ICAR

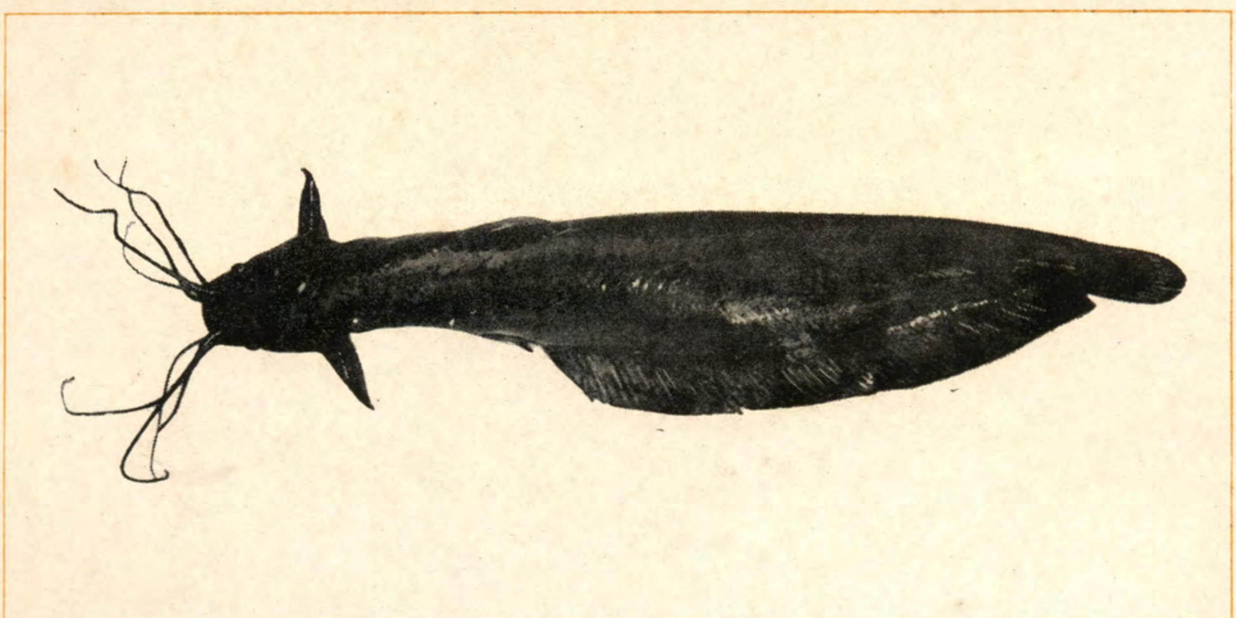
SYNOPSIS OF BIOLOGICAL DATA ON SINGHI

Heteropneustes fossilis (Bloch, 1795)

PREPARED BY

N. K. Thakur & P. Das

BULLETIN NO. 39 **APRIL 1986**



CENTRAL INLAND FISHERIES RESEARCH INSTITUTE • BARRACKPORE

SYNOPSIS OF BIOLOGICAL DATA ON SINGHEE
Heteropneustes fossilis (Bloch, 1794)

N.K. THAKUR AND P. DAS

Bulletin No. 39 October, 1985

CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
Barrackpore 743 101
India

Published by : D.D. Halder on behalf of Director,
Central Inland Fisheries Research Institute,
Barrackpore – 743 101,
West Bengal, India.

CONTENTS

1 IDENTITY

1.1 Definition

(According to Berg. 1947)

Phylum Vertebrata
Subphylum Craniata
Superclass Gnathostomata
Series Pisces
Class Teleostomi
Subclass Actinopterygii
Order Cypriniformes
Suborder Siluroidei
Superfamily Siluroidae
Family Sacchobranchidae
Genus *Heteropneustes* Muller, 1839
Species *Heteropneustes fossilis* (Bloch) 1794

1.1.2 Description

The fin formula of *H. fossilis* as described by various authors is given in Table I.

Table I
Fin formula of *H. fossilis* as described by various authors

Author	Fin formula				
Day (1889)	D.6-7;	P.1/7;	V.6;	A. 60-79;	C.19
Munro (1955)	D.7-8;	P.1/7;		A. 68-78	
Shaw and Shebbeare (1937)	D.6-7;	P.1/7;	V.6;	A. 60-79;	C.19
Srivastava (1968)	D.6;	P.1/7;	V.6;	A. 62-66;	C.19
Misra (1976)	D.6-7;		V.6;	A. 60-79;	C.19

Body elongate, subcylindrical to pelvic base, compressed behind. Head depressed, covered with osseous plate, dorsally and laterally; width equalling its length, 6.5; depth 7.5 in total length (5.4 and 6.4 in standard lengths) Snout 3.4 in head. Eyes with free orbital margins, lateral, 10.2 in head, 2.0 to 3.0 in snout. Nostrils wide apart, anterior tubular, the posterior slit-like, behind the nasal barbels. Mouth small, terminal, transverse. Maxillary barbels extending to middle of pectoral or to pelvic base; the outer and inner mandibular barbels extending beyound ends of pectoral; the nasal barbels to middle of pectoral. Teeth in villiform band in jaws; the vomarine in two pyriform patches on either side converging anteriorly and widely diverging posteriorly. Gill openings wide; gill membranes free from isthmus.

Dorsal short, without spine, 2.0 in head, in the anterior third of standard length, much nearer to snout end than caudal base. Pectorals 1.2 in head, not quite reaching pelvics, with a strong spine serrated internally, with a few external serrations at the anterior end, 1.5 in head. Pelvics 2.2 in head, reaching or not reaching anal; origin slightly behind or opposite dorsal origin, much nearer to anal origin than to pectoral base. Anal very long, not confluent with caudal origin; base 2.0 in total length. Caudal rounded, free from anal, 1.4 in head, 9.0 in total length. Lateral line.

Colour description of the fish as described by different authors is given in Table II.

Table II
Colour description of H. fossilis as described by different authors

Author	Colour description
Day (1889)	Leaden, sometimes with 2 longitudinal yellowish bands. The youngs are occasionally reddish.
Munro (1955)	Copper red in young. Dark brown in adult with two lateral yellow bands, ventrally lighter.
Shaw and Shebbeare (1937)	Dark purplish-brown, almost black, the young reddish brown.
Srivastava (1968)	Dark leaden brown, the youngs are reddish.
Misra (1976)	Skin smooth. Leaden or dark purplish brown; often with two yellowish lateral bands; young reddish brown.

The fish is very much dreaded for its poisonous pectoral spines which can inflict very painful wounds leading to local inflammation or even fever. Bhimachar (1944), who carried out studies on the poison gland in the pectoral spine of the fish, mentioned that the poison is secreted by the basal epithelial cells of the epidermis covering the spine. There is no special duct conveying the poison to the outside. When the spine is erected and brought into action, pressure is exerted by the skin on the poison and consequently, it is assumed, the poison is ejected through a temporary rupture of the skin at the tip of the spine into the wound made by the latter. The poison of the fish has both neurotoxic and haemolytic effects as it appears to affect both the nervous and blood systems. The prick of the pectoral spine of H. fossilis is sometimes fatal to other fishes. Day (1889) wrote that fishermen dread it so much that they prefer cutting the meshes of their nets and allow it to escape than endeavour to remove it uninjured. Putting the stung portion in hot water or over a hot plate gives a good deal of relief from pain (Personal experience).

H. fossilis is characterised by the possession of an accessory aerial respiratory organ in the form of a diverticulum on either side of its pharynx, which excavates the lateral body muscles and extends almost up to the tail end as a hollow tubular lung, which retains air and diffuse it to the blood channel. Morphological and anatomical details of the accessory respiratory organs of the fish have been studied by Munshi (1962), Hughes and Munshi (1973), Hughes et al. (1974), Munshi (1976).

1.2 Nomenclature

1.2.1 Valid scientific name

Heteropneustes fossilis (Bloch) 1974

1.2.2 Synonyms

1794 Silurus fossilis Bloch, Naturg. Ausland. Fische, 8, p.46 pl. 370, fig. 2 (type locality: Tranquebar).

1822 Saccobranchus singio Hamilton, Fish. Ganges, pp. 147, 374 pl. 37, fig. 46 (type locality: Ganges river).

1864 Saccorbranchus singio Gunther, Cat. Fish. Brit. Mus., 5, p.50 (Ganges, Bengal; Cochinchina; adult half grown and young from Ganges, presented by G.R. Whitehouse types of the species.)

1864 Saccobranchus fossilis Gunther, Cat. Fish. Brit. Mus., 5, p.51 (Delhi; Nepal; Khasi Hills)

1864 Saccobranchus macrocephalus Gunther, Cat. Fish. Brit. Mus., 5, p. 51 (type locality: Ceylon; 10 1/2" long).

1877 Saccobranchus fossilis Day, Fish. India, p. 486, pl. 114, fig. 1 (freshwaters of Sind, India, Ceylon, Burma and Cochin-China).

1889 Saccobranchus fossilis Day, Fauna Brit. India. Fish., 1, p. 125 fig. 53

1907 Saccobranchus fossilis Regan, Rec. Indian Mus., 1, p. 158 (Kathmandu, Nepal).

1910 Saccobranchus fossilis Jenkins, Rec. Indian Mus., 5, p. 138, (Bhamo).

1913 Saccobranchus fossilis Chaudhuri, Rec. Indian Mus., 8 pp. 244, 255 (Dibrugarh).

1920 Saccobranchus fossilis Pillay, J. Bombay Nat. Hist. Soc., 33 p. 358 (Trivandrum)

1936 Heteropneustes fossilis Hora, Rec. Indian Mus., 38, p. 202

1936 Saccobranchus fossilis D' Abrue, Rec. Nagpur Mus., 9 . p.32 (Godavari basin)

1937 Clarislurus kemratensis Fowler, Proc. Acad. nat. Sci. Philad., 89, p. 133, fig.5,6 (type locality: Kemrat).

1938 Heteropneustes fossilis Shaw and Shebbeare, J. Roy. As. Soc. Bengal. Sci., 3 (1937) No. 1, p.81, text-fig.71 (rivers and tanks in the Terai and Duars).

1938 Heteropneustes fossilis Hora and Misra, J. Bombay nat. Hist. Soc., 40, p.23 (Deolali).

1941 Heteropneustes fossilis Hora and Law, Rec. Indian Mus., 43, p.238 (Ceylon, India, Burma, Siam, Chochin-China).

1941 Heteropneustes fossilis Sen, J.Roy. As. Soc. Bengal. Sci., 7 p.9 (Salt lake, near Calcutta).

1945 Heteropneustes fossilis Smith, USS. nat. Mus. Bull., 188, p.345, (Thailand).

1948 Heteropneustes fossilis Chacko, J. Bombay nat. Hist. Soc., 48, p.191 (Periya lake, 3000 feet above sea level).

1955 Heteropneustes fossilis Munro (partim), Mar. Freshwater Fish. Ceylon, p.50, fig. 137 (ponds and tanks).

1.2.3 Standard common name and vernacular names

See: Table III

Standard common name and vernacular names of H. fossilis

Country	Standard common name	Vernacular names
Bangladesh		Singhi
Burma		Nga-gyee, Nga-kyee, Nga-khu, Nga-gyi
India	Singhee	Singee, Sheen-ee (Assam); Singhi (Bengali); Kamacha Singgi (Bhagalpur) Bitchu ka mutchee (Hindi); Bitchu, Talia, Singee (M.P.); Kahree-meen Theyli (Malayalam); Singi, Rata (Oriya); Lahoord (young ones), Nullie (adults) (Punjab); Thay-lee (Tamil); Marpu (Telugu); Singhee (U.P.)
Pakistan		Lohar, Lahoord, Nullie
Sri Lanka		Hunga, Kaha-hunga, Lai-hunga, Vel-hunga (Singhalese); Shunken (Tamil)
Thailand		Pla Cheet

1.3 General variability (races, varieties, hybrids)

No distinct races or varieties of H. fossilis are known. Baruah (1968) reported on occurrence of an immature albino specimen of H. fossilis from a pond at Joysagar Fish Farm in Assam. Intraspecific variation in H. fossilis has been studies by Gupta et al. (1963).

Ramaswami (1958) reported obtaining of intergeneric hybrids by crossing male *H. fossilis* with female *Clarias batrachus* and male *C. batrachus* with female *H. fossilis* and observed certain distinctive characters in them. Some work on hybridization has also been done during 1981 under the Coordinated Research Project (Workshop Report, 1982).

1.3.2 Genetic data
(Chromosome number, protein specificity)

Chromosomal studies in *H. fossilis* have been carried out by Verma (1961) and Nayyar (1966). The deploid number of chromosome in the fish has been reported to be 56, all being acrocentric type.

Some studies on the karyomorphology of *H. fossilis* have also been made under the Coordinated Research Project from the kidney tissue following the colchicine Citrate Air-drying Giemsa stain technique. Examination of more than 50 well spread metaphase plates in both males and females revealed the deploid number of 56 chromosomes in the overwhelming majority of cells. The morphological study indicated that the chromosome compliments consisted of metacentric, sub-metacentric and acrocentric types (Workshop Report, 1982).

The free amino acid make up of the fish, using paper chromatographic technique, has been studied by Siddiqui & Siddiqui (1969).

2 DISTRIBUTION

2.1 Natural range of distribution

Misra (1976) gives - "India: freshwaters and rarely in brackinsh pools of India, Pakistan, Bangladesh, Nepal, Burma, Sri Lanka, Indochina, Thailand, in the latitudinal and longitudinal range of 7° to 31° 37'N., 62°20' to 97°17' E. in Indian region and 14° to 15° N., 103° -109° E beyond Indian region".

2.2 Ecological characterization of its habitat

Same, as reported in the case of *C. batrachus*.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1. Sexuality

H. fossilis is heterosexual, Externally, sexes can be distinguished accurately only during the breeding season when the secondary sexual characters become prominent in the fish. Sexual dimorphism in the fish has been studied by Mookherjee et al. (1942), Sircar (1970) and Dehadrai et al. (1973).

The best morphological character indicative of a good brood female H. fossilis is a well rounded abdomen, the fullness of which extends posteriorly past the pelvic fins. The males, on the other hand, look lean. In a mature female, the genital papilla remains in the form of a raised prominent structure, looking round and blunt with a slit-like opening in the middle while in males, it remains in the f m of a pointed structure. During the breeding season, the papillionic difference becomes more marked as the palilla gets suffused with blood, looking more firm and reddish in colour.

Males of H. fossilis do not develop any sign of roughness on the dorsal surface of their pectoral fins as found in the case of Indian major carps with the advent of monsoon.

3.1.3 Maturity

Bhatt (1968) classified the gonads of H. fossilis on the basis of microscopic appearance into five maturity stages (Table IV).

Table IV
Maturity stages of gonads of H. fossilis
(Bhatt,1968)

Females	Males
Stage I - Immature virgins	
Ovaries small, eggs microscopic translucent	Testes thread-like, slightly along the outer margin, pinkish white, seminal vesicles invisible
Stage II - Maturing virgins and Recovered spent	
Ovaries cylindrical, oblong, occupying 1/3 to 1/2 of the body cavity, eggs visible to the naked eye, reddish to dull green.	Testes looking like serrated ribbon, reddish white, seminal vesicle small and looking like a part of the testicular serration
Stage III - Ripening	
Ovaries enlarged, occupying 1/2 to 3/4 of the body cavity, eggs clearly visible, light green in colour.	Testes swollen, serrations forming lobes, light yellow, seminal vesicles enlarged, almost 1/4th the size of gonad

........8/-

Table IV (Contd.)

Females	Males
Stage IV - Ripe	
Ovaries very large, occupying the whole of the body cavity, green, eggs large and green.	Testes well develop ed, lobules thick and pronounced, colour bright yellow, seminal vesicles large and swollen.
Stage V - Spent	
Ovaries shrunken and flaccid with some residual eggs, dull red with greenish hue.	Testes shrunken, seminal vesicles also shrunken but still prominent, testicular serrations feeble, dull yellow in colour.

The stage I of the maturity begins to occur in October and continue till January. The stage II goes on till May. During this period, the gonads remain in totally dormant state, showing no apparent advancement in maturation. The colour, shape, size and weight of the gonads study almost unchanged. The fishes with next higher stage of maturity (stage III) appear towards the end of May. In June, their number increases considerably. The maximum percentage of ripe fishes (Stage IV) is found in July and August. The spent fishes (Stage V) start appearing in August/September.

Bhatt (1968) stated that H. fossilis matures when about 12 cm in length, which is probably the second year of its life. Investigations carried out under the Coordinated Research Project revealed that the fish attains maturity at the end of the first year of its life when females measures about 12 cm in length and males, only 8 cm. This has now been also confirmed through rearing experiments too.

3.1.3 Mating

Studies on the size frequency distribution of intra-ovarian eggs as well as the gonadosomatic index (Bhatt, 1968) reveal that H. fossilis possesses only one group of eggs and that each individual spawns only once during the breeding season.

H. fossilis appears to be a monogamous fish. Thakur et al.(1977) while experimenting on induced spawning of the fish through hypophysation in glass aquaria and plastic pools, observed that whenever two males were used against one female, the mating process invariably started with a combat between the two males. Soon the supremacy on one male over another was established and the weaker male was driven away into a corner by aggression.

3.1.4 Fertilization

Fertilization is external. The fish does not exhibit parental care.

3.1.5. Fecundity

Bhargava (1970) made investigations on fecundity of H. fossilis collected from Killa Fish Farm at Cuttack (Orissa) during 1962-63. In a mature fish, the ovary occupies about 3/4th of the body cavity. The fecundity is reported to vary from 2,843 to 44,724 in fishes ranging from 164 mm to 307 mm in length and it increases at the rate less the third power of the total length (2.65681).

Some observations on the fecundity of H. fossilis were also made at the Bihar Centre of the Coordinated Research Project. The results are summerized in Table V.

Table V
Fecundity of H. fossilis
(Workshop Report, 1972)

Total length of the fish (mm)	Total weight of the fish (g)	Ovary weight (g)	Total number of mature eggs
220	75.8	7.7	15,280
226	74.1	12.6	27,675
226	79.0	12.3	28,069
239	80.0	12.2	27,443
240	67.0	7.7	14,733
251	84.0	10.7	23,228
255	97.0	12.5	20,391
256	92.0	11.5	19,953
285	112.0	13.6	36,706

3.1.6 Spawning

- Spawning season

The period of maximum gonadal activity in H. fossilis as reported by Ghosh and Kar (1952), is from April to July. According to Sunderaraj (1959), the spawning of the fish continues till late October due to heavy rains in September-October in Bangalore. Qasim and Qayyum (1961) reported that the time of maximum spawning in H. fossilis is August to September. Bhatt (1968) has also concluded that August and September are the main spawning months of the fish.

Investigations carried out under the Coordinated Research Project in Bihar, Assam and West Bengal reveal that H. fossilis spawns during June to September and sometimes owing to the delayed break of monsoon, it even continues up to October.

Sunderaraj and Goswami (1969) observed that exposure of H. fossilis to long photoperiod (14 hours/day) during the early preparatory period (February) advances the formation of large yolky eggs by as much as 3 months. They were also able to successfully breed those precociously gravid fishes using the catfish pituitary extracts.

Mukhopadhyay (1972) indicated the possibilities of extending the spawning season of the fish from June to December, when subjected to long photoperiods.

- Frequency of spawning

Studies on the growth and maturation of oocytes in the fish indicate that the eggs begin to develop in April. They get bigger in size in May. In June, a single batch of eggs destined to be spawned, gets separated from the original stock and attain the maximum sise. In July, the stock of eggs becomes more concentrated though the size of eggs remains unchanged. In August, when the fishes are running, this stock of eggs becomes free and ready for spawning. No eggs are seen in spent fishes during September/October. It obviously indicates that each individual spawns only once during the breeding season.

- Spawning time of day

No reports are available on the spawning time of the fish in natural environments. However, in the case of induced spawning through hypophysation, the fish breeds regardless of the time of the day when it is injected. Artificial spawning can thus be induced at any desired time by spacing the time of injection (Sunderaraj and Goswami, 1969).

- Spawning ground

In North Bihar, swampy patches falling within the flood regime of Kosi river system seem to offer a favourable habit to H. fossilis.. From the end of winter, as these waters start shrinking and breaking off, applying indigenous practices, the fish is caught in large numbers. The left-overs multiply during the next monsoon to make up the population. The points of ecology related to establishment of H. fossilis in this region are not known beyond the fact that the soft nature of soil is conducive to burrowing habit of the fish.

Unlike carps, H. fossilis is capable of breeding in the confined waters of ponds, derelict pools and ditches. The only essential prerequisite of breeding probably is the accumulation of sufficient rain water in the environment where it lives. It is not uncommon to see certain derelict ponds serving as a permanent natural source of giving sizeable yield of H. fossilis in some areas. In fact, a government pond located in the Cumla subdivision of the Ranchi district is well known for sustainingly giving a rich crop of H. fossilis every year. The depleted stock is made up by the process of self recruitment during the next breeding season and likewise the cycle continues.

H. fossilis is rarely seen migrating on land during rains which probably suggests that the required conditions of breeding in ponds in the case of H. fossilis get filled relatively more easily compared to C. batrachus.

3.1.7 Induction of spawning

The first success in induced spawning of H. fossilis was achieved in mid-fifties by Ramaswamy and Sunderaraj (1956) by using homoplastic pituitary glands, the optimal dose being 1½ pituitaries from the male donors or only ½ pituitary from the female. Sunderaraj and Goswami (1966 a and b) reported their findings on the relative potencies of several purified mammalian hypophyseal hormones in inducing ovulation and spawning in hypophysectomized gravid H. fossilis. Successful spawning, using pituitary materials of the Indian major carps, was subsequently reported by Pal and Khan (1969) and Khan (1972 a and b). Under the Coordinated Research Project, in seventies again, a good deal of work was carried out on the induced breeding of the fish with the objective to develop effective methodologies for mass scale seed production (Workshop Reports), 1972, 1976, 1978, 1980 and 1982).

For the induction of spawning in H. fossilis, pituitary glands of Indian major carps prove effective and economical, particularly for large scale experimentations, the routine dose being 8 to 10 mg of gland/100 g weight of the recipient. For the preparation of the pituitary extract, the standard methodology, as prescribed for carps, is followed.

Unlike C. batrachus, the maintenance of breed stock in the case of H. fossilis is not a problem. It easily matures under captive conditions. In one bamboo mat or nylon net cage of 2XIXI m size, about 50 spawners can be maintained upon a diet of fish meal and rice bran (1:1) at the rate of 5% of the body weight (Thakur and Murugesan, 1979).

Intramuscular injections are given slightly above the lateral line around caudal peduncle region. Giving injections a little posterior to the vent below lateral line is also in practice. The extract is usually injected in a single instalment. Normally, two males: one female is the combination in which the fish is bred. Spawning activity starts about 6 to 12 hours after the injection and it lasts for a period of 2 to 6 hours. A female weighing 100 g, normally, produces about 800 eggs.

3.1.8 Spawn

Fertilized eggs of H. fossilis are adhesive, demersal and spherical in form. The yolk sphere contains no oil globule. Due to the adhesive nature of the egg, considerable debris gets adhered to the egg capsule. The egg capsule is transparent and greyish-white in colour, while the yolk is green or brown. The perivitalline space is large, measuring 0.1 to 0.2 mm in width. The eggs become translucent as the development progresses. The measurements of the eggs are as follows:

	Range(mm)	Average(mm)
Diameter of the egg capsule	1.4-1.6	1.475
Diameter of the yolk sphere	1.2-1.4	1.293

Chaudhuri (1971) and Khan (1972 a and b) stated that the eggs of H. fossilis are green in colour. Thakur et al. (1974) while experimenting on the induced breeding of the fish, observed that the eggs in various sets of breeding were shed either in green colour or in brown colour. This colour difference was found in the laid eggs of the different sets of spawners and never within the same set, which probably suggests that there might be having two different races of the fish in the locality.

3.2 Larval history

3.2.1 Embryonic phase

The developmental features of fertilized eggs of H. fossilis are given in Table VI.

Table VI
Development of fertilized eggs in H. fossilis
(Workshop Report, 1972; Thakur et al. 1974)

Time after fertilization	Developmental features
0h 0 min	Fertilized eggs
0h 30 min	Two-celled stage
0h 45 min	Four-celled stage
01h 00 min	Eight-celled stage
01h 20 min	16-celled stage
01h 30 min	Morula stage
02h 00 min	Formation of germinal ring
04h 00 min	Head and tail ends of embryo are distinguishable
05h 30 min	Somites differentiate
07h 00 min	12 somites are distinct, optic cups are visible
11h 00 min	Number of somites increases to 22, Kupfer's vesicle appears
12h 00 min	Kupfer's vesicle disappears, lens in optic cups visible
12h 30 min	Twitching movement starts
13h 00 min	Caudal end of the embryo getting free from yolk mass
14h 00 min	Notochord visible as a tubular structure
14h 30 min	Frequent twitching movement
16h 00 min	Twitching movement more vigorous
17h 00 min	Egg membrane weakens
18h 00 min	Membrane ruptures and larva hatches out

The incubation period in H. fossilis, as observed by different authors, is shown in Table VII. All the eggs of the same brood kept in the same rearing media do not hatch out simultaneously. It continues for a few hours.

Table VII
Incubation period in H. fossilis as reported by different authors

Author	Hours	Temperature (°C)
Sunderaraj and Goswami (1969)	Wibhin 24	25
Chaudhuri (1971)	20 to 24	27 to 30
Khan (1972 b)	18 to 20	26 to 30
Thakur et al. (1974)	Assam: More than 24	24 to 26
	Bihar: 18 to 20	26 to 29

3.2.2 Larval phase

The newly hatched larva measures 2.72 mm in total length. It has a pigmentless and laterally compressed body. It is characterised by the possession of an almost round yolk sac, the diameter of which is about 42% of the total length of larva. The streak of notochord is quite prominent. About 26 to 28 myometes are distinct and another 10 to 12 are apparent at the tail region. The tip of the tail remains round and the fin-fold is differentiated, though not very clearly. Hatchlings are not active and mostly remain in resting stage lying on their sides at the bottom of the rearing container.

The different stages of the larval development of the fish are given in Table VIII.

- Post larva

Yolk gets completely consumed by the end of the 4th day of development. It commences feeding even before the completion of the yolk absorption. On 5th day of development, the post-larva measures about 6.6 mm in total length. Streaks denoting rudimentary rays start appearing in caudal fin. Thickening of tissues at dorsal fin base becomes more conspicuous. Pectoral fin buds assume the form of flaps. If examined from the ventral side, eight paira of branchiostegal rays are noticeable.

Post-larva now starts wanderin in search of food. If the food is not supplied, the tendency of intrabrood belligerence develops. At this stage, it feeds best on minute zooplanktonic organisms such as ciliates, Brachionus, Keratella, Polyarthra, Filinia, the nauplii of copepods, small cladocerans etc. The presence of Cyclops in the ambient water, even in small number, may cause serious damage to the growing young ones. The risk from Cyclops could be minimised considerably by filtering plankton samples through some suitable sieve cloth. Nylon cloth with 50 mesh/linear cm is ideal for the purpose because it filters out the Cyclops quite effectively and at the same time allows the ingress of minute planktonic organisms in the filtrate. For mass scale operation, the best is to rear the post-larvae straight way into nylon hapas made of such cloth.

Table VIII
Larval development of H. fossilis
(Thakur et al., 1974)

Days after hatching	Length of larva (mm)	Developmental features
1	4.6	Barbels appear in the form of tiny protuberances. Jaws are formed. Lower jaw moves occasionally. Alimentary canal appears in the form of straight. tube. Scanty pigmentation. Notochord deflected upward at tail-end. Movement mostly confined to the bottom zone.
2	5.5	Lower jaw shows the presence of conical teeth. Eyes get darkly pigmented. Pigmentation denser in head region. Operculams are formed. Alimentary canal appears functional. Anal opening differentiates and peristalsis commences. About 42 myomeres are distinct. Yolk sac in slightly diffused state showing dirty brown colouration. Heart pulsates @ 155 ppm. Fin-fold continuous. The larva moves lashing its tail vigorously.
3	5.7	Barbels elongate. Arterial and venous flow of blood in barbels clearly noticeable. Barbels smooth on one side while on the other, there is a row of elevated points as the precursors of nerve ends. Further shrinkage in yolk sac and the resultant space getting filled up by the developing stomach and intestine. Head region looks darker due to denser pigmentation. Pectoral fins appear in the form of elevated points. Larva starts making directive movement.
4	5.8	Fin-fold although still continuous, the differentiation of dorsal and caudal fins apparent. Pectoral buds more conspicuous. The intestinal coiling in the alimentary canal noticeable. Pigmentation on the head obscures transparency. On the body, pigments in rows on the muscle segments. Yolk gets fully consumed by the end of the 4th day of development.

Khan and Mukhopadhyay (1973) noted that while feeding the young ones with live plankton, an application of yeast (0.05 g/1) and cobalt chloride (1 ppm) in water enhances the survival rate up to 80%.

Khan and Mukhopadhyay (1971) made certain observations on the utilization of tubificed worms by H. fossilis and noted that the cannibalism in the young age can be considerably reduced if proper type of food is supplied to the fish in sufficient quantities.

Post-larvae at this stage, make attempts to come up to the surface by wriggling through the water column. The urge for this vertical trip gets accentuated on subsequent days of development. The aerial respiration appears to start apparently from about 8th day of development. This necessitetes the water column of the rearing container to be maintained at an appropriate level so that it does not become strenuous for the post-larvae in undertaking vertical trips.

By 10th day of development, the post-larva measures about 7.5 mm in total length, 6.8 mm up to the tip of the notochord at the tail and 2.8 mm up to the vent. Dorsal differentiates showing six branched rays. Spine and rays develop in pectorals. Pelvics yet to d fferentiate. Caudal fin shows 8 branched rays but are still continuous with the anal and dorsal fin folds. Of the total 53 myomeres,14 are preanal. Post-larva now look blackish. It is an active swimmer at this stage and moves into every nook and corner of the rearing container probably in search of food. It also undertakes vertical trips to the surface of water to gulp in air. While doing so, it breaks the surface of water, takes in mouthful of air and then sinks passively in head up and tail down position. This vertical disposition is actually caused due to the air filled aerial respiratory organ which impart buoyancy to the fish (Qasim et al., 1960).

Post-larvae at this stage, feeds voraciously on zooplanktonic organisms. It welcomes any kind of artificial feed. It does not hesitate to bite even if the size of the food is too big for its mouth. It goes on eating voraciously and does bot stop till the stomach becomes gorged with food.

The fifteen day old post-larva, on an average, measures about 12 mm in total length, 10.3 mm in standard length and 4.8 mm in vent length. The dorsal fin gets fully differentiated with 6-7 branched rays as in adult. Pectoral spine becomes stout. Branched rays develop in ventral fin. About 47 to 48 rays develop in anal fin. The anal and caudal fins are still continuous with the intermediation of the fin fold. The caudal fin rays, which are 13 in number at this stage, establish articulation with the developing hypurals. Of the 55 myomeres, 15 are preanal. Vertebral segmentation is clearly noticeable. Pigmentation becomes more pronounced both on the head as well as on the body.

It has been observed that for the growth of the young ones, apart from food and stocking density, running space also is one of the important factors. The young ones reared in nylon haps (2XIXI m) show atleast two times better growth than those reared in glass aquaria (Thakur et al., 1974).

3.3 Juvenile stage

The wild stock of juvenile specimens (5to 10 cm total length) caught during post-monsoon and summer months from swampy and marshy tracts applying indigenous contrivances, form a sizeable seasonal fishery at quite a number of places in Bihar, Assam and West Bengal. These juvenile specimens are sold in the fish markets in small lots by individual fishermen.

In North Bihar, the period October/November (Particularly near about the time of "Chhath" festival), is marked out for boom occurrence of juveniles of H. fossilis when they are caught from the inundated fields in relatively heavier bulk employing a very unique method of fishing called "Chhoh" (See: Section 5.1.1).

A survey made during 1981-82 in the districts of Goalpara and Kamroop in Assam revealed that there are a number of beels in these districts which can form a dependable source of seed of H. fossilis for undertaking culture operations (Workshop Report, 1982).

Bhatt (1968) made certain observations on the food of small sized fishes in the length range of 7 to 10 cm and observed that the fish at this stage feeds mainly on copepods, daphnids, algae and other planktonic organisms. The mollusca, shrimps, fish etc. eaten by the adults, are not encountered in the gut contents of the young fishes.

Huq et al (1973) carried out experiments on the feeding of fry of H. fossilis.

3.4 Adult history

3.4.1 Longivity

Bhatt (1968) analysed the length frequency data of H. fossilis which gave evidence of 4 modal peaks indicating about 4 years of life span of the fish, the maximum total length of the fish in his sample being 34.9 cm The length of the largest recorded H. fossilis is, however, 38 cm from the backwaters of Madras (CSIR, 1962)

3.4.2 Hardiness

As already stated under section 1.1.2, H. fossilis is characterised by the possession of an aerial respiratory organ which enables it to survive for sufficiently long durations of time in captivity even in small quantity of water. It is due mainly to this accessory respiratory apparatus that the fish is able to live under the inimical conditions of water areas such as those of swamps, marshes and certain categories of organically polluted waters, where the usual water-breathing fishes cannot ordinarily thrive.

3.4.3 Competitors

More or less the same as stated in the case of C. batrachus.

3.4.4 Predators

Exactly the same as stated in the case of C. batrachus.

3.4.5 Parasites and diseases

The following parasites and diseases have been recorded from H. fossilis:

Bacteria	Acromonas salmonicida causing abscess on the body; sensitive to Chloramphenicol (Workshop Report, 1980).
	Alcaligenes faecalis causing furunculosis; sensitive to Kanamycin and Chlorotetracyclin (Workshop Report, 1982).
Trematoda	Kakaji (1969); Pandey (1971 a and b);
	Diplostomulum singhii causing loss of equilibrium, occasional convulsions, darting movements and frequent air-breathing (Srivastava et al., 1976; Thakur, 1977).
Nematoda	Chakravarty et al., (1963), Rai (1969).
Pox disease	Small reddish-white spots on the body (Workshop Report, 1976).

3.4.6 Injuries and abnormalities

Lehri (1963) made observations on the regeneration of barbels in H. fossilis. Datta and Ghosh (1975) reported on an instance of bifurcated left maxillary barbel in H. fossilis collected from a local fish market at Barrackpore.

Mathur and Yazdani (1969) came across one deformed H. fossilis whose axis was sharply bent upward almost at right angle from the middle region of the body. A similar type of vertebral column deformity in H. fossilis was also spotted out during the netting operation of a pond at Ulubari Fish Farm, Gauhati on 10.6.1980. The specimen had an upwardly deflected tail. The X-ray examination revealed that the vertebral column took a gradual upturn from its usual linear arrangement from 41st vertebra onward, finally making an angle of about 80° with the main axis. When it was paired with two normal males and subjected to hypophysation, it bred successfully with about 80% fertilization (Workshop Report, 1982).

Thakur and Munnet (1982) made observations on the occurrence of teratological manifestations in H. fossilis based on the examination of a random sample of 916 specimens in the length range of 91 to 116 mm. These fingerlings were obtained as stock material from the catches of the wet-marshy lands and low-lying paddy-fields of Darbhanga region in North Bihar. The study indicated the possibility of occurrence of one abnormal fish out of every 183 normal ones. The highest frequency of teratological manifestation was found in barbels.

Subedar and Rao (1971) reported on an unusual instance of occurrence of oocytes in the kidney of H. fossilis.

3.4.7 Maximum size

According to Day (1878), H. fossilis attains a foot or more in length. Shaw and Shebbeare (1937) took them up to about 9 inches long. Bhatt (1968) observed the length of the fish up to 34.4 cm while Misra (1976) states that it attains up to 305 mm in length. The longest recorded length of the fish, however, is 38 cm from the backwaters of Madras.

3.5 Nutrition and growth

3.5.1 Food and feeding habits

Alikunhi (1957) mentioned that H. fossilis is predacious in habit but not markebly piscivorous. Insects, ostracods, worms, algal matters, organic debris and fish and fish remains constitute the main items of food. Varying quantities of mud or sand are also often taken in.

Hora and Pillay (1962) wrote that H. fossilis is a bottom feeder. Protozoa, curstacea, worms and insects constitute 75% of the diet, the rest consisting of algae and higher plants.

Chaudhuri (1971) writes that the food and feeding habits of koi, singhi and magur are more or less similar. The larvae and young fry feed mainly on phyto- and zoo-plankters including micro-crustanceans and also insects.. The juveniles and adults feed on insects and insect larvae, crustaceans, shrimps, ostracods, worms and also on algae, higher plants and organic debris. They are predominantly insectivorous and though predatory in habit, are not markedly piscivorous.

The frequency of occurrence of the important food items encountered in the gut contents of *H. fossilis* is shown in Table IX.

Table IX
Frequency of occurrence of various food items encountered in the gut contents of *H. fossilis*
(Bhatt, 1968)

Food items	Frequency of occurrence
Molluscs	15.5%
Cypris	15.6%
Chironomid larvae	13.4%
Fish scales and fish	11.1%
Eggs of invertebrates	13.2%
Copepods	16.5%
Weeds	20.3%
Debris	41.0%
Algae	16.3%

It can be seen from Table IX that *H. fossilis* does not have any regular food preference. Bhatt (1968) noted that gastropods during certain months (August-September) form the chief food of the fish. In some of the examined specimens, the big and small shells of gastropods were stuffed in the entire length of the gut, giving it a beaded appearance. He remarked that the size of some of the ingested shells was so big that it became impossible to believe how they could be taken in and even more supprising was to comprehend as to how these could be excreted. The portions of the gut containing these shells were fully distended, almost to the bursting point. Sengupta *et al.* (1972) also indicated about the preference of *H. fossilis* for molluscs.

Certain observations were made to see the efficacy of the common gastropod *Vivipera bengalensis* as a feed (in crushed form) upon *H. fossilis* at the Bihar Centre of the Coordinated Research Project. As control, cut fish flesh was also provided. The experiment showed that although *H. fossilis* ate molluscan flesh quite actively, the conversion ratio was better in favour of cut fish flesh (Workshop Report, 1978), Saigal *et al.* (1974) investigated upon the presence of carbohydrates in the digestive tract and the liver of *H. fossilis*. A moderate to strong amylase activity in thestomach, strong activity in the intestine and weak to moderate activity in the liver was observed. The invertase was moderate in the intestine and weak in the liver while in the stomach, it was negative. The study indicated that the enzyme equipment of *H. fossilis* is well fitted for digesting carbohydrate foods which shows the possibility of culturing the fish upon diets supplemented with carbohydrate type of foods which are deficient in feeds of animals origin.

Bhatt (1968) observed that the rate of feeding in *H. fossilis* remains high during the post-monsoon and winter months. During summer, it goes on declining till it records its lowest in June. In july and August also, the rate of feeding remains quite low. However, in September, it reaches to its peak. The period of relatively intensive feeding remains maintained in the subsequent months. In March, it again increases and attains its second highest peak.

3.5.3 Age and growth

No reports are available pertaining to the detailed studies on the age and growth of *H. fossilis*.

Analysis of the size frequency distribution of the fish, however, reveals the possibilities of modal peaks around 120 mm, 170 mm, 210 mm and 250 mm suggesting probably the lengths of the fish at ages 1,2,3 and 4 years respectively. Certain investigations are under way to determine the age and growth using hard parts of the fish (Kohli,MS), the result of which would throw further light on this aspect.

Investigations carried out on the length-weight relationship of *H. fossilis* obtained from the catches of wild waters in North Bihar revealed that the males of the species become lighter for their length as they grow larger in size (Thakur and Das, 1974). The regression equations derrived separately for juveniles, male and female specimens are as follows:

Juvenile : $\text{Log } W = -5.6460 + 3.1646 \text{ Log } L$

Female : $\text{Log } W = -5.0817 + 2.9418 \text{ Log } L$

Male : $\text{Log } W = -4.2147 + 2.5271 \text{ Log } L$

Bhatt (1968) observed that the monthly fluctuations in condition factor (K value) of the fish are more closely related to the feeding rhythm than with the cycle of gonadal weight. The lowest and highest values of K are obtained in June and September months which exactly correspond to the periods of lowest and highest periods of feeding intensity in the fish respectively.

3.6 Behaviour

3.6.1 Resting and locomotory behaviour

Like *C. batrachus*, *H. fossilis* also rests mostly in two positions. While resting at the bottom, the alignment of the body gets fixed up at angles ranging from 20° to 90° with the caudal fin just touching the bottom. When resting at the surface, the fish usually keeps itself vertically disposed in head-up and tail-down position. In both the cases, the fish is able to keep itself in a totally standstill stage, the duration of which may range from a few seconds to several minutes. During the course of resting, the aerial respiratory apparatus is actually taken advantage of which imparts buoyancy to the fish for displaying such unusal angles of body alignment.

There is a distinct difference in the resting and the active states of the fish. In the resting state, the fish keeps itself in an absolutely standstill state, looking as if lying in a deep slumber. And than when it comes in action, it would appear as if it has been perforce awakened. It would reorient its body alignment and wriggle out. After a brief spell of active movement here and there, it would again go back into the resting state. The suddenness with which it takes place, gives an impression as if there exists a system of switch-off and switch-on mechanism somewhere.

3.6.2 Respiratory behaviour

Unlike *C. batrachus*, which is an obligatory air-breather, *H. fossilis* is facultative in its air-breathing habit. Studies on the gills of *H. fossilis* are better adapted for gas exchange than those of *C. batrachus* (Munshi and Singh, 1968). According to Hughes and Singh (1971), *H. fossilis* obtains more of its total oxygen supply from water (59.17%) than from air (40.83%) while *C. batrachus* does just the reverse. It derives more of its total oxygen supply from air (58.4%) than from water (41.6%). Measurements of the air/blood pathway using electron microscopy (Hughes and Munshi, 1973) have shown thinner water/blood barrier in *H. fossilis* than *C. batrachus*. And, probably, that is the reason for greater ability of *H. fossilis* to survive in water without surfacing. the gill respiratory epithelia show that

3.6.3 Feeding behaviour

A good deal of similarities exist between the feeding behaviour of *H. fossilis* and *C. batrachus*.

H. fossilis does not exhibit any regular preference for a particular item of diet which shows that the fish feeds rather indiscriminately, devouring all that come across its way.

Like *C. batrachus*, *H. fossilis* also lacks the ability to prey, probably because of poor eye sight.

3.6.4 Mating behaviour

Sundararaj and Goswami (1969) and Thakur et al. (1977) made certain observations on the mating behaviour of *H. fossilis* while carrying out experiments on the induced breeding of the fish through hypophysation. The mating activity of the fish starts about 6 to 10 hours after the administration of pituitary extract injection. The mating activity lasts for varied durations of 2 to 6 hours. During this period, intermittent mating acts takes place, the average rate of mating being once every 2 to 3 minutes in the initial stages and 5 to 10 minutes or even longer in the later ones.

In the initial 2 to 3 hours after the injection, the spawners do not reveal any sign of obvious activity which would indicate their intentions of mating. During this period, they just rest at the bottom in a standstill position keeping themselves carefully concealed in the darker corners of the container. When the impulse of excitement comes, the restlessness and intentional togetherness are apparent. Male takes the major load in making advances and look more agile and fast in his actions. Female, on the other hand, remains passive and tries to keep away from the approaching male. Due to this reluctance of female, the male has to resort to a good deal of chasing and running around for quite some time. While chasing, the male follows the female very closely and generally swims underneath her speeding body. In this course of action, the male often boldly obstructs her path and tries to excite her with his nudging actions. In doing so, the male shivers his head, displaying ticklish and caressing actions. After repeated attempts, the male succeeds in inducing female to participate.

The excited female tries to place and adjust her snout at the genital region of the male. The male responds to it by twisting its body in a "horseshoe-shaped" style so as to embrace the snout of female. The whole action would appear from a distance as if the male is enjoying a joyride over the female. In this posture, the pair remains motionless for a second or two. When closely observed, the shivering body of male can be clearly noticed. The action finally culminates into a jerk in females body with simultaneous expulsion of a good number of eggs from her genital opening. Soon after this occurs, the pair parts and goes to relax. Owing to the watery texture of the milt, it is generally not possible to observe its actual transference from male to the released eggs of female. After having a recess of a few minutes, the pair indulge into the next round of the mating act. The number of eggs released during each mating is roughly around 100 to 150 with a distinct declining trend in the later stages of the mating activity.

4 POPULATION

4.1 Structure

4.1.1 Sex ratio

Bhatt (1968) examined a total of 1,239 specimens of *H. fossilis* to find out the ratio. The total number of males and females was found to be 406 and 833 respectively, showing that in the population, the ratio of males to females is 1 :2. The size difference of males and females was also significant. The maximum size of male was 24.2 cm, while that of female was 34.4 cm.

4.1.2 Age composition

Data pertaining to age composition of *H. fossilis* in market landings are not reported anywhere. However, the data available on the length frequency distribution of the fish indicate that the maximum landing of the fish comprises catches of 1 and 2 year old individuals falling within the length range of 10 to 19 cm.

4.1.3 Size composition

The size composition of *H. fossilis* in market landings is given in Table X.

Table X
Size frequency distribution of *H. fossilis* in market landing
(computed from Bhatt, 1968)

Length range (mm)	Frequency percentage
100	8.0
101-150	49.5
151-200	29.4
201-250	10.7
251-300	2.1
301-350	0.2

5 EXPLOITATION

5.1 Fishing equipment

5.1.1 Fishing gear

- Fishing with hand

Seasonal supply of H. fossilis comes mostly from the catches of low lying swampy and marshy tracts as well as derelict pools and puddles which remain in the process of drying up during summer months. The usual practice of fishing is to divide the water area in small compartments by building coffer dams, bail out the water from the enclosed areas and pick up the fish by groping into the mud by hand.

During summer months, when the water masses start drying up, H. fossilis is reported to busy itself in the soil and aestivate. Many fishes live together in such pits. In local language, these pits are called as 'Gharia'. There can be a number of pits in large sized ponds. Expert fishermen hunt out such pits and make quite a wholesome catch. It is reported that the fish during aestivation lives only on its body reserves.

H. fossilis also makes nest holes in the embankments of a pond and live there in colonies. Such holes are usually constructed about a foot below the water surface in the form of anastomosing tubes having several exits. From one such complex of holes, as many as 364 specimens of H. fossilis have been retrieved. These holes usually get unvailed when the culture ponds are dewatered for harvesting.

- Vessel traps

In this method of fishing, unserviceable earthen pitchers are placed in ponds or a ditch where H. fossilis is known to abound. The fish gets attracted towards these pots and start utilizing them as their nests. Sometimes, certain attractants such as cooked rice, wheat flour etc. are also placed inside the installed vessels. Giving some time gap, the vessels are lifted out, taking due care not to allow the trapped fishes to escape out. The fish is trapped in varying numbers ranging from a few to about 30, big and small sizes both.

Vessels traps work well only for H. fossilis. Other fishes are rarely trapped.

- Cast net

For taking the catch of H. fossilis or for that matter any other air-breathing fish, which are in the habit of burrying themselves into the mud, no sooner the net is cast, the net is used in a different style. The net after it is cast, is allowed to settle at the bottom and then its periphery is hurridly sealed by pushing them inside the mud by foot. The enclosed area is them searched for the entrapped fishes and the catch is carefully collected.

- Drag net

Drag netting operations pose similar problems in the retrieval of air-breathing fishes as the cast netting. The operation is made effective by dragging a long rope studded with bricks at small intervals just in front of the operating drag net. The bricks studded in the rope rakes the bottom causing the fishes to come out of the muck and get trapped in the operating net.

Pocketed drag nets with heavy sinkers are relatively more effective for retrieving these bottom dwelling fishes (Sec: Rout et al., 1979)

- Gill net

Gill nets no doubt work quite effectively but there is a handicap with this net. The gilled fishes succumb/"drowning" and / to the catch thus comprises only dead specimens with considerably reduced market value.

- "Chhoh"

This is a unique method of fishing which is prevalently used in North Bihar for taking the catch of H. fossilis from low lying fields soon after monsoon.

The details pertaining to this method of fishing have been studied by Thakur and Banerji (1980). See: Synopsia of C. batrachus.

- Fishing by tobacco poisoning

Same as described for C. batrachus.

5.1.2 Fishing boats

Boats are not needed in the exploitation of H. fossilis.

5.2 Fishing areas

See: Section 2.1

5.3 Fishing season

Employing various methods of fishing, H. fossilis is caught practically all round the year. However, the post-monsoon and summer months are marked out for relatively intensive periods of fishing.

6 CULTURE

6.1 Culture in ponds

H. fossilis is best suited for culture in shallow ponds having a depth of not more than 1 to 1.25 m. In addition to its suitability for culture in derelict waters, it can also be cultured in proper, well managed ponds for achieving high targets of production. The traditional nursery ponds, which remain fallow after carp seed harvesting operation, come in handy for carrying out culture of H. fossilis. It serves ideally for raising short term crops of the fish from January to June every year without disturbing the practice of conventional carp seed production.

To produce marketable size of H. fossilis, a period of six months is normally quite sufficient. It is best suited for culture on monoculture basis. However, it can be cultured in combination with C. batrachus and A. testudineus as well. Like C. batrachus, H. fossilis also can form a very good component for culture in carp ponds. (Dehadrai and Thakur, 1980).

6.1.1 Procurement of stock

Stockable size young ones of H. fossilis can be obtained either by rearing the fry produced through induced breeding (See: Section 3.1.7) or by collecting them from natural resources. In induced breeding, the technique of larval rearing still requires a good/for large scale application. Hence, like C. batrachus, for the culture of H. fossilis also, the nature forms the only source of its stocking material at present.

Of late, many places in West Bengal, Bihar and Assam have been located for abundant natural availability of H. fossilis fry and fingerlings. During post-monsoon and early winter months they are sold in fish markets in live state in considerable quantities which form the mainstay of H. fossilis seed presently in the country.

/ deal of further investigation for making the technology hold good

6.1.2 Transportation

Fry and fingerlings of H. fossilis are transported in galvenized tin drums having perforated lids. In a drum of about 25 l capacity, half filled with water, about 4 to 5 thousand fingerlings of 6/to 12 hours. In palce of tin drums, plastic drums, or biscuit tins as well can be used . / to 8 cm average size can be safely transported involving a journey of 10

6.1.3 Holding of stock

The inherent small size of H. fossilis permits high stocking density for achieving higher yields. The carrying capacity of the pond under such conditions can be adequately enhanced by renewing or replenising the water from time to time.

Various rates of stocking ranging from 40,000 to over 500,000 fingerlings/ha have been tried in the culture demonstrations of the fish in different parts of the country. The ideal stocking rate, however, for semi-intensive culture operations should not go beyond 50,000 fingerlings/ha.

6.1.4 Management

For effective management with the suggested technique, the culture pond should not be more than 0.1 ha in size. In case of perennial ponds, the care has to be taken to remove or kill the existing pradatory fishes (particularly murrels) and other predators like snakes which could prove highly damaging to the crop of the growing young ones of the fish.

No fertilization or manuring is necessary.

To avoid infection, the fingerlings should be given a bath of 200 ppm of formalin for 40 seconds before releasing them into the prepared ponds.

Regular supplementary feeding is a must. Day (1889) stated that when food is plentiful, H. fossilis fattens well, if the reverse, it becomes lanky. In culture operations, feeding with low grade dried marine trash fish and rice bran has been found to bring about a profitable conversion with fast growth. A mixture of oilcake, rice bran and biogas slurry in the ratio of 1:1:1 has also proved as a successful low cost feed for H. fossilis.

Feeding should be done by broadcasting the feed in small amounts into the pond. Also feed baskets may be lowered in water near the banks once daily in addition to broadcasting of feed. This ensures feeding by all the fish in the stock.

Occasionally, there may be excessive accumulation of metabolites in the pond, rise in ammonia content and occurrence of algal bloom, if feeding is done indiscriminately. Treatment of water with potassium permanganate @ 300 ppm in such cases helps. Spreading of Lemna or water hycinth in the pond would control algal blooms. Under acute conditions of fouling, a change of pond water is recommended. If the foul water is to be changed, it could be gainfully used in the adjacent agricultural plots for irrigation as well as fertilization.

6.1.5 Harvesting

Under favourable conditions of management, H. fossilis attains weights up to 30 g, if not more within six months of growing period. In case of low growth rate round during the periodic check, it would be necessary to review the management precedure.

Production potentials of H. fossilis have been amply assessed by quite a number of field trials in Assam, Bihar and West Bengal (Table XI).

Harvesting is done by dewatering the ponds during summer months.

Table XI

Production potential of H. fossilis in mono and mixed culture combinations

Place and water area	Stocking density (per ha)	Feeding	Production	Remarks
1	2	3	4	5
ASSAM				
Derelict pond 0.10 ha	43,000 (with Anabas Clarias)	M. oilcake, rice bran & silkworm pupae	916kg/ha/yr	Pathak et.al. (1980)
Derelict pond 0.10 ha	80,000 (with Anabas Clarias)	-do-	1547kg/ha/yr	
Farm pond 0.10 ha	120,000 (with Clarias)	-do-	5043kg/ha/yr	
Farm pond 0.015 ha	300,000	Rice bran, mustard oil-cake & fish meal (1:1:1)	6947kg/ha/5 months	Pathak et.al. (1980)
Farm pond 0.02 ha	127,000	Rice bran & Fish meal(1:1)	5100kg/ha/ 14 months	Workshop Report (1982)
BIHAR				
Derelict pond 0.03 ha	170,000	No feeding	200 kg/ha/ 6 months	Workshop Report (1976)

Table XI (Contd.)

1	2	3	4	5
Derelict pond 0.04 ha	40,000 (with Anabas)	No feeding	524 kg/ha/ 10 monthe	Workshop Report (1976)
Derelict pond 0.03 ha (makhana pond)	70,000 (with Clarias and Anabas)	-do-	1200 kg/ha/ 7 months	Thakur (1978)
Makhana pond 0.04 ha	55,000 (with Clarias and Anabas)	Flat-rice husk + fish meal	2250 kg/ha/ 10 months + 320 kg of makhana seed	CIFRI Newsletter (1977)
Derelict pond 0.02 ha	250,000	Rice bran, crushed molluscs + cut minnows all doughed in cowdung	4400 kg/ha/ 4 months	
Derelict farm pond 0.02 ha	225,000	Rice polish, poultry feed & cowdung during first year	1397 kg/ha/ 2 years	Survival 1. probably due to heavy predation by water snakes
Village pond 0.10 ha	20,000 with residual carp seed.	Feed mixture (fish meal+ GNOC+rice bran+mineral mixture)	265 kg carps and 62.1 kg H. fossilis - 3262 kg/ha/ 10 months	Workshop Report (1982)
NEW DELHI				
Newly excavated pond with facilities for frequent change of water 0.2 ha	250,000	Dried marine trash fish+ rice bran	35,000 kg/ha/ 7 months with 90% survival	Workshop Report (1978)

Table XI (Contd.)

1	2	3	4	5
WEST BENGAL				
Village pond 0.04 ha	250,000	GNOC + rice bran + fish meal	4815 kg/ha/ 6¼ months	Sengupta et.al. (1979)
Farm pond 0.04 ha	60,000	Fish meal + rice bran + cowdung	1642 kg/ha/ 7 months	
Farm pond 0.03 ha	430,000	-do-	7300 kg/ha/ 9 months	Workshop Report (1980)
Farm pond 0.01 ha	70,000	Fish meal + rice bran (1:1)	2800 kg/ha 6 months	Workshop Report (1982)
Farm pond 0.1 ha	70,000	-do-	3080 kg/ha/ 6 months	

6.2 Culture in cages

Experiments carried out on cage culture of *H. fossilis* in swampy waters of Assam, gave a production of 4.8 kg/cage of 2X1X1 m size in 90 days of rearing at the stocking rate of 200 fingerlings/cage (Dehadrai et al.,1975).

Recently, some cage culture experiments were carried out in nylon hapas at Assam Centre which gave a production of about 2.85 kg/m^2 in 90 days with a survival of 72% (Workshop Report, 1982).

6.3 Intensive culture with frequent change of water

An experiment on intensive culture of *H. fossilis* was undertaken at Khanpur in New Delhi in an enterpreneur's agricultural farm by constructing one 0.2 ha pond which was already partially excavated for brick making. One irrigation well located in the farm's premises with an electric pump was the source of water supply which helped in maintqining an average water depth of 75 cm in the pond throughout the course of culture operation. The pond was stocked with 250,000 fingerlings/ha rate, the actual number of the stocked fingerlings being 50,000. The avorage weight of the fingerlings at the time of stocking was 8 to 10 g. The fingerlings were procured from the seed collection centres in West Bengal.

Fishes were fed with a mixture of dried marine trash fish and rice bran in the ration of 3:1 during the first three months and 2:3 during the remaining period. Feeding was done during dark hours of the day and fishes were kept fully satiated.

Heavy stocking density with intensive feeding resulted in accumulation of metqbolites at the pond bottom and often in algal and Microcystis blooms, turning the pond water totally green. Frequent change of water was resorted to. The pond was dewatered every second week and refilled with freshwater.

The culture operation yielded an actual production of 7,200 kg of *H. fossilis* with 90% survival. On per hectare basis, this works out to approximately 35,000 kg. The entrepreneur earned a handsome profit (Workshop Report, 1978).

7 ACKNOWLEDGEMENTS

Authors are grateful to Dr. A.V. Natarajan, Director, CIFRI, Barrackpore and Dr.V.R.P. Sinha, Head, Freshwater Aquaculture Research and Training Centre, Kausalyaganga for their kind interest shown in the work and the encouragement provided. The help rendered in various ways in the preparation of this synopsis by S/Shri H.A. Khan, G.S. Purushothaman and P.K. Pandit is thankfully acknowledged.