Demonstrative samples of hook specimens, line and bait used were also collected as a part of investigation. Identification of the fish species (both fish as bait and as catch), biological baits like prawns, mollusc, earthworm, insects, etc. were confirmed after bringing to the laboratory following several taxonomical key[9,10,11,12].

Results and discussion

Size of hook

Hooks are made up of stainless or iron wire bent into a 'J' shape which has a pointed barb at the end for catching even most tough jawed fishes. The fish bites the bait attached at the pointed barb and hooks itself somewhere in the mouth. The target of fisher for

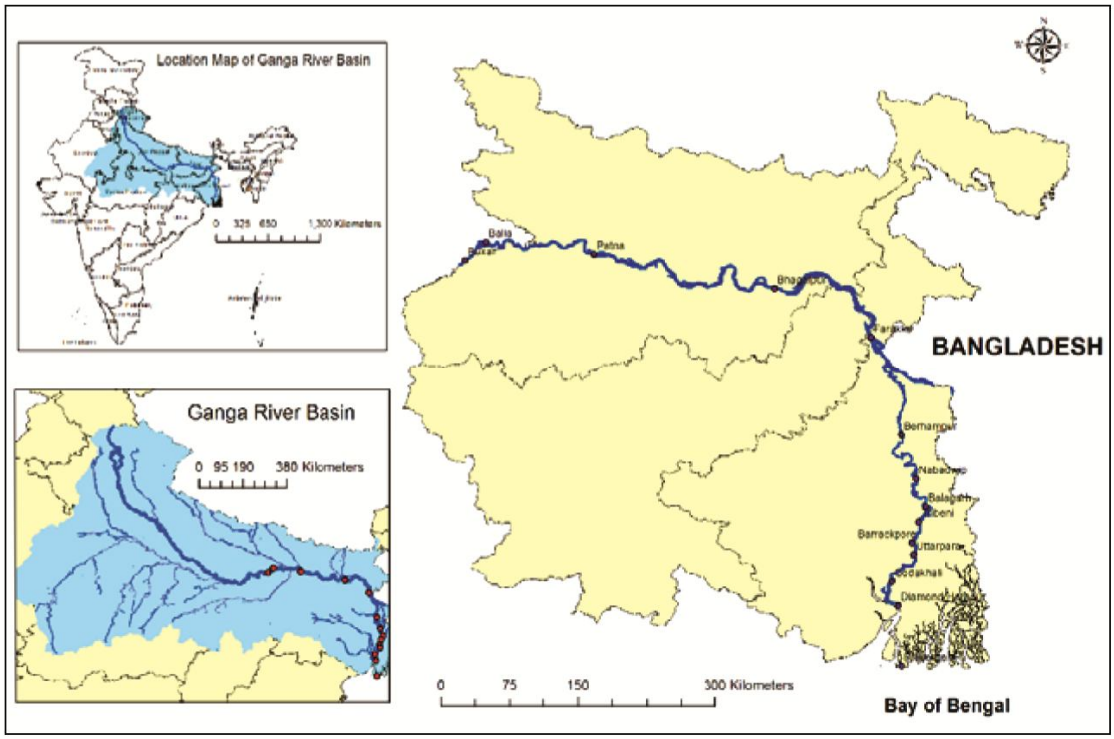

Fig. 1 — Sampling sites in middle and lower stretch of river Ganga, India

a particular size group of fishes certainly reflects in the size of hook used. Hook sizes are usually designated by numbers. The more is the number the less is the size and vice versa. Generally, sizes ranging from 2/0 to 14/0 are operated in river Ganga. Detail specifications of few hooks are mentioned as per the observation (Table 2).

Arrangement of hook

Four different types of arrangement of hook were recorded during the investigation. Considering the number of fishes targeted in a single operation, it can be divided into single hook and multiple hooks. Single hook is generally operated from a line attached with poles, usually made of long or short bamboo twigs or sometimes also used without any pole (Fig. 2a & Fig. 2b). The later, i.e., hand line (without any pole) has been recorded from Diamond Harbour (West Bengal), whereas the single hook (with long pole) was found operational at all the stations surveyed. Single line attached with short pole (drift line) was recorded at Nabadwip (West Bengal). In case of multiple hooks, it can further be classified into three different types, viz., one where multiple lines with attached hook are suspended separately from a single long line (Fig. 2c & Fig. 2d) and another where multiple lines with hooks are joined together. The later one is again can be subdivided into one where seven number of lines with attached hooks are clubbed together (Fig. 2e & Fig. 2f) and the second where two lines with hooks are joined together (Fig. 2g & Fig. 2h). Such special arrangement of seven hooks locally called as 'Tuka' or 'Feka' are explicitly used by the fishermen of Buxar (Bihar) to catch Indian Major Carps (IMCs) from river Ganga,

Table 1 — Geographical coordinates of the sampling points

Stations	Latitude	Longitude	Stations	Latitude	Longitude
Buxar	25°33'43.09" N	83°56'03.01"E	Tribeni	22°59'19.02"N	88°24'14.79"E
Patna	25°36'51.66"N	85°12'07.02"E	Uttarpara	22°38'59.66"N	88°21'07.79"E
Bhagalpur	25°15'28.33"N	86°58'53.89"E	Godakhali	22°23'57.29"N	88°08'03.04"E
Farakka	24°47'38.47"N	87°55'26.41"E	Diamond Harbor	22°09.53'85"N	88°12'19.21"E
Berhampore	23°50'11.01"N	88°13'52.08"E	Fraserganj	21°35'40.58"N	88°15'28.92"E

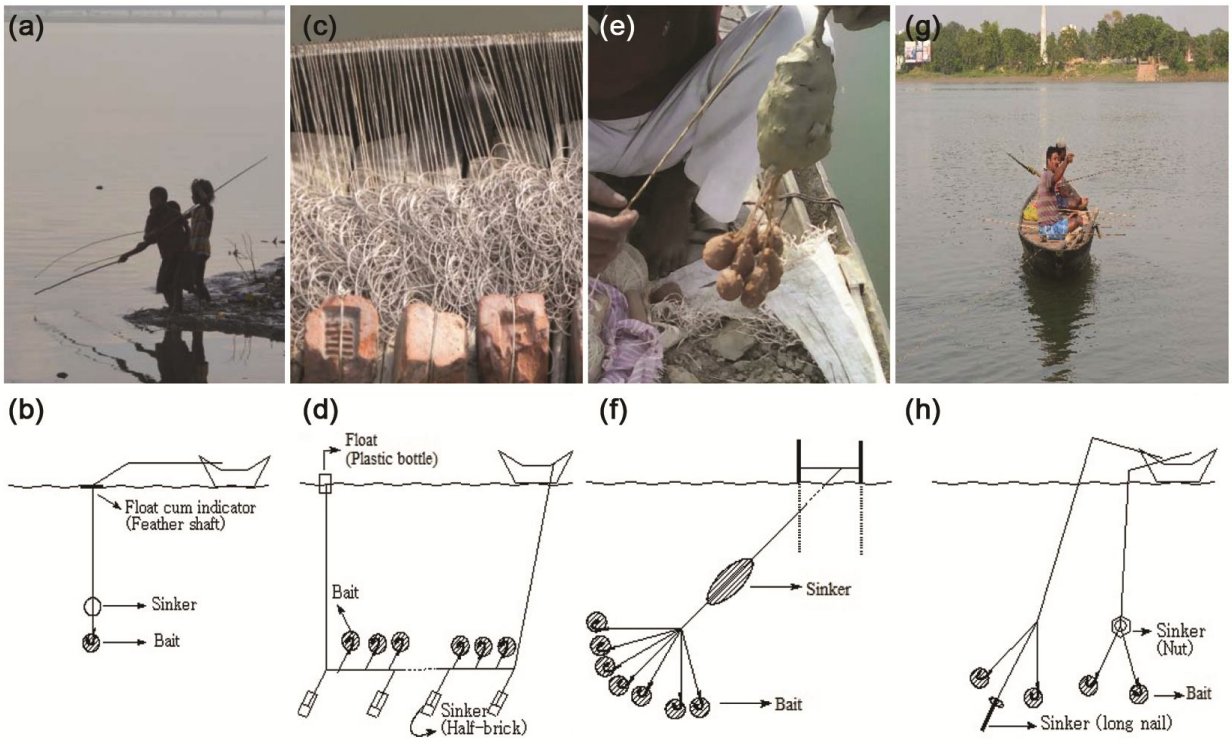

Fig. 2 — Different arrangement of hook as recorded from river Ganga. (a) Single hook from long pole; (b) Schematic diagram of single hook; (c) Multiple hooks ready for deployment; (d) Schematic diagram of multiple hooks; (e) Seven hooks from a single line (Buxar); (f) Schematic diagram of seven hooks from a single line (Tuka); (g) Operation of two hooks from a single line; (h) Schematic diagram of two hooks (Barrackpore).

while the arrangement of two hooks are found operational along Barrackpore (West Bengal) stretch of the river. Similar types of such multiple hooking systems are often utilized in the natural water bodies of north eastern states as reported[7].

Mode of operation

Single hooking system

Single hooking system (*banshi* or *barshi*) is mostly operated as a part of hobby by angling enthusiasts in the river not contributing much to the total catch. The system is operational throughout the year. The entire process is generally carried out from the riverbank or shoreline with no such specific spots. However, it can also be carried out from local plank-built boats. The operation of the gear is generally performed by one person at a time. Long nylon threads are used to lift out fishes directly from the water once those are attached to the hooks. This demands more activism from fishers who employ special expertise to lift hook-attached fishes out of the water as soon as there is an indication. Further, the single hooking system can be broadly classified into three different subcategories as observed in river Ganga.

Pole and line

In this type of fishing gear, a line with attached hooks is added to a long pole usually made up of bamboo twigs (Fig. 2a & Fig. 2b). Sometimes lines are passed through a small pulley fixed at the terminal end of the twig. The pulley allows swift movement of the line once the bait is gulped by a fish. A small piece of peacock feather shaft fastened with line acts as a float and as well as an indicatory material.

Hand line

Somewhat different from the traditional pole and line, here fishes are caught using hook and line devoid of any strong supportive rod. In this, the lines attached with baited hooks are usually thrown at long distances from the shoreline. Sinkers are used in the form of iron nuts (weighing approximately 50 g) (Fig. 3a). However, clusters of 5-6 nuts are also attached as sinkers depending upon the water flow and tidal effects along the estuarine zone of the river.

Drift line

Common drift lines (*nolbarshi*) are operated mainly in open wetlands adjacent to the main river channel where the flow is relatively low. This system was only recorded from Nabadwip (West Bengal) during the study period. In this, a hook (preferably No.8/0) is attached to a comparatively shorter (3.5 ft) line which is allowed to be suspended from a hollow short stick made up of local bamboo or hollow jute sticks of approximately 20.5 cm length. To avoid drifting of hooks, macrophytes like *Eichhornia crassipes* are attached to hold the bamboo pieces at a gap of approx. 5 ft. Similar practice of such *nolbarshi* was also recorded from the wetlands of northeastern India[7].

Multiple hooking systems

The concept behind multiple hooking methods is to entangle a greater number of fishes at a single operation. Such type of hooks (*Joar/Barshi*) is operated extensively from locally designed plank-built boats or *nauka*. At a time two to three individuals together go out for such hook and line fishing in the river. Even minor boats built with tin (locally called *Tiner donga*) comprising of single individual capacity are also used to lay hooks in the entire Farakkato Berhampore stretch of the river in West Bengal. Three types of such multiple hooking methods are mentioned below.

Table 2 — Size of hook vis-à-vis targeted species in river Ganga

Number of the hook	Length of hook (cm)	Gape of hook (cm)	Thickness of hook (mm)	Fish species targeted	Place of record
2/0	4.5	2.62	5.94	IMCs, *E. vacha, C. garua*	Patna, Berhampore, Uttarpara
3/0	3.0	7.81	5.11	*R. rita*, *M. armatus*, *Sperata* sp., *Mystus* sp., IMC, *Channa* sp.	Buxar, Farakka
4/0	2.4	1.94	5.36	*R. rita*, *M. armatus*, *Sperata* sp., *Mystus* sp., *W. attu, Bagarius* sp., *Sperata* sp., *C. garua*	Patna, Farakka Berhampore
5/0	5.3	16.95	1.52	*L. rohita, G. catla, C. mrigala*	Buxar
6/0	6.0	11.70	4.69	*R. rita*	Buxar
7/0	6.0	15.09	2.21	*W. attu*	Patna, Buxar, Farakka, Tribeni
8/0	4.9	13.26	2.17	*Bagarius* sp., *W. attu*	Berhampore
10/0	3.5	7.60	2.81	*Sperata* sp., *W. attu, Channa* sp.	Farakka, Berhampore
12/0	2.2	3.97	3.23	*M. rosenbergii*	Berhampore
14/0	2.5	2.66	5.27	*Channa* sp., *R. rita, C. carpio, M. armatus, Sperata* sp.	Buxar, Farakka

Long line

Hooks ranging from 500 to 2000 numbers are attached with bait which is mainly species specific. Nylon threads with such attached hook and bait are suspended with a fixed gap between each other from another thicker long nylon ropes in perpendicular manner (Fig. 2c and Fig. 2d). This remains fixed at the place of operation as heavy sinkers are attached with the line. Taking account of its easy availability, half-bricks weighing maximum of 1-1.5 kg each are customarily attached as sinkers in most of the long multiple hooking systems (Fig. 3b). Sinkers are attached after every ten to twelve numbers of threads with hooks. The more is the number of hooks, the less is the distance between sinkers. At the end of the entire system, float preferably of plastic bottle is affixed as a point of mark. At the other end, a full brick is attached as terminal sinker (Fig. 3c). Gap between two consecutive hooks remains at approximately 4.5 to 5 ft, long enough to avoid mingling of two consecutive threads. It involves much less activism as compared to pole and line operation. Owing to the river flow, the threads usually remain inclined in upright manner with attached hook and bait in the water column. Though the intensity of laying hooks increases during monsoon months (July–September), they are found in operation throughout the year in studied stretch of the river.

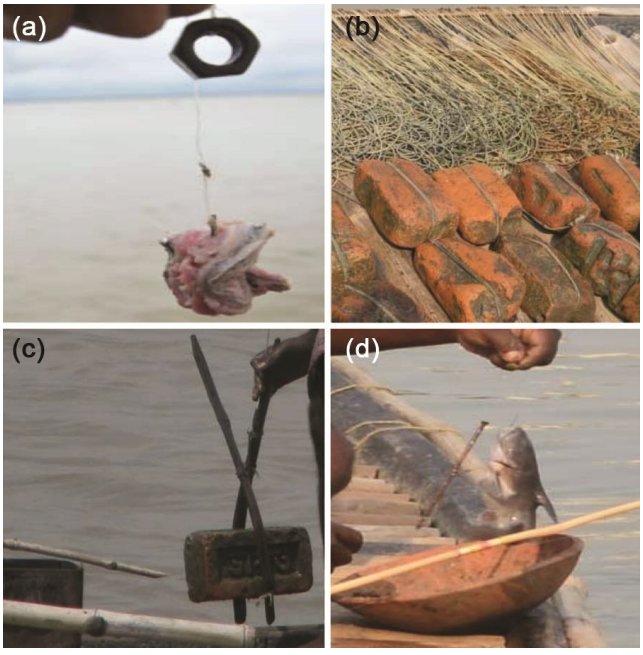

Fig. 3 — Different types of sinkers used in hook & line fishery of river Ganga. (a) Nut as sinker in Diamond Harbour; (b) Half-brick as intermittent sinker; (c) Full brick as terminal sinker; (d) Iron nail as sinker in Barrackpore

Aggregation of seven hooks

Aggregation of hooks was found to be important and unique fishing practices only in the Buxar-Balia stretch of the river. Seven lines with hooks (No. 5/0, 3/0 and 2/0) are attached to a main chord typically like a tree branch (Fig. 2e). Specially prepared bait (Fig. 12) is engraved to individual hooks separately or sometimes clubbed together as recorded. Sinkers comprising of heavy loaded adhesive mud are accumulated around the main single chord to settle the hooks in the river bed (Fig. 2e & Fig. 2f).

Aggregation of two hooks

Single line with two hooks has been recorded from Barrackpore and Diamond Harbour region of West Bengal. The design consists of a main chord from which two lines with attached hooks diverts (Fig. 2g & Fig. 2h). With the similar aim, a separate line with long (06 inch) nail or multiple iron nuts is joined to the main chord as a third branch which acts as sinker (Fig. 3d).

Timing of operation

Line with single hook is mostly operated during day hours as this type of fishing requires active participation by the fisher to make the hooked fish out of water. Complete operation of multiple hooking systems preferably takes place during night hours (6-12 h operation) and fishes are harvested in early morning between 4.00 to 5.00 h. Intermittent checking is also performed to see whether any fish has been caught in hook or any bait has been detached. However, it was also observed to be laid at any time during the day.

Categorization of the bait

Bait can be simply expressed as a piece of food material through which fish species can be tempted and caught. Bait may be broadly classified into two forms according to its mode of attachment such as live and dead. Selection of a suitable bait is the most important feature in hook and line fishery. Baits recorded under the present study are classified into seven major categories. These were gastropods, bivalves, insects, annelids, decapods, pisces and miscellaneous baits (Table 3). Miscellaneous baits included raw mutton fat, wheat ball, specially modified baits for IMCs made of dust of red soil, boiled rice, fenugreek etc., silkworm pupae based processed bait for herbivore species, flesh based processed bait for carnivore species, gram flour based processed bait for the planktivore species, etc. Out of all, fishing baits consisting of earth worm and small sized prawns were observed to be ubiquitous.

Table 3 — Classification of bait used in hook and line and their target species

Sl. No	Category of bait	Type of bait	Condition of bait	Fishes caught	Area of operation
1.	Gastropod	*Pila globossa* (Swainson, 1822)	Dead	*W. attu, Sperata* sp., *R. rita, Bagarius* sp., *M. aramtus, C. carpio, L. calbasu, P. pangasius, Notopterus notopterus*	Buxar, Patna, Berhampore
		Tarebia granifera	Dead	*C. carpio*	Buxar
2.	Bivalve	*Lamellidens marginallis* (Lamarck, 1819)	Dead	*R. rita, W. attu*, *Sperata* sp., *Bagarius* sp., *M. aramtus*, *L. calbasu*, *C. carpio, E. vacha*	Buxar, Patna
		Assiminea sp.	Dead	*C. carpio*	Buxar
		Parreysia sp.	Dead	*C. carpio*	Buxar
3.	Insecta	*Periplanetta americana* (Linaeus, 1758)	Dead	*P. pangasius*, *E. vacha*	Barrackpore
		Bombyx mori (Linnaeus, 1758)	Dead	*Clupisoma garua*	Berhampore
		Hodotermes sp. (Isoptera)	Dead	*C. garua,*	Tribeni
		Gryllotalpa sp.	Dead	*Channa* sp.	Nabadwip
4.	Annelida	*Metaphire posthuma* (Vaillant, 1868)	Dead	*W. attu*, *Sperata* sp., *M. aramtus*, *L. calbasu*, *E. vacha, R. rita*	Buxar, Patna, Bhagalpur
			Dead	*Channa* sp., *M. armatus*	Farakka
			Dead	*E. vacha, C. garua*	Berhampore
			Dead	*N. notopterus, Channa* sp., *M. armatus*	Nabadwip
			Dead	*R. rita,* *M. rosenbergii*	Barrackpore and Berhampore
			Dead	*Mystusgulio*	Lower estuary
5.	Decapoda	*Macrobrachium* sp.	Dead	*Sperata* sp., *Rita rita*	Buxar
		Metapenaeus sp.	Dead	*H. sagor*	Diamond Harbour
		Metapenaeus sp.	Dead	*P. paradiseus, Platycephalus indicus, Plotosus canius*	Lower estuary (Frasreganj)
		Macrobrachium sp.	Dead	*N. notopterus, Channa* sp., *Mystus* sp.	Nabadwip
		Metapenaeus sp.	Dead	*Arius arius*	Barrackpore
		Mangrove tree crab	Live	*Plotosus canius, P. pangasius*	Lower estuary (Frasreganj)
		Metapenaeus sp.	Dead	*Johnius dussumieri, A. arius*	Lower estuary (Frasreganj)
			Dead	*Lutjanus johnii, Eleutheronema tetradactylum, Scromberomorus commersoni, Johnius dussumieri*	Indian Sunderban
6.	Pisces	*Acanthocobitis botia* (Hamilton, 1822)	Dead	*R. rita*, *Sperata* sp., *W. attu*, *Bagarius* sp.	Buxar
		Boleopthalmus sp. (Pallas, 1770)	Dead	*P. canius*	Lower estuary (Frasreganj)
		Ilishaelongata (Bennett, 1830)	Dead	*H. sagor*	Diamond Harbour
		Macrognathus pancalus (Hamilton, 1822)	Dead	*R. rita, W. attu, Bagarius* sp.,	Buxar
		Salmostoma bacaila (Hamilton, 1822)	Dead	*W. attu, M. armatus*	Buxar
		Puntius sp. /*Pethia* sp.	Dead	*C. garua, Sperata* sp., *Bagarius* sp., *W. attu*	Farakka, Berhampore
		Pisodonophis boro (Hamilton, 1822)	Dead	*Scylla* sp.	Lower estuary (Frasreganj)
7.	Other forms of baits	Mutton fat	Raw	*C. garua, E. vacha*	Patna
		Wheat ball	-	*M. rosenbergii*	Godakhali
		Specially modified baits made of dust of red soil, boiled rice, fenugreek etc.	Processed	Indian Major Carp (IMC)	Buxar-Balia
		Silkworm pupae-based bait for herbivore species	Processed	Indian Major Carp (IMC)	Farakka
		Flesh based bait for carnivore species	Processed	*Sperata* sp., *W.attu*, *Rita rita*, *C. garua*	Farakka
		Gram flour-based bait for the planktivore species	Processed	*G. catla*	Farakka

Gastropods as bait

Invertebrate animals belonging to the group gastropods are widely used to attract fish species especially pertaining to the top level of trophic structure. Raw flesh of gastropod, *Pila globossa* are chopped and attached with the hook to attract fishes like *Wallago attu*, *Rita rita, Bagarius* sp., *Mastacembelus armatus*, *Cyprinus carpio* as observed at Buxar, Patna and Berhampore (Table 3 & Fig. 4).

Bivalves as bait

Due to its high demand for local consumptions, *C. carpio* (Common carp) is caught extensively using freshwater bivalves in Buxar (Bihar) from river waters. The bivalve muscle is attached with the hook after removing the hard shell. Flesh of freshwater mussel *Lamellidens marginalis*, is spotted also to attract good number of catfishes like *R. rita, W. attu* etc. in Patna, Bihar (Table 3 and Fig. 5).

Insects as bait

Insect like *Gryllotalpa* sp. is also considered to be useful for luring snake head murrels (*Channa* sp.) in Nabadwip area of West Bengal. Insects are collected from the compost mainly consisted of dry roots of water hyacinth (*Eichornnia crassipes*) for usage. Silkworm pupae (*Bombyx mori*) locally termed as '*polupoka*' was also observed to influence high catches of *Clupisoma garua* at Berhampore region of West Bengal. Fishers capitalize the pungent odour of such pupae as a trick to catch garua catfishes during monsoon to winter months. Flying termites (*Hodotermes* sp.) are often used to target *C. garua* at Tribeni. Similarly, cockroach (*Periplaneta americana*) was observed to lure *Pangasius pangasius* and *Eutropiicthys vacha* at Barrackpore (Table 3 and Fig. 6).

Fig. 4 — Gastropods as bait and its catch (*Bagarius bagarius*)

Fig. 5 — Bivalves as bait and its catch (*Rita rita*)

Annelida as bait

Earthworm (*Metaphire posthuma*) was found to be the most common and frequently used bait. For its easy handling and availability (Table 3) it was observed to be highly demanding bait for catching *Mystus gulio* in the estuarine stretch (Sunderbans) of river Ganga (Fig. 7). Likewise, earthworms are also used to catch large bagrid cat fishes and eels like *R. rita, Sperata* sp. and *M. armatus* from Farakka to Barrackpore (freshwater) stretch of the river.

Decapoda as bait

Prawns as baits were witnessed both in freshwater and estuarine stretch of river Ganga. Small non-peneaid and peneaid prawns of 1.0 to 2.0 cm size lengths are caught extensively every preceding night of the hook & line operation using seine net or bag net. Prawn as bait exhibits good catch of catfishes like *Sperata* sp., *R. rita* etc. (Table 3 & Fig. 8). Headless small prawns are used mostly in hand line and multiple line system as observed at Diamond Harbour and Barrackpore region for targeting catfish like *Arius arius*. They are also considered to be ideal bait for prized brackish water fishes namely *Polynemus paradiseus* and *Eleutheronema tetradactylum* from lower estuary.

Fig. 6 — Insect baits and its catch (*Channa marulius*)

Fig. 7 — Common earthworm and its catch in lower estuary (*Mystus gulio*)

Fig. 8 — Decapod as bait and its catch (*Arius arius*)

Pisces as bait

Small Indigenous Fish species (length<25 cm) like *Acanthocobitis botia* (Hamilton, 1822), *Puntius* sp. /*Pethia* sp., *Macrognathus pancalus* (Hamilton, 1822), *Salmostoma bacaila* (Hamilton, 1822), *Boleopthalmus* sp., *Ilisha elongata* (Bennett, 1830), etc. often regarded as by catches are extensively used to catch carnivorous fishes (Table 3 and Fig. 9). Common mud crab *Scylla serata* (Forskål, 1775) are widely caught through crab lining in the lower estuarine zone of river Ganga (Indian Sunderban) from mud flats or creeks. Small pieces of fish meat are tied with ropes devoid of any hooks. Crabs are pulled out of the river water once they hold the bait tightly[13]. Muscle pieces of paddy eel (*Pisodonophis boro*) are observed to be the most preferred fish to lure the crabs (Table 3 and Fig. 10).

Miscellaneous baits

Torn mutton fats as bait

Discarded mutton fats from slaughter houses are widely used to tempt minor catfishes such as *C. garua* and *E. vacha* in Patna stretch. This interesting form of bait is reported to attract riverine catfishes more effectively.

Processed baits

Beside involvement of several raw biological baits as discussed above, use of processed baits is also practiced. Though time consuming, it is almost like preparation of an appealing dish using a mixture of various ingredients. There are additions of many supplements to the main bait to make it more powerful attractant as observed. Bait preparation techniques is somewhat different from each other as seems to be modified by local fishers (ITK). Some of those processed baits are described below:

Fig. 9 — Fish bait (*Puntius* sp.) and their catch in river Ganga (*Clupisoma garua*)

Fig. 10 — *Pisidonophis boro* used as catch crab (*Scyla serrata*) in lower stretch of Ganga

Wheat ball as bait

Pieces of bread modified with several local accessible attractants are randomly used for enticing Giant Freshwater Prawn *Macrobrachium rosenbergii* at Godakhali-Uluberia region of lower estuarine stretch of Ganga (Table 3 & Fig. 11). Such miniature wheat balls are also used to grab catfish like *E. vacha* at Bali - Uttarpara stretch of the river in West Bengal.

Specially modified baits for Indian Major Carps

In 'Tuka' or 'Feka' fishing practice, bait blended with dust of red soil, boiled rice, fenugreek, gram powder, cardamom, master oil cake dust, locally available Dolphin oil etc. are randomly used to catch Indian Major Carps (IMC) around Buxar-Balia in middle stretches of river Ganga (Table 3 & Fig. 12). The sweet odour of the bait is reported to be appealing for carps.

Fig. 11 — Bait made of wheat ball and its catch of giant river prawn (*Macrobrachium rosenbergii*)

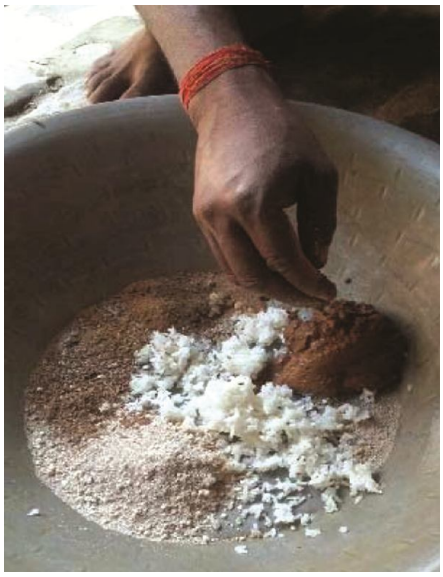

Fig. 12 — Preparation of bait for IMC in 'Tuka' fishery at Buxar-Balia, Uttar Pradesh

Gram flour based processed bait for the planktivore species

Ingredients: Gram flour (250 g), coconut oil (5 g), ghee (5 g), nutmeg powder (1-2 pieces), mace powder (5 g), cinnamon (2-3 g), cardamom (3-4 g), rice dust (5-6 g) and sugar syrup.

For preparation of bait, mace powder, nutmeg powder and cardamom are dry fried at first. Subsequently, other ingredients are mixed comprehensively with them to prepare into small pieces of sample bait. The adhesive nature of the sample is created using both ghee and coconut oil. Moreover, 2 to 3 cups of sugar syrup, alcohol (*mohua*) is also reported to be added while preparing the bait which mainly acts as useful fish attractant for fishes like *Gibelion catla* as observed in Farakka (Table 3, Sl. 7).

Silkworm pupae based processed bait for herbivore species

Ingredients: Silkworm pupae (250 g), boiled rice (40 g), bread (3-4 pieces), flour (50 g), gram flour or sattu (50 g), dried coconut powder (25 g), fragrance (2 pinches) and optional red ant egg (20 g).

Collected pupae are boiled for 30 min followed by drying. Dried boiled pupae are then made to dust before mixing it with pieces of bread. Further, they are thoroughly blended with dried coconut powder, boiled rice, gram flour and wheat to make a composite semi solid sample. Fresh and stale baits are reported to attract *Labeo rohita* and *Cirrhinus mrigala* respectively. Addition of locally available fragrances like vermilion (*suhaga/sindoor*) is also essential for enticing IMCs as recorded in Farakka (Table 3).

Flesh based processed bait for carnivore species

Ingredients: Pieces of fish flesh, gut contents of fish and attractants.

Deboned chopped pieces of minor carps like *Labeo bata, Cirrhinus reba* (250-300 g size) along with gut contents of *Labeo rohita* are chief ingredient for carnivore fishes. This results in catching large and minor catfishes like *Sperata* sp., *W. attu*, *R. rita*, *C. garua*, *E. vacha* and *Mystus* sp. as observed in Farakka (Table 3).

Bait in hook and line vis-à-vis feeding habit of targeted species

In riverine fishing conditions such as in river Ganga, fishers generally lay their hooking system in a method which coincides with the behavioural pattern of a targeted fish species. Fishermen imply their inherited knowledge in relation to the fishes to be captured and thus, procuring higher amount of catch. Such knowledge mainly includes feeding habit and dwelling habitat of a targeted fish species. Table 4 describes different baits used in hook and line vis-à-vis reported feeding habit of fish species harvested. From the information collected from various literatures as mentioned in Table 4, it is indicated that baits used in hook and line fishery are in agreement with the reported dominant feed component of the corresponding targeted fish species. In case of estuarine catfish species *Hexanematichthys sagor,* frequently used bait as observed is small shrimps and small flesh of fishes. However, as per its gut content analysis, the fish is reported to consume polychaetaes (61.7%), aquatic insects (18.2%), isopod (4.9%) to be the most. Thus, the process of selecting baits in hook & line fishery is mostly based on the economic conditions of the fishers; easy availability and cost effectiveness often overpower the feeding habit of the targeted species during selection of bait.

Conservation issues associated with hook and line fishery

Increasing human population is posing challenges for conservation of natural resources. Over the years, the growing fishing pressure has caused over exploitation of various resident aquatic animals of River Ganga. The most prominent example is of Gangetic Dolphin (*Platanista gangetica*), National Aquatic Animal of India. The species, which is listed as an endangered in the IUCN Red list (ver. 3.1), is witnessing a steady decline in its population from past few decades. Surprisingly, its oil is being frequently used as a fish attractant[14]. Oil extracted from the animal is mixed with the bait along with other ingredients in 'Tuka' fishery (Fig. 2e & Fig. 2f) to catch IMC in the stretch of river Ganga between Buxar and Patna in Bihar as reported. Fishers can be made aware about alternative attractant as mentioned by Sinha (2002)[14].

Besides Dolphin, vulnerable Gangetic River tortoises *Nilssonia gangetica* (Cuvier, 1825) are also susceptible to hook and line operation as noted from Berhampore in West Bengal. They often get hooked (No. 2/0) by gulping the bait containing silkworm pupae that are put inside water targeting fishes. When hooked, they are sold at local markets at high prices instead of being released back to the river, similar to the decline of certain sea birds and sea turtles around the world through hook and line fishing[15]. Intentional practice of targeting tortoise is also noted, which is highly detrimental for its sustainability. Fishers can be made aware about conservation need of this river tortoise species and also about the possible offence under Wildlife Protection Act, 1972.

Table 4 — Bait in hook and line vis-a-vis feeding habit of targeted species harvested

Fish & shellfish species	Commonly used bait as observed	Common food items of the targeted species	Feeding habits
Arius gagora (Hamilton, 1822)	Prawn	Crustacean->20%, Mollusc-20%, Fishes- 40%, Polycheates and detritus- 20%	Carnivore[18]
Bagarius bagarius (Hamilton, 1822)	*Pila globossa* *Lamellidens marginallis* *Macrognathus pancalus*	Mainly feeds on insects, small fishes, frogs and shrimps.	Carnivore [19]
Bagarius yarrelli (Sykes, 1839)	*Acanthocobitis botia* *Puntius* sp./*Pethia* sp.		
Channa marulius (Hamilton, 1822) *Channa striata* (Bloch, 1793) *Channa punctata* (Bloch, 1793)	*Gryllotalpa* sp.	Zooplankton-12.50%, Insects-23.53%, Crustacean-22%, Annelids-7.40%, Molusc-3.70%, Fish-55.56%	Carnivore[20]
Clupisoma garua (Hamilton, 1822)	*Hodotermes* sp. *Bombyx mori* *Puntius* sp./*Pethia* sp. Raw mutton fat	Insects- 40.80%; Fish -3.10%, Animal flesh-8.30%, Crustaceans & Molluscs- 1.10%, Algae & higher plant- 0.70%	Omnivore[21]
Cyprinus carpio (Linnaeus, 1758)	*Pila globossa* *Parreysia* sp. *Tarebia* sp. *Assiminea francessiae*	Detritus- 39.80%, Insect- 36.40%, Macrophytes-12.40%, Phytoplankton- 4.4%, Ostracods- 3.8%, Zooplankton- 2.2%, Gastropods- 1.0%	Omnivore[22]
Eleutheronema tetradactylum (Shaw, 1804)	*Metapenaeus* sp./*Penaeus* sp.	Feeds mainly on small crustaceans and fishes	Carnivore[23]
Eutropiichthys vacha (Hamilton, 1822)	*Lamellidens marginallis* *Periplaneta americana* *Metaphire posthuma* *Puntius* sp./*Pethia* sp.	Crustacean- 80%, Aquatic insect- 18.2%, Fish-13%, Mollusc- 4%	Omnivore[24]
Hexanematichthys sagor (Hamilton, 1822)	*Metapenaeus* sp. *Ilishae longata*	Insects- 3.1%, Aquatic insect- 18.2%, Shrimp-4.7%, Polychaetes-61.7%, Isopod-4.9	Carnivore[25]
Labeo calbasu (Hamilton, 1822)	*Pila globossa* *Lamellidens marginallis* *M. posthuma*	Organic matter-44.08%, Mollusc-19.27%, Diatoms- 8.34%, Plant matter- 6.42%, Algae-4.35%	Omnivore[26]
Mastacembelus armatus (Lacepède, 1800)	*Salmostoma bacaila*	Fish- 16.60%, Aquatic insects- 14.75%, Crustaceans- 10.78%, Molluscs- 8.50%, Annelids – 8.28%, Unidentified – 27.57%	Carnivore[27]
Macrobrachium rosenbergii (De man,1879)	*Metaphire posthuma* Modified wheat ball	Aquatic worms, Aquatic insects and insect larvae, Molluscs and crustaceans, Grain, seeds, nuts and fruits	Omnivore[28]
Mystus gulio (Hamilton, 1822)	*Metaphire posthuma*	Insect- 60%, Diatoms- 55%, Cladocerans- 7.2%, Prawns & Fish -12.14%, Gastropod – 6%	Omnivore[29]
Notopterus notopterus (Pallas, 1769)	*Metaphire posthuma* *Pila globossa*	Fish- 56.13%, Prawn- 85%, Insect- 30%, Insect larvae- 33.34%	Carnivore[30]
Johnius dussumieri (Cuvier, 1830)	*Metapenaeus* sp.	Polychaetos- 40.00%, Lingula- 40.00%, Crustaceans- 20.00%	Omnivore[31]
Pangasius pangasius (Hamilton, 1822)	*Periplaneta americana* Mangrove tree crab	Crustacea-17.50%, Insects- 14.15%, Mollusc-14.55%, Fish- 7.65%, Misc (plant matter)- 9.73%	Omnivore[32]
Polynemus paradiseus (Linnaeus, 1758)	*Metapenaeus* sp.	Feeds mainly on crustaceans (especially shrimps), small fishes, and bottom-living organisms.	Carnivore[23]
Plotosus canius (Hamilton, 1822)	Mangrove tree crab *Boleopthalmus* sp.	Crab- 80.63%, Insects- 7.67%, Fish- 7.18%, Aquatic insect- 16.89%	Carnivore[33]
Rita rita (Hamilton, 1822)	*Acanthocobitis botia* *Metaphire posthuma* *Macrognathus pancalus*	Mollusc- 29.2%, Insects- 24.8%, Teleost- 28.2%, Copepod- 9.1%	Carnivore[34]
Scromberomorus sp. (Lacepède, 1800)	*Metapenaeus* sp.	Fish – 98.58%, Isopod- 0.85%, Cephalopods-0.57%	Carnivore[35]

Contd.

Table 4 — Bait in hook and line vis-a-vis feeding habit of targeted species harvested (*Contd.*)

Fish &shellfish species	Commonly used bait as observed	Common food items of the targeted species	Feeding habits
Scylla serata (Forskål, 1775)	*Pisodonophis boro*	Mollusc – 51.85%, Fish- 22. 22%, Crustaceans- 10.19%, Mixed food – 5.56%	Carnivore[36]
Sperata aor (Hamilton, 1822)	*Acanthocobitis botia* *Pila globossa* *Lamellidens marginallis*	Teleost-58.70%, Insects- 27.73%, Crustacean- 8.21 %, Plant matter- 5.36%	Carnivore[37]
Sperata seenghala (Sykes,1839)	*Acanthocobitis botia* *Lamellidens marginallis* *Pila globossa*	Teleost- 92.46%, Insect- 22.44%, Crustacea- 11.66%, Plant debris- 11.05%	Carnivore[37]
Wallago attu (Bloch & Schneider, 1801)	*Salmostoma bacaila* *Pila globossa* *Metaphire posthuma* *Macrognathus pancalus* *Acanthocobitis botia*	Fish- 78.0%, Crustacea– 14.0%, Insects- 7.0%, Mollusc-1%	Carnivore[38]

On the other hand, for better returns, berried Giant freshwater prawns *Macrobrachium rosenbergii* are caught indiscriminately using hook and line with specially modified wheat balls as bait in Uluberia-Godakhali estuarine stretches. Fishermen deliberately lay their hooks and restrict their operation in the shallow regions to catch them during their breeding migration to brackish water zones and thus causing recruitment overfishing. Fishers from surroundings migrate to the region especially for gravid prawns posing immense fishing pressure.

Commonly available Gangetic schilbeid catfish *Eutropiichthys vacha* has been reported to be endangered in India[16]. However, in the face of rising demand they are also targeted through hook and line from the lower stretch (Bally-Uttarpara) of river Ganga much below (90 mm to 120 mm) their reported maturing size i.e., 131 mm to 140 mm[17] (Table 3). This is unfortunate to observe small fishes to be the prime target nowadays which were recorded to be as by catches previously. Again, rampant hauling of undersized catfishes *Rita rita* and *Sperata* sp. were noticed especially from middle stretches (Buxar and Farakka) of the river through hook and line. This should require immediate intervention by promoting mass fishing education, otherwise this deliberate act might have deleterious effect in the riverine food chain in future.

Conclusions

For pursuing and developing an effective fisheries management through hook and line, one must create a sound comprehension of the bait in accordance to the targeted fish species. Though there are number of fishing gears which often overexploit the fishery of river Ganga, the effect of hook and line in riverine fisheries is comparatively less destructive. Fishing using hook and line requires relatively less expertise and limited investment as compared to other fishing gears. It is counted to be the most suitable gear for poverty-stricken fishermen. Hook and line fishery attains second best popularity among the fishermen of river Ganga after gill net as observed. However, specific knowledge regarding bait for the targeted fish species is a prerequisite. Local knowledge for preparation of bait should be conserved through documentation; otherwise it may go into oblivion with time as young generation sometimes avoid fishing occupation due to less catch from the river. From the present investigation, it was observed that different types of baits are used in diverse places for the same target fish species. Hence, further study is required to identify the best i.e., the most suitable bait for a particular fish species. This in turn will help in standardizing the proper selection of best bait to entice the targeted fish species and thereby helping in the development of sport fishery in river Ganga.

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