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Catfish diversity, reproductive biology and development of induced breeding techniques for riverine catfishes of Bangladesh

Md. Khalilur Rahman* and Jubaida Nasreen Akhter
Bangladesh Fisheries Research Institute
Mymensingh-2201
*Corresponding author: e-mail: krahman2863@yahoo.com

Abstract

Species diversity, research status, and induced breeding techniques of catfishes of Bangladesh have been presented in this paper. A total of 55 catfish species have so far been recorded from different aquatic habitats of Bangladesh. Abundance and commercial importance have also been highlighted. The significant achievements in catfish research in Bangladesh so far been made is also stated. Catfishes being important food fishes of the people of Bangladesh and because recently their production is decreasing from inland openwater, induce breeding techniques of commercially important riverine catfishes have been developed. Among the different species, *Pangasius hypophthalmus* and *Pangasius pangasius* have successfully been induced by cPGE and HCG in 1993 and 2004, respectively. The breeding season, fecundity, hatching rate, % survival and nursery rearing techniques have also been discussed. Except for the *P. hypophthalmus* and *P. pangasius* none of the riverine catfishes could bred by applying inducing agents.

Key words: Diversity, Catfishes, Research status, Induced breeding, Bangladesh

Introduction

Fisheries are an important sector of economy, playing a dominant role in nutrition, employment generation and foreign exchange earning of Bangladesh. It contributes nearly 60% of the total animal intake, 4.37% to the GDP and 5-6% to country's exports earnings. About 1.2 million people are employed full time in the sector and 12.20 million people are partially dependent for their livelihood or employment.

The present fish production of the country is about 4.277 million tons of which catfish contribute a significant amount. From inland open water about 50,000 tons of catfishes are being harvested every year. Recent introduction of catfishes as culture species and due to development of their induced breeding, the contribution of catfishes is more than 4,41,600 tons from the pond culture system. Overall, the contribution of catfishes is about 10-15% of the country's total production. Instead of increase of catfish production from the culture, the

production is being depleted from natural waters because of improper management, over fishing and increasing unfavorable environmental conditions. Due to these and other man-induced changes, the natural spawning areas of these fishes have decreased rapidly limiting the natural recruitment. As a result, some of the species are now endangered and need protection from being extinct.

With the above background, a programme to study the reproductive biology and development of induced breeding technique of important riverine catfishes such as *Bagarius bagarius, Eutropiichthys vacha, Mystus aor, Pangasius pangasius, P. hypophthalmus* (*sutchi*), *Rita rita, Silonia silondia,* and *Wallago attu* was undertaken at Riverine Station, Chandpur from 1988. Research on riverine catfishes is being continuing to refine induced breeding technique and to develop nursery rearing method.

Although, some important work with the fishes belonging to the family Clariidae, and Heteropneustidae done both in Bangladesh and India, but the work with riverine species is more or less new in this sub-continent. The pond culture feasibility study of *Pangasius pangasius* was done earlier by Hannan *et al.* (1988) and Rahman *et al*. (1991 & 1992). Due to problem with induce breeding of local *P. pangasius,* fingerlings (3-5 cm size) of exotic *P. hypophthalmus*, whose artificial breeding in captivity is possible (Potaros & Sitasit 1976) was imported from Thailand in 27 August 1990. The species was successfully introduced and induce breeding technique was developed in Bangladesh in 8 May 1993 (Rahman *et al*. 1993). *Pangasius pangasius* was bred successfully for the first time in Bangladesh with cPGE at Riverine Station, Chandpur in 30 June 2004 (Rahman *et al*. 2006).

Materials and Method

To review the species diversity and state of catfish research, the published journals, books and references were consulted and compiled. The classification and arrangement of families up to genera were done in accordance with Rahman (2005). Taxonomic features were taken from Joyaram (1981) and Rahman (2005) and remarks on abundance and commercial importance of the species were done in accordance with Rahman (2005), authors own publications (Rahman *et al*. 1991, 1992, 1993, 1994a, 1994b, 1995 & 2006, Haldar & Sorowardi 2000) and from field observations. Most of the materials of reproductive biology and breeding technique study are the results of the riverine catfish project conducted at Riverine Station, Chandpur, during 1988-2006.

Moreover, published papers and articles on different aspects of biology, induced breeding and rearing of various catfishes have been reported by Hamilton (1822), Hora (1939), David (1963 & 1962), Bardach *et al*. (1972), Aizam *et al.* (1983), Ali *et al.* (1985), Hannan *et al*. (1988), Meenakaran (1986), Varikul & Boonsom (1968), Vinci (1984), Saxena (1972), Afser (1992), Devi *et al* (1991, Khan (1924 & 1934), Raj (1940), Chacko & Kuriyan (1948), Saigal & Motwani (1962), Azadi *et al*. (1985, 1988, 1990a, 1990b & 1992), Hossain *et al*. (1991 & 1992), Mollah & Tan (1982 & 1983), Mollah & Karim (1990), Zaman & Seng (1987), Bhatt

(1971a, 1971b, 1970 & 1968), Pantulu (1961 & 1962), Ahmad (1944), Anwar & Siddiqui. (1992), Khumar (1985), Lal & Dwivedi (1965 & 1969) and Doha (1974) were also consulted.

Brood management for gonadal development of *P. pangasius*

Experiments on the gonadal development of *P. pangasius* were conducted under different environmental conditions. A total of 80 fishes weighing 8-12 kg each, collected from the River Meghna during 1989-1991 and were stocked in three ponds of 0.17ha each. The stocking density was maintained at 1,025 kg/ha. Fish were reared with a non-pelleted feed containing fish meal 15%, mustard oil cake 30%, rice bran 30%, wheat bran 20%, wheat flour 3% and molasses 2% at the rate of 5% (wet weight basis) daily. Total daily ration was divided into two equal splits and was administered twice daily in each pond. Besides pond, 10 pairs of adult fish were reared with the same feed in a cage of 10 x 5 x 4 m size in the River Dakatia. In addition to the above brood stock, juveniles of Pangas (average 3-5 cm size) were collected during 1990 and 1991 and were reared in a separate pond with the above mentioned non-pelleted feed to develop a new brood stock.

A total of 40 old broods of *P. hypophthalmus* were reared in a pond while a new brood stock of about 100 individuals have been raised since 1993 from the fingerlings of the first generation of the old stock. Fishes were reared with a non-pelleted feed as done for *P. pangasius*. Observations on the maturity stages of ovaries and testes of *P. hypophthalmus* were made according to the methods prescribed by Nikolsky (1963).

Brood management for gonadal development of *Rita rita*

Rita rita, a bottom dwelling riverine catfish, is found in the large rivers of Bangladesh. Experiment on the rearing of broods of *R. rita* was carried in the freshwater ponds of the Riverine Station, Chandpur in 1990-1996. A total of 110 broods of *R. rita* averaging 1.0 kg were collected from the river Meghna during 1990 and 1996. All these fishes were reared in a pond of 0.17 ha at a stocking density of 650 kg/ha. Fishes were reared with a non-pelleted feed as supplied for *P. pangasius*. Monthly sampling was done to monitor the development of secondary sexual characters.

Brood management for gonadal development of *Mystus aor*

M. aor, a bottom dweller and nest builder, is found to breed in freshly inundated river banks. A total of 85 adult fish of *M. aor* averaging 2.5 were collected from the River Meghna in 1993 and 1995. The fish were reared in a pond of 0.17 ha along with *R. rita* at a stocking density of 700 kg/ha. A similar type of feed and feeding regime of *P. pangasius* was employed for their rearing. Monthly sampling was done to monitor their gonadal development and development of the secondary sexual characters.

Brood management for gonadal development of *Silonia silondia*

S. silondia is highly sensitive to pollution and oxygen depletion. Only 34 adult individuals of *S. silondia* weighing 2 to 4 kg were collected in December 1995 and were reared in a pond with other riverine catfishes. During May-July 1996, a total of 52 juveniles of *S. silondia* averaging 100-150 g were also collected from the River Meghna. Feed and feeding regime were similar to those of *P. pangasius*. Gonadal development was monitored monthly.

Brood management for gonadal development of *Bagarius bagarius*

Bagarius bagarius, a giant, voracious and deep water riverine catfish was collected from the River Meghna. It is a bottom dweller having carnivorous feeding habit. Only 27 adult individuals of *B. bagarius* averaging 5 to 7 kg were collected in December 1994 and reared in a pond with other catfishes. During May-July 1996, a total of 22 juveniles of *B. bagarius* averaging 200-300 g were also collected from the River Meghna. Feeding management and monitoring schedule were similar to those of other riverine catfishes were followed for *B. bagarious* also.

Artificial breeding

Experiments on the standardization of the hormone doses required for artificial breeding for above mentioned species were conducted with both carp pituitary extract (cPGE) and human chrionic gonadotropin (HCG). cPGE were prepared instantly during hormone administration from locally procured carp pituitary glands while imported HCG (Pregnyl of Organon and Profasi of Serono) were used.

Results

Species Diversity of Freshwater Catfishes

Bangladesh is rich with its fish fauna. About 260 species of freshwater fishes, 20 species of exotic fish including three catfishes occur in freshwater of Bangladesh. Accordingly, the species diversity of catfishes is also rich. About 50 species of catfishes were so far been registered. The species names of freshwater catfishes along with their genus and family are given below:

Family, Genus and Species	Key Characters and Remarks
Family Clariidae Genus *Clarias* Scopli, 1777 1. *Clarias batrachus* (Linnaeus)	Air breathing catfish, four pairs of barbels, rayed dorsal fin long, 66-71 rays and without any spine. Single species, confined to stagnant and muddy water. Culture and induced breeding technique developed. High priced commercial fish.

Family Siluridae Genus *Wallago* Bleeker, 1851 2. *Wallago attu* (Bloch)	Freshwater shark, mouth sub-terminal up to anterior border of eyes. Dorsal fin inserted above half of the pectoral fin, without a spine, pectoral fin with smooth spine. Single species, commercially important, found almost in all rivers and flood plain. Voracious feeder highly predatory behavior.
Genus *Ompok* Lacèpéde, 1803 3. *Ompok pabda* (Hamilton) 4. *O. bimaculatus* (Bloch) 5. *O, pabo* (Hamilton)	Butter catfishes, two pairs of barbels, maxillary and mandibular, latter rudimentary or small. Rayed dorsal fin, 4-5 rays without spine, pectoral fins with feebly serrated or smooth spine. Commercially important, high priced fish. Induced breeding developed, Occasionally mixed culture practiced. DO sensitive, Carnivorous.
Family Heteropneustidae Genus *Heteropneustes* Müller, 1840 6. *Heteropneustes fossilis* (Bloch)	Stinging catfishes, rayed dorsal fin short, without spine, adipose dorsal absent, pectoral fin with seven or eight rays and a strong spine serrated along the inner edge. Single species, primarily occur in freshwater pond, ditches swamps and marshy land. High priced commercial fish. Induced breeding developed.
Family Olyridae Genus Olyra McLelland, 1842 7. *Olyra Kempi* (Chaudhuri)	Barbels four pairs, dorsal fin without spine, pectoral with a short stout spine. Found occasionally in hill streams. DO sensitive.
Family Plotosidae Genus *Plotosus* Lacèpéde, 1803 8. *Plotosus canius* (Hamilton)	River eel catfish, rayed dorsal fins with both edges serrated pungent spine, pectoral fins laterally inserted with a strong serrated spine. Found in the estuaries and bay, ascend in rivers. Little commercial importance. Endangered.
Family Chacidae Genus *Chaca* Gray, 1831 9. *Chaca chaca* (Hamilton)	Square-head catfish, rayed dorsal fin with pungent spine, pectoral fins with strong serrated spine, six barbels. Found in rivers and flood plains. No commercial importance, even not eaten. Deep water bottom dweller, carnivorous. Endangered.
Family Schilbeidae Genus *Silonia* Swainson, 1839 10. *Silonia silondia* (Hamilton)	Two pairs of barbels; rayed dorsal fin with a spine. Pectoral with a strong spine serrated along both edges. Found in rivers and estuary, commercially important, landing decreasing.

Genus *Pangasius* Valenciennes, 1840 11. *Pangasius pangasius* (Hamilton)	Large size fishes, two pairs of barbels, rayed dorsal fin with a spine, pectoral fin with strongly serrated spine. Commercially important high priced fish, found in big rivers and estuaries sometimes in flood plains. One species present.
Genus *Clupisoma* Swainson, 1839 12. *Clupisoma garua* (Hamilton) 13. *C. murius* (Hamilton)	Four pairs of barbels, rayed dorsal fin, seven rays and a spine, pectoral fin with a spine serrated along inner edge. Two species, *C. garua* is dominant, have commercial importance, found in rivers, streams and canals.
Genus *Pseudeutropius* Bleeker, 1863 14. *Pseudeutropius atherinoides* (Bloch)	Four pair of barbels, rayed dorsal fin with a spine, pectoral fins with a spine serrated along both margin. Vary small size, have some commercial importance, found in rivers and floodplains.
Genus *Eutropiichthys* Bleeker, 1862 15. *Eutropiichthys vacha* (Hamilton)	Four pairs of barbels, rayed dorsal fin with a spine, pectoral fins with a smooth spine. Found in rivers and flood plains, have commercial importance.
Genus *Ailia* Gray, 1830 16. *Ailia coila* (Hamilton)	Four pairs of uniform barbels, longer than head. Rayed dorsal fin absent, pectoral fin with a smooth or serrated spine. Found mainly in the rivers, have commercial importance.
Genus *Ailiichthys* Day, 1871 17. *Ailiichthys punctata* Day	Barbels four pairs, shorter than half of the standard length, dorsal fin absent, pectoral well developed, occur mainly in river, little commercial value.
Family Amblycipitidae (Torrent Catfishes) Genus *Amblyceps* Blyth, 1858 18. *Amblyceps mangois* (Hamilton)	Four fairs of barbels, rayed dorsal and pectoral fin with a week spine, very rarely found, little commercial value
Family Bagridae Genus *Mystus* Scopoli, 1777 19. *Mystus aor* (Hamilton) 20. *M. seenghala* (Sykes) 21. *M. menoda* (Hamilton) 22. *M. gulio* (Hamilton) 23. *M. tengara* (Hamilton) 24. *M. vittatus* (Bloch) 25. *M. cavasius* (Hamilton) 26. *M. bleekeri* (Day)	Four pairs of barbels, generally longer than head, rayed dorsal fin with a spine, pectoral fins spine serrated along the inner edge. Most important food fishes of Bangladesh. Represented by nine species, these fishes are very numerous in the inland water of Bangladesh, exception is the *M. gulio* which is abundant in the estuaries and the Bay. *M. tengara* is the commonest of all available species. *Mystus armatus* is rare.

27. *Mystus armatus* (Day)	*Mystus seenghala* and *Mystus aor* are the largest members of the group. Jayaram (1955) proposed the sub-genus *Osteobagrus* for possessing an interneutral shield between occipital process and the basal bone of dorsal fin and elevated to genus *Aorichthys.* Commercially important.
Genus Bleeker, 1858 28. *Rita rita* (Hamilton)	Three pairs of barbels, dorsal fin rayed with a spine, pectoral fins with a serrated spine along the both edges. Found in river and estuaries. Moderate size fish, have commercial importance, but now endangered.
Genus *Chandramara* Jayaram, 1972 29. *Chandramara chandramara* (Hamilton)	Barbels four pairs, unserrated dorsal spine moderately strong, pectoral spine stout, small size, found in ditches, streams and canals, little commercial value.
Genus *Batasio* Blyth, 1860 30. *Batasio tengana* (Hamilton) 31. *B. batasio* (Hamilton)	Four pairs of barbels, rayed dorsal fin with a spine, rayed pectoral fin with a serrated spine along inner edge. Small size fish, have little commercial importance, found in rivers and canals.
Family Sisoridae Genus *Sisor* Hamilton, 1822 32. *Sisor rhabdophorus* (Hamilton)	Sucker catfishes, elongate, tapering posteriorly. Five pairs of barbels, dorsal spine week, finely serrated, pectoral spine serrated on both edge. Found in rivers of northern region of Bangladesh, very rare, little commercial importance.
Genus *Bagarius* Bleeker, 1853 33. *Bagarius bagarius* (Hamilton)	Four pairs of barbels, rayed dorsal fin with a smooth spine, pectoral fins' spine serrated along inner edge. Found through out Bangladesh, voracious and predatory, very big size (180 cm recorded) have commercial importance.
Genus *Gagata* Bleeker, 1858 34. *Gagata gagata* (Hamilton) 35. *G. cenia* (Hamilton) 36. *G. viridescens* (Hamilton) 37. *G. nangra* (Hamilton) 38. *G. youssoufi* (Rahman)	All the species have four pairs barbels, with dorsal and pectoral spines, found in rivers. Very small size, little commercial importance.

Genus *Hara* Blyth, 1860. 39. *Hara hara* (Hamilton) 40. *Hara jerdoni* (Day)	Very small size, no commercial importance. Bottom dweller, Clear and highly oxygenated water. Carnivorous. Pollution and DO sensitive. Endangered.
Genus *Erethistes* Müller and Troschel, 1845 41. *Erethistes pusillus* Müller & Troschel	Very small size, no commercial importance. Bottom dweller, carnivorous. Endangered.
Genus *Conta* Hora, 1949 42. *Conta conta* (Hamilton)	Barbels four pairs, dorsal and pectoral spine serrated both edges, found in flowing stream with sandy bottom, no commercial importance. Bottom dweller, Clear and highly oxygenated water. Carnivorous. Endangered. Pollution and DO sensitive.
Genus *Glyptothorax* Blyth, 1860 43. *Glyptothorax horai* Shaw and Shebbeare 44. *G. telchitta* (Hamilton) 45. *G. shawi* (Hora) 46. *G. rebeiroi* (Hora)	All the four species found in the Northern and Eastern rivers, little commercial importance. Pollution and DO sensitive.
Family Tachysuridae Genus *Tachysurus* Lacèpéde, 1803 47. *Tachysurus gagora* (Hamilton) 48. *T. nenga* (Hamilton)	Marine and estuarine, enters rivers, have little contribution in inland catch but contributes significantly along with other catfishes in marine catch (about 1% of the country total).
Genus *Batrachocephalus* Bleeker, 1846 49. *Batrachocephalus mino* (Hamilton)	Found in estuarine and Bay of Bengal, enters rivers, little commercial importance.
Genus *Osteogeneoiosus* Bleeker, 1846 50. *Osteogeneiosus militaris* (Linnaeus)	Found in estuarine and Bay of Bengal, enters rivers, very small size, little commercial importance.

Exotic catfish introduced in Bangladesh

Family, Genus and Species	Key Characters and Remarks
51. *Pangasius hypophthalmus* (Fowler)	Introduced from Thailand in 1990, adapted well, induce breeding and culture technique developed.
52. *Clarias gariepinus* (Burchell)	as above
53. *C. macrocephalus* (Güther)	as above
54. *Pangasianodon gigas* Chevey	Introduced from Thailand in 2006
55. *P. bocourti* Fowler	Introduced from Thailand in 2009

State of Catfish Research in Bangladesh

Bangladesh is abounding with a large variety of fishes but very little scientific studies have been done on fish and fisheries. Although the systematic studies of freshwater fishes fauna of this continent goes back to the work of Francis Hamilton, 1822. With other fish species of the sub-continent, Francis Day in 1878, published scientific account of the catfishes. Many useful taxonomic contributions on the fish fauna of India including Burma and Sri Lanka were done by many authors. Among them taxonomic account of freshwater fishes published by Jayaram (1981) is an excellent work. The most outstanding work on taxonomy of the fishes of Bangladesh was done by Rahman (1989). Among other contribution, the works of Hussain (1970), Doha (1973) and Rahman *et al*. 1991, 1992, 1993, 1995 & 2006 are important. The concepts of induced breeding and culture of freshwater catfishes of Bangladesh started with the establishment of Bangladesh Fisheries Research Institute in 1984. Both from its two stations, the Freshwater Station, Mymensingh and Riverine Station, Chandpur, a considerable amount of work have been carried out (Table 1). Some important works on catfishes were also carried out from different universities of Bangladesh (Table 1).

Table 1: Important research work done on catfishes of Bangladesh

Clarias macrocephalus:

Authors	Works done
1. Hussain A.K.M.A. 1988	Studied first feeding of *C. macrocephalus*
2. Mollah and E.S.P. Tan 1982	Studied reproductive biology of *Clarias macrocephalus*
3. Mollah and E.S.P. Tan 1983	Induce spawning of *Clarias macrocephalus* by HCG
4. Mollah M.F.A. 1984	Studied the effect of water temperature on the growth and survival of *C. macrocephalus* larvae
5. Mollah M.F.A. 1985	Studied the effect of stocking density and water depth on growth and survival *C. macrocephalus*
6. Mollah M.F.A. 1986	Cyclic changes in the ovary of *Clarias macrocephalus*

Clarias gariepinus

Authors	Works done
7. Ahmed *et al*. 1997	Studied the culture feasibility of *C. gariepinus* fry in glass tank and synthetic hapa
8. Alam *et al*. 1998	Studied the effect of testosterone propionate on growth, survival and sex ratio of African Catfish, *C. gariepinus*
9. Hussain *et al*. 1998	Studied on the optimum protein energy-ratio of *C. gariepinus*
10. Mollah and Karim 1990	First induced breeding of African catfish, *Clarias gariepinus* with mixture of HCG and cPGE

Clarias batrachus

11. Ahmed *et al*. 1980	Studied the food and feeding habit of *Clarias batrachus*
12. Ahmed *et al*. 1981	Tried for induce spawning of *Clarias batrachus*
13. Alam and Mollah 1988	Formulated artificial dry feed for nursing of *Clarias batrachus*
14. Alam and Mollah 1989	Experimented moist diets for rearing *C. batrachus* larvae
15. Bairage *et al.* 1988	Compared the different feed for *C. batrachus* fry rearing.
16. Barua *et al*. 1988	Studied L-W relationship and condition of *Clarias batrachus*
17. Barua *et al*. 1988 & 1986	Studied the reproductive biology of *Clarias batrachus*
18. Barua G. 1990	Studied gonadal development of *Clarias batrachus*
19. Islam *et al*. 1986	Determine the influence of stimulant, size and stock of fishes on the success of induce breeding of *C. batrachus*
20. Kamal Y. M. 1987	Standardized the breeding technique of *C. batrachus* and *Heteopneuestes fossilis*
21. Mollah and Nurullah 1988	Studied on the effects of feeding frequency on the growth and survival of *Clarias batrachus* larvae
22. Mollah M. F. A. 1987	Developed mass production and rearing of *C. batrachus* fry
23. Paul *et al*. 1989	Attempted to breed *Clarias batrachus* by PG extract
24. Rahman *et al.* 1987	Formulated quality feed from indigenous raw materials for culture of *Clarias batrachus*
25. Rahman *et al*. 1995	Produced hybrid vigor through cross breeding between *Clarias batrachus* and *Clarias gariepinus*
26. Rahman *et al*. 1997	Studied the effect of supplemental feeds on survival and growth of *Clarias batrachus* fry
27. Rahman *et al*. 1997	Experimented on breeding of *Clarias batrachus* in paddy field
28. Rahmatullah *et al*. 1983	Attempted to breed *C. batrachus* by pituitary hormone
29. Rashid *et al*. 1983	Recorded some metazoan parasites of *Clarias batrachus*
30. Saha *et al*. 1998	Developed rearing technique of *C. batrachus* larvae with formulated diets

Heteropneustes fossilis

Authors	Works done
31. Mollah *et al*. 1973	Experimented on the feeding of *H. fossilis* fry
32. Ahmed & Sanaullah, 1976	Studied metazoan parasites in *H. fossilis* and *C. batrachus*
33. Ahmed & Sanaullah, 1977	Studied infestation of helminths in *H. fossilis* and *C. batrachus*
34. Huq M. F. 1977	Determined the sexes of catfishes of Bangladesh through external characters
35. Mia G. K. 1984	Studied L-W relationship and condition factor of *H. fossilis*
36. Azadi & Siddique 1986.	Estimated the fecundity of *Heteropneustes fossilis*
37. Haque *et al*. 1988	Studies culture prospects of *H. fossilis* in floating net cages
38. Latifa and Begum 1989	Studied sex ratio and size frequency distribution of *H. fossilis*
39. Chandra and Khatun 1993	Identified a new species of *Caryophallacid cestoda* from *H. fossilis*

Pangasius pangasius* and *P. hypophthalmus

40. Ali *et al*. 1985	Food and feeding habits of *Pangasius pangasius*
41. Hannan *et al*. 1988	Studied culture feasibility of *Pangasius pangasius* in pond.
42. Rahman M. K. 1989	Formulation of feeds for *Pangasius pangasius*.
43. Rahman *et al*. 1992	Studied comparative growth rate and survival of two *Pangasius* species, *P. pangasius* and *P. sutchi*
44. Rahman *et al*. 1993	Developed induced breeding of *P. sutchi* for the first time
45. Rahman *et al*. 1994	Studies on embryonic and larval development of *P. pangasius*
46. Rahman *et al*. 1995	Studied the biology of *P. pangasius* of natural waters
47. Rahman *et al*. 1995	Produced hybrid pangas (*P. sutchi* ♀ X *P. pangasius* ♂)
48. Rahman *et al*. 2006	Developed induced breeding of *P. pangasius*

Rita rita

49. Rahman *et al*. 1991	Studied pond culture feasibility of *Rita rita*

Mystus cavasius

50. Akhtaruzzaman *et al*. 1991	Developed induced breeding technique of *Mystus cavasius*
51. Hossain *et al*. 1998	Studied on polyculture feasibility of *M. cavasius* with *Puntius gonionotus* and *Hypophthalmichthys molitrix*
52. Kohinoor *et al*. 1994	Studied monoculture feasibility of *M. cavasius* in pond

Mystus tengara

53. Alam S.M.N. 1989	Studied fecundity of *Mystus tengara*

Mystus aor* and *Mystus seenghala

54. Azadi *et al*. 1990	Established relationships between body measurements and some internal organs of *Mystus aor*
55. Azadi *et al*. 1992	Studied biology and fishery of *Mystus aor* in Kaptai Reservoir

Ompok bimaculatus* and *Ompok pabda

56. Hossain *et al*. 1991	Studied food and feeding habits of *Ompok pabda*
57. Hossain & Rahman 1992	Studied reproduction and fecundity of *Ompok pabda*.
58. BFRI 1994	Developed induce breeding technique of *Ompok bimaculatus*

Wallago attu

59. Anon 1997	Studied some aspects of biology of *Wallago attu*
60. Haldar & Sorowardy 2000	Studied food, feeding habit, predation rate, induced breeding and culture feasibility of boal fishes, *Wallago attu*

Eutropiichthys vacha

61. Azadi *et al*. 1988	Established length-weight and girth-weight relationships and condition factor of *Eutropiichthys vacha*
62. Azadi *et al*. 1990	Studied reproductive biology of *Eutropiichthys vacha*
63. Azadi *et al*. 1991	Studied food and feeding habits of *Eutropiichthys vacha*

Reproductive biology and development of breeding techniques

Gonadal development and induced breeding of *P. pangasius*

Microscopic examination revealed that the male fish developed secondary sexual characters by May which could be identified by their oozing condition of milt. Females though were found having slightly bulging belly yet they did not develop well. Artificial propagation were tried respectively with cPGE @ of 12 mg/kg of body weight (bw) and/or HCG @ 5,000 IU/kg bw during August to September, but ovulation did not took place except a few in 1992. Using the ovulated eggs embryonic and larval development was studied (Rahmat *et al*. 1994). All the fishes of the new stock seemed matured by May 1996 attaining an average weight of 3-4 kg. Most of the males were found at oozing condition but the females did not show the sign of ripeness. During August-September attempts were again made to induce them with cPGE and HCG at the earlier mentioned doses. There was no ovulation success with these stocks as well. In 1996-1998, a group of adult fishes (4-8 kg sizes) were kept under extreme feeding care both in the pond and riverine condition (floating cages hanged in the river Dakatia) and fed them as discussed earlier. Fishes kept in the ponds were given primary hormone dose with cPGE @ 2.0 mg/kg of bw, once monthly during January to July for expedition their gonadal development. Besides, another group of pond reared fishes were given priming hormone dose with LHRH-A_3 @ 4.0 and 10.0 μg/kg of bw, once monthly during January-July period for expediting their gonadal development.

Females which showed little swelling of the abdomen were injected with a preparatory dose of Damperidon @ 5.0 mg/kg of bw + Salmon gonadotropine 10.0 μg/kg of bw and a resolving dose of cPGE @ 5.0 mg/kg of bw at an interval of 12 hours during June to July. Yet, there was no ovulation. Males showed development of milt with injection of cPGE at 2.0 mg/kg of bw.In 2004, *Pangasius pangasius* was bred successfully with cPGE at the rate of 9 mg per kg of bw and the male received 3.0 mg of cPGE. Food and feeding rate are two important factors regulating optimum maturation of *P. pangasius*.

Gonadal development of *P. hypophthalmus*

Gross microscopic examination revealed that the ovaries of *P. sutchi* could be placed in six maturity stages (Table 2) and the testes in five (Table 3).

Table 2: Descriptions of maturity stages of the ovary of *Pangasius hypophthalmus*

Maturity stages	Descriptions
1. Immature virgin	Ovary colorless to translucent-cream, lanceolate and lobular in appearance. No oocytes are visible in naked eyes.
2. Developing virgin	Ovary translucent, yellowish in color and occupies 1/2 of the length of peritoneal cavity. Individual oocytes as tiny specks are visible in naked eyes.

3. Maturing or ripening	Ovary opaque-yellowish-brown in color, occupying about 1/2 of the ventral cavity. Eggs are visible in naked eyes as brownish-yellow granules. Blood capillaries are visible around the ovary.
4. Mature or ripe	Ovary large, opaque, brownish-yellow in color. Egg-yolk laden and are clearly visible by the naked eyes. Ovary occupies 4/5 of the peritoneal cavity. Blood capillary networks are highly developed around the organ.
5. Running or spawning	Eggs translucent and easily are extruded on slight pressure after cPGE or HCG treatment. Maximum sized eggs.
6. Spent	Ovary flaccid, flabby and blood-shot with thick whitish tough walls. Genital aperture of female looks inflamed. Some translucent and opaque (residual) eggs visible by the naked eyes.

Table 3: Descriptions of maturity stages of the testes of *P. hypophthalmus*

Maturity stages	Descriptions
1. Immature virgin	A pair of small, thread-like elongated colorless organ with slightly serrated edges.
2. Developing virgin	Testes translucent opaque white color, occupying about 1/3 of the length of the body cavity. Serration at edges becomes more sharp and pronounced.
3. Maturing or ripening	Testes more enlarged, occupying 1/2 of the length of the body cavity, opaque and dirty-white in color.
4. Mature or ripe	Turgid, greasy-white in color, greatly enlarged, occupying about 2/3 of ventral cavity. Finger-like structures become full of milt and are easily extruded by soft pressure as in other fishes.
5. Spent	Testes shrunken and flaccid. Finger-like structures revert to original sharp condition.

Breeding season of *P. hypophthalmus*

Observations were made for determining the breeding season of *P. hypophthalmus.* It was found that the breeding season starts from the late March and continues up to late August. However, peak spawning season lies between May and July. Spent and immature virgin fishes were found during September and October while developing virgin and maturing fishes were found between November and January. Mature fishes were found between February and March while running or spawning fish were found during the period of late March through mid September. It was also observed that spent male recover their milt after 2 months of stripping while female require 3 months to regain their eggs.

Fecundity of *P. hypophthalmus*

Relative fecundity (number of eggs per unit of fish) of *P. hypophthalmus* was estimated by gravimetric method. Total weight of the ovary was taken after removing excess water. Then sub-samples of eggs of 5g each were taken from the anterior, posterior and middle portion of the ovary. Each sub-sample was counted separately and the mean number was taken. Total numbers of eggs were calculated by multiplying the mean number of eggs in a sub-sample with the total weight of the ovary. *Pangasius sutchi* fishes matured at a minimum size of 2.0 kg. Mature and berried females had a mean (±sd) of 146.7±38.84 g of eggs/kg of bw with a mean number of 1350.5±272.8/g of eggs. Mean relative fecundity was 1936.5±503.2 eggs/g of bw. Smaller fishes had higher number of eggs/g of bw than those of the larger fishes and the ratio was 1.25:1. It is a quite high fecund fish in comparison to the other.

Egg colour and size of *P. hypophthalmus*

The color of unfertilized egg was yellowish-gray. The size of the unfertilized and fertilized eggs was 0.9 and 1.7 mm in diameter, respectively. Both fertilized and unfertilized eggs were adhesive, demersal and spherical in shape.

Induced breeding of *P. hypophthalmus*

On the basis of maturity of the fish and the breeding season, females were injected with cPGE @ of 6-10 mg/kg of bw and a dose of 8.0 mg/kg of bw was found very effective (Table 4). In case of HCG, females were given @ 1,000-3,000 IU/kg of bw, while males were given @ 100 to 300 IU/kg of bw. For females, 1/3 of the total dose of the required hormone was applied as preparatory dose after 6h of interval the rest 2/3 was injected as decisive dose.

Males received single hormone dose of cPGE @ 1-3 mg/kg of bw (usually 2.0 mg 3.0 kg of bw) during the decisive injection of the females. Females, were found ready for stripping after 6±1h of the final injection. The ready females were stripped and jets of yellowish-gray eggs were collected in a dry enamel bowl. Immediately after this, the males were stripped and the milt was mixed with the eggs for fertilization. Dry method of fertilization was followed to fertilize the eggs. Ratio of the male and female spawners was maintained at 1:1 and often 2:1. Though milt from one male is sufficient to fertilize the eggs of one female, yet milt of two males were generally used during fertilization. The eggs and milt were mixed together very gently using a bird feather for one and half minute and then rinsed with water for 2-3 minutes, to remove excess milt and the mucus. Before the eggs develop stickness, they were transferred to galvanized iron trays, round circular tank and cisterns, with water showers. Higher doses of hormone were required during the early and the late breeding season while low dose was required in the peak breeding season.

In all trials, *P. hypophthalmus* injected either with cPGE or HCG responded positively and ovulated within 5-7h after the final injection. During early and late breeding season, ovulation took little longer period of up to 10 h while it was shorter of up to 4 h during the peak season. Both cPGE and HCG were found effective for inducing *P. hypophthalmus* in captive condition. However, genital opening may be clogged due to improper doses of hormone during early and late seasons. Fertilization rate of eggs ranged from 75 to 95% depending on the season and the latency period. If the latency period is longer than normal, the fertilization rate was low. It may be due to accumulation of water within the ovary and the eggs shell.

Hatching of *P. hypophthalmus*

The fertilized eggs of *P. hypophthalmus* were found sticky and were reared in galvanized iron trays of 2.13 x 0.61 x 0.31 m (7 x 2 x 1 feet) size at a density of 30,000 per tray for 5 days. Continuous water shower was provided in each tray at the rate of 5.0 1/min. Hatching of the eggs started within 18 h and mostly completed by 24 h after fertilization, ranging between 27.1 and 29.20 day degrees (Table 4). The suitable water temperature for incubation ranged between 27°C and 29°C. Hatching often did not took place at water temperatures below 25°C and beyond 32°C, respectively. Hatching rate was satisfactory and ranged between 80 and 90% while survival of hatchling varied between 55 and 75%. Surface water from the nearby pond had to be used for hatchery operations that contained silts, debris, plankton and other aquatic organisms. Yolk-sac absorption usually completed with 48 h after hatching, ranging between 54.10 and 58.4 day degrees (Table 4, Fig. 1).

First feeding starts within 15-18 h after hatching although the fry contains yolk-sac at that time. Hatchlings were fed boiled egg yolk mixed with water or fish muscle paste from 18 h after hatching up to the next 36 h and then *Artemia* nauplii and live zooplankton were supplied as supplemental feed. It was observed that the hatchling became extremely cannibalistic if sufficient food was unavailable after 2nd day of hatching. A total of 4,50,000 to 5,50,000 numbers of 2 days old larvae were calculated from one kg of spawn. After this period their survival was recorded as 15%. Overall, low survival was probably due to the poor quality of water and inappropriate food at the early rearing stage. Use of only *Artemia* nauplii (Red Jungle brand) even after the 5th days after hatching (DAH) showed different rates of survival with different feeding and incubation regimes. An incubation rates of 1.0g egg/L of water and feeding with nauplii produced from 15.0, 35.0 and 40.0g or 5.0, 7.5 and 10.0g of *Artemia* after 5, 8 and 11 DAH produced the highest numbers (38 and 27 respectively) of fry/l of water (Table 4). Administration of minced but live *Tubifex* sp. every 6 h interval from the 4th day onwards increased the larval survival to a greater extent. After every feeding uneaten food stuff were siphoned out to prevent water fowling. After 5 to 10 days of rearing, fry were ready for stocking in the nursery pond. Further experiments are needed to increase the rates of survival in the hatching units or to develop other rearing methods.

Table 4: Mean numbers of 12 days old fry of *P, sutchi* produced/L of water (% in the parenthesis) at different incubation and feeding regimes, Bangladesh (degree days = days x mean water temp. in ^{O}C, DAH = days after hatching).

Egg incubation (g/l water)	Hatching duration (daydegrees)	Yolk-sac absorption (daydegrees)	Feeding upto 5 DAH with nauplii produced from	Feeding upto 8 DAH with nauplii produced from	Feeding upto 11 DAH with nauplii produced from	Fry produced (nos/L water)
0.75	27.10	58.10	10 g of *Artemia*	10 g of *Artemia*	20 g of *Artemia*	3.35 (2%)
1.0	29.20	58.15	5 g of *Artemia*	7.5 g of *Artemia*	10 g of *Artemia*	27.0 (12%)
1.0	28.87	57.80	10 g of *Artemia*	15 g of *Artemia*	20 g of *Artemia*	8.3 (4%)
1.0	29.07	58.40	15 g of *Artemia*	35 g of *Artemia*	40 g of *Artemia*	38 (17%)
1.25	28.90	58.00	10 g of *Artemia*	15 g of *Artemia*	20 g of *Artemia*	22.4 (8%)
1.5	28.90	58.00	10 g of *Artemia*	15 g of *Artemia*	20 g of *Artemia*	14.2 (4%)

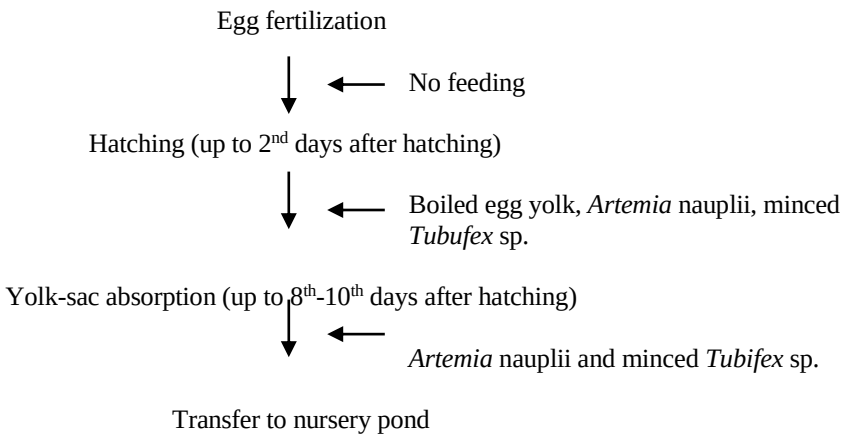

Fig.1: Schematic presentation of egg fertilization and larvae production in *Pangasius hypophthalmus*

Rearing technique of *P. hypophthalmus* in nursery pond

Fry of 5-7 days old were stocked in the nursery ponds at the rate of 2,000 to 3,000 individuals/decimal (40 m^2). Before stocking, ponds were prepared with lime and cow-dung respectively at the rate of 1 and 4 kg/decimal. Fry were reared for one month in the nursery ponds in the beginning alternately with live and minced *Tubifex* sp. and oil cake pest with 4

times feeding daily @ 10-12% of their bw. Later on a locally prepared non-pelleted diet containing 50% oil cake and 25% rice polish and 25% wheat flour was fed @ 10% of their bw daily. The total daily ration was divided into two equal portions and was given 2 times a day. Gradually feeding was reduced to 6-8% of the bw, daily. The fry attained a length of 5.5 to 8.0 cm after 15 days of rearing. The survival ranged from 10 to 15% only. The low survival might be due to poor quality of water and pond condition. Further investigations are required to find out the optimum stocking density and to increase the survival in the nursery ponds.

Gonadal development and induced breeding of *R. rita*

During the breeding season (May-July) adults never show secondary sexual character but females were found having soft belly with reddish oval genital opening and male were found with protruded genital organ but no milt. Females were injected with cPGE @ 3.0 kg/kg of bw. One third of the total hormone was injected as preparatory and the rest as decisive dose. Interval between the two injections was 6h. Males were injected with cPGE @ 3.0 mg/kg of bw at the time of final injection of the females. Other pairs of females were injected with HCG at a total dose of 3,000 IU/kg of bw. One third of the total hormone was injected as preparatory dose and the rest two third as final dose with 6 h intervals between the two injections. Males were injected once, @ 300 IU/kg of bw at the time of final injection of the female. The fishes were checked for 6 h after final dose. No sign of ovulation and oozing of milt were observed.

After that these fish were dissected to examine the maturity of the gonad. It was found that the fish with projected genital organ contained highly branched, thread like testes with milt, and the fish with oval shaped genital organ contained ovary with light yellowish ova.

Their annual cycle of GSI need to be studied both from the wild and culture origin to understand the state of maturity of ova and the breeding period.

Gonadal development and induced breeding of *M. aor*

During their breeding season (late February-June) females and males did not show external sign of gonadal development. Regular monthly monitoring of their maturity did not show any sign of swollen abdomen in the females and presence of milt in the males. Yet females with slightly distended abdomen were injected with cPGE @ 20.0 mg/kg of bw. One third of the total hormone was injected as preparatory dose and the rest two third as final dose. Interval between two injections was 6 h. Males were injected with cPGE @ of 5 mg/kg of bw once, at the time of final injection of the female. Other females were injected with HCG @ of 5,000 IU/kg of bw. One third of the total dose was injected as preparatory and the rest as final with 6 h interval between the two injections. Males were injected once with HCG at the time of final injection of the females @ of 500 IU/kg of bw. The fishes were checked up to 6 h after the final injection. There were no sign of ovulation and oozing of milt in all these cases too.

However, natural breeding of *M. aor* was observed in the pond during the first shower of monsoon. Small fingerlings of 0.5-0.7 inch sizes were found in the pond during late March onwards. Besides bowl shaped fine and smooth nests (quite different from those built by Tilapia) found in the pond bottom were though to be built by the *M. aor*. This feature indicates that *M. aor* is a low fecund fish. These features indicate that their state of maturity can not be confirmed by their external appearance. Their annual cycle of GSI need to be studied both from the wild and culture origin to understand the state of maturity of ova.

Gonadal development and induced breeding of *Silonia silondia*

This species also did not show secondary sexual characters during their breeding season (April-July). Yet, some females with soft, distended belly, reddish oval genital opening and males with protruded genital organ were selected for breeding under controlled conditions. Females were injected with cPGE @12.0 mg/g of bw. Similarly, one third of the total hormone was injected as preparatory and the rest as final dose. Interval between the two injections was 6 h. Males were injected @ of 3.0 mg/kg of bw once, at the time of final injection of the female. The fishes were checked up to 6 h after the final. No sign of ovulation and oozing of milt were observed. *S. silondia* was found to be very sensitive to handling an dissolved oxygen content of water. They were often found dead when handled and dissolved oxygen content of water goes <4.0 mg/L. Their annual cycle of GSI need to be studied both from the wild and culture origin to understand the state of maturity of ova and the breeding period.

Probable reasons for failure in induced breeding of local riverine catfishes

Poor gonadal development was observed in *B. bagarius, E. vacha, M. aor, R. rita* and *S. silondia* which might be due to environmental and/ or nutritional factors.

Problems in the understanding of the state of gonadal maturity of these fishes by their external appearance.

Sufficient number of adults could not be sacrificed and the state of ovarian maturity and GSI could not be ascertained due to shortage of fish and often funds.

Conclusion

Brood management, artificial breeding and nursery rearing techniques of *P. hypophthalmus* were established. Induced breeding techniques of *Pangasius pangasius* were developed with cPGE that needs refinement for mass seed production. While artificial breeding and consequent larval and nursery rearing techniques of *B. bagarius, E. vacha, M. aor, R. rita* and *S. silondia* could not be established.

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