



SYNOPSIS OF BIOLOGICAL DATA ON CATLA

Catla catla (Hamilton, 1822)

Prepared by

V. G. Jhingran



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1968

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SYNOPSIS OF BIOLOGICAL DATA ON CATLA

Catla catla (Hamilton, 1822)

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PREPARATION OF THIS SYNOPSIS

A revision of the provisional version issued in May 1966 for presentation at the FAO World Symposium on Warm-Water Pond Fish Culture, Rome, 18-25 May 1966.

This synopsis was prepared by the author with the assistance of Messrs. H.A. Khan, A.G. Jhingran and R.K. Saxena of the Allahabad Substation of the Central Inland Fisheries Research Institute, India.

Distribution

Author
FAO Department of Fisheries
FAO Regional Fisheries Officers
Regional Fisheries Councils and Commissions
FBCB Selector SI

"Current Bibliography" entry

Jhingran, V.G. (1968) 14-6F290
FAO Fish.Synops., (32)Rev.1:pag.var.
Synopsis of biological data on catla,
Catla catla (Hamilton, 1822)

Identity. Distribution. Bionomics and
life history. Population. Exploitation.
Fisheries management. Pond culture.
NE 11-23136. Do 9-091me.

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1 IDENTITY

1.1 Taxonomy

1.1.1 Definition

(According to Berg, 1947)

Phylum Vertebrata
 Subphylum Craniata
 Superclass Gnathostomata
 Series Pisces
 Class Teleostomi
 Subclass Actinopterygii
 Order Cypriniformes
 Division Cyprini
 Suborder Cyprincoidei
 (Eventognathi)
 Family Cyprinidae
 Subfamily Cyprinini
 Genus Catla
 Valenciennes, 1844
 Species Catla catla
 (Hamilton) 1822

No closely related species of the genus Catla has been reported.

1.1.2 Description

Genus Catla Valenciennes, 1844
Gibelion, Heckel, 1841
Hypselobarbus, Bleeker, 1860

"Head broad; snout with very thin integuments, upper lip absent, the lower moderately thick, having a continuous and free posterior margin. The lower jaw with a moveable articulation at the symphysis, but lacking prominent tubercle. No barbels. Gill rakers long, fine and closely set. Eyes with free orbital margins. Pharyngeal teeth plough-shaped, 5, 3, 2 / 2, 3, 5. Dorsal fin rather long, without osseous ray, commencing somewhat in advance of the ventrals; anal short; caudal forked. Scales of moderate size, no tiled row along the base of the anal fin. Lateral line continuous to the centre of the base of the caudal fin." (Day, 1878).

Catla catla (Hamilton) 1822
 (Figure 1)

The following description of Catla catla is based on Hamilton (1822), Günther (1868), Day (1878 and 1889), Shaw and Shebbeare (1937), Misra (1959).

B.3; D.3-4/14-16; P.21; V.9; A.3/5; C.19
 L.1.40-43; L.tr.7 $\frac{1}{2}$ /9; barbels nil; head 4.2 to 4.7; depth 3 to 3.5 in total length; body deep; dorsal profile more convex than that of ventrals; head broad; mouth wide; lower jaw prominent and with moveable articulation at the symphysis, but lacking prominent tubercle; eyes in front of head, 6 to 7 in head; dorsal commences somewhat in advance of ventrals, is 2/3 as high as

the body, and with a concave upper edge; pectoral extends to the ventral; anal shorter than dorsal; caudal deeply forked; all fins rather elongated; body greyish above, silvery on sides and below; fins dark.

1.2 Nomenclature

1.2.1 Valid scientific names

Catla catla (Hamilton) 1822

The species Cyprinus catla was first described by Hamilton (1822), the type locality being the rivers and tanks of Bengal. The genus Cyprinus, being a composite one, Valenciennes proposed a separate genus for Cyprinus catla in 1844, tautotypically designating Hamilton's species as the type of his new genus Catla. The species thereafter came to be known as Catla buchanaui and was adopted as such by subsequent workers, till Raj (1916) re-designated it as Catla catla (Hamilton).

1.2.2 Synonyms

Cyprinus catla, Hamilton (1822);
 McClelland (1839); Valenciennes (1842).

Leuciscus catla, Valenciennes (1834).

Cyprinus abramioides, Sykes (1840).

Hypselobarbus (Tambra) abramioides,
 Bleeker (1860).

Catla buchanaui, Valenciennes (1844);
 Bleeker (1853); Hyrtle (1864); Günther
 (1868); Day (1869); Day (1873); Beaven
 (1877); Day (1878); Günther (1880);
 Vinciguerra (1889); Day (1889); Thomas
 (1897); Jenkins (1909); Chaudhuri (1911);
 D'Abreu (1925).

Catla catla, Raj (1916); Shaw and
 Shebbeare (1937); Misra (1959).

1.2.3 Standard common names,
vernacular names

See Table I

1.3 General variability1.3.1 Subspecific fragmentation
(races, varieties,
hybrids)

No distinct races or varieties of catla are known. Meristic counts of Catla catla, as described by various authors, are presented in Table II. However, this species has been confused with an allied form occurring in Thailand, Catlocarpio siamensis (Boulenger), due to extraordinary superficial resemblance of the two, more

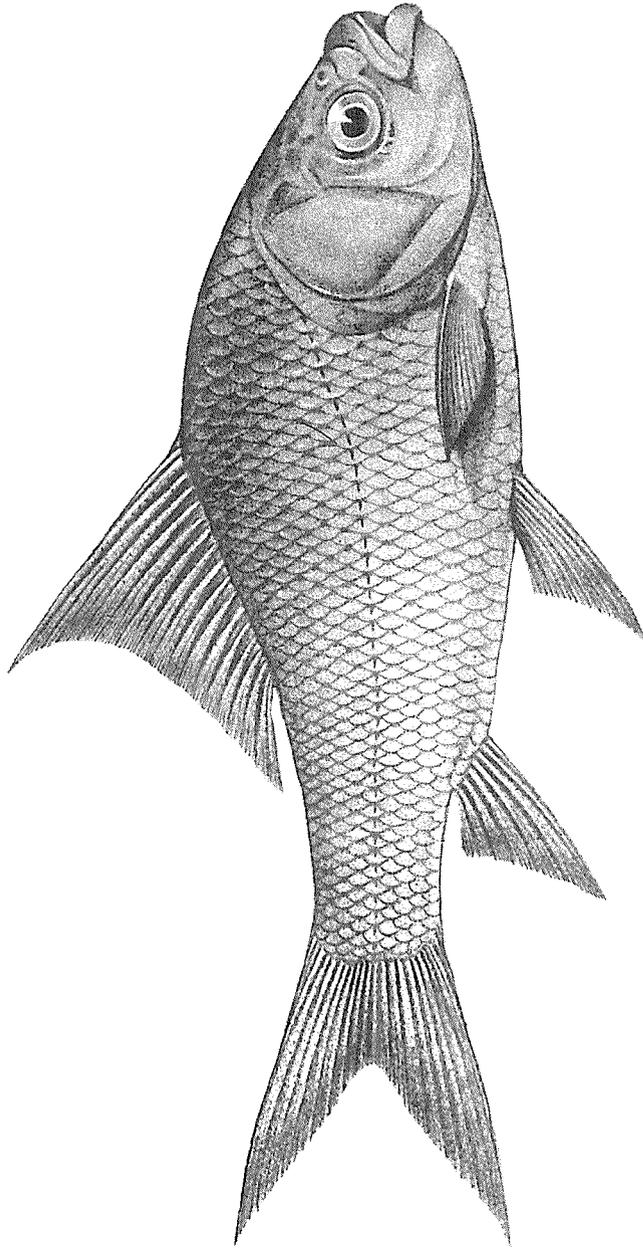


Figure 1. Catla catla (Hamilton)

Table I
Standard common names, vernacular names

Country	Standard common name	Vernacular name
Burma		Nga-thaing
India	Catla	1/. Baudhekra (Assamese) Catla (Bengali) Tambra (Gujarati) Bhakur, Boassa, Chepti, Katla (Hindi) Karakatla (Malayalam) Catla (Marathi) Bakur, Barkur (Oriya) Theil, Theila (Punjabi) Krishnabotcha, Botchee, Bocha (Telegu) Koorra-Kendai, Yamaneri-Kendai, Kanavi Theppu-meenu, Thoppa-meenu Thoppa, Japankendai (Tamil)
Pakistan	Katla	2/. Catla (Bengali) Boassa (North-West Frontier Provinces, in Hindi) Theila (Punjabi) Taylee (Sindhi)

1/, 2/. These languages are spoken in India and Pakistan.

Table II
Meristic counts of Catla catla

B	D	P	V	A	C	L.l.	L.tr.	Vert.	Authors
3	18	-	9	8	19+	-	-	-	Hamilton (1822)
-	17-19	-	-	7	-	40-41	$\frac{7-8}{9}$	-	Günther (1868)
3	3-4/14	21	9	3/5	-	40-43	$\frac{7\frac{1}{2}}{9}$	17/18	Day (1869)
3	3-4/14	21	9	3/5	19	40-43	$\frac{7\frac{1}{2}}{9}$	17/18	Day (1871)
-	17-18	-	-	8	-	40-43	$\frac{7\frac{1}{2}}{9}$	-	Day (1873)
3	17-19(3-4/14-16)	21	9	8(3/5)	19	40-43	$\frac{7\frac{1}{2}}{9}$	17/18	Day (1889)
-	17-19(3-4/14-16)	21	9	8(3/5)	19	40-43	$\frac{7\frac{1}{2}}{9}$	17/18	Thomas (1927)
-	3-4/14-16	21	9	3/5	19	38-43	-	-	Shaw and Shebbeare (1937)
-	17-19(3-4/14-16)	21	9	8(3/5)	19	40-43	-	-	McDonald (1948)
-	3-4/14-16	21	9	3/5	-	40-43	$\frac{7\frac{1}{2}}{9}$	-	Misra (1959)

especially in the enormous head. Catlocarpio is often mistakenly referred to as catla even in ichthyological literature in Indo-China and Cambodia. The former has 4 pharyngeal teeth in one row on each side and the latter 10, arranged in three rows (5,3,2 / 2,3,5), on each side. Other characters of Catlocarpio are a very broad dermal fold bordering the gill cover, numerous gill rakers (110 on first arch), eyes invisible from above, mouth extending as far back as eye, lower lip thick and the post-labial groove interrupted medially and complete lateral line with 39-40 scales (Smith, 1945).

In 1960, several thousands of coloured (golden) catla fry were obtained from one induced-bred specimen, and when these coloured catla were interbred, all the progeny were found coloured (Chaudhuri, personal communication).

Five hybrids, namely: male catla X female rohu, male catla X female kalbasu, male catla X female mrigal (Chaudhuri, 1959), male rohu X female catla, and male fimbriatus X female catla (Chaudhuri, personal communication), have been produced artificially by pituitary hormone administration, followed by stripping. In 1962, one pair of catla-rohu hybrid was induced to spawn by injecting pituitary hormone, which resulted in the successful production of a second generation of the hybrid.

1.3.2 Genetic data (chromosome number, protein specificity)

Haematological studies of catla, carried out by Das (1958), have revealed average counts of r.b.c. to be 431,500 and that of w.b.c. 8,172. The haemoglobin content of the blood was found to be 10 g. The author stated that, compared to human beings, the average r.b.c. count is only 1/10, but other figures are comparable.

A comparative study of the albumin value of Catla catla with those of the other Indian carps Labeo rohita, Cirrhina mrigala, Labeo bata and Labeo kalbasu showed little difference excepting for L. bata which has the maximum (58.6 percent). On this component, the t value between bata and catla is significant at 1 percent level. The α_1 -globulin value is the lowest in catla and t value ratios between α_1 -globulin values of catla and the rest of the four species are significant at 1 percent level. The high concentration of β -globulin (23 percent) in catla is noteworthy. The t values of this component between catla and the rest of the species are all significant at 1 percent level. γ -globulin concentrations are high in catla and t value of γ -globulin between catla and mrigal is significant at 1 percent level. Of the total serum protein, which is highest in catla, the t value between

catla and bata is significant at 1 percent level and those between catla and mrigal and catla and kalbasu at 5 percent levels. On both α - and β -lipoprotein, the t values between catla and rohu and catla and bata are significant at 1 percent and 5 percent levels respectively, while that between catla and kalbasu is not significant (Chandrasekhar, 1959).

Means and standard deviations of biochemical and electrophoretic measurements of catla are presented in Table III. Figure 2 presents the densitometric curve of the electrophoretic pattern of the plasma protein fractions of catla (Das, 1961).

Marked differences were observed in blood sugar, globulin, plasma protein and lipoprotein fractions of different carps. While catla is the heaviest of the species investigated, its blood sugar is notably less than that of Labeo rohita and Cirrhina mrigala. One lipoprotein fraction, designated α_F was found absent in catla and present only in Cirrhina mrigala. Catla and mrigal have similar values for the β -lipoprotein fraction. Electrophoresis for haemoglobin has shown two bands in catla, as against only one each in Cirrhina mrigala and Labeo rohita (Das, 1961).

A study of the free amino acid pattern of seventeen different species of fish, used for confirming the taxonomical differences between them, indicated that alanine, glutamic acid, glycine, histidine and taurine were present in all the species. Proline and cystine were, however, absent in catla. The free amino acid pattern of different species of fish being similar, taxonomic differentiation of the species even up to genera was not possible (Sreenivasan and Chandrasekaran, 1961).

Table III

Biochemical and electrophoretic characters of catla
(after Chandrasekhar, 1959; Das, 1961)

Measurement	Mean	Standard deviation
Blood sugar (milligrams per 100 millilitres)	67.29	8.17
Total plasma protein in gm per 100 millilitres (micro-Kjeldahl)	3.11	0.45
Plasma albumin (percentage)	42.58	9.27
α_1 plasma globulin (percentage)	8.83	3.51
α_2 plasma globulin (percentage)	15.17	4.36
β plasma globulin (percentage)	(26.00 23.00)	(2.71 2.71)
γ plasma globulin (percentage)	10.42	5.77
α_F lipoprotein (percentage)	-	-
α lipoprotein (percentage)	53.11	18.89
β_2 lipoprotein (percentage)	46.89	18.89
Plasma albumin (g/100 ml)	0.99	0.28
α_1 plasma globulin (g/100 ml)	0.21	0.09
α_2 plasma globulin (g/100 ml)	0.41	0.28
β plasma globulin (g/100 ml)	0.58	0.29
γ plasma globulin (g/100 ml)	0.28	0.23
Total plasma protein (electrophoresis)	2.47	1.07
α_F lipoprotein (g/100 ml)	-	-
α lipoprotein (g/100 ml)	1.20	0.82
β lipoprotein (g/100 ml)	1.04	0.72
Total lipoprotein (electrophoresis)	2.24	1.16

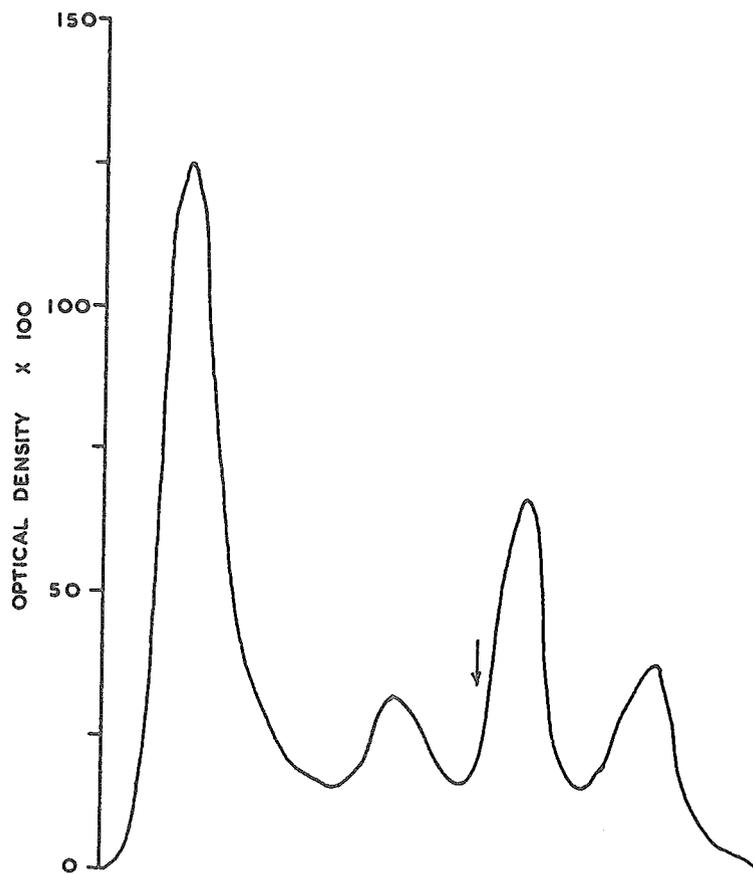


Figure 2. Densitometric curve for plasma protein fraction of catla. The albumin fraction and globulin fractions α_1 , α_2 , β and γ appear when the graph is read from left to right (after Das, 1961)

2 DISTRIBUTION

2.1 Delimitation of the total area of distribution and ecological characterization of this area

The original natural range of distribution of catla was freshwater rivers throughout India, down to the Krishna river, Pakistan (W. Punjab and E. Bengal) and Burma. The fish has also been reported from Nepal (De Witt, 1960).

However, because of successful transplantations carried out since the beginning of the 20th century, and the wanderings of the fish, facilitated by the development of extensive canals, catla has now spread over the whole of peninsular India. Catla fingerlings were introduced in 1909 from the river Godavari into the Cuddapah-Kurnool canal (at present in Andhra Pradesh), where they established themselves and spread in the Pennar river, as well as the connected tanks in the Nellore district (Jones and Sarojini, 1952). The fish was first recorded in the markets of Madras City in 1912 (Raj, 1916). Stray records of catla also appear to have been made close to the Tungabhadra Dam site during 1945-47 just prior to its construction which could be due to the escape of individuals from the canal into the main river. However, catla is now being recorded as stray individuals in the headwaters of the Tunga river as a result of the stocking operation being carried on in the reservoir from 1956-57 onwards (David, personal communication). Catla fingerlings, from the Godavari, were introduced in 1921 into the Cauvery river, below the Hogainakal falls, and into the Bhavani (Hornell, 1924), where the species is now established. About 150 catla fingerlings were procured by the Superintending Engineer and stocked in 1934 in the Vanivilas Sagar lake, built in 1904-5 on a seasonal stream Vedavathi, where the species now exclusively dominates the commercial catches. In 1945, catla fingerlings were sent to Cochin, where again the species is thriving well. They were also introduced from the Godavari into Periyar lake in October 1946 (Chacko, 1948). The Bombay Fisheries Department first introduced the fry of catla from Patna (Bihar) into Powai lake, Greater Bombay, in 1937 (Goldschmidt, 1953), where the fish has established itself (Kulkarni, 1947). It has also been transplanted to Ceylon, where it is believed not to have thrived. In 1954, catla fingerlings were sent in two shipments from India to Israel, where they were stocked in the Dor station ponds. These specimens, which on an average weighed 12.5 g in February 1954, attained an average weight of 3847.0 g in December 1957. However, doubt has been expressed about the identification of the imported species (Yashouv, 1958). Fish Seed Syndicate, Calcutta, has exported 1600 and 1200 catla fingerlings to Japan and Mauritius in 1960 and 1961 respectively (Anon., 1965a). Figure 3 portrays the geographical distribution of catla, including areas where it has success-

fully established itself as a result of transplantations, while Table IV shows the rivers and lakes where its occurrence has been reported in ichthyological literature.

Catla can thrive in nearly all freshwaters below an altitude of approximately 549 m (Motwani, unpublished). David (personal communication) has recorded stray specimens of catla as far up the river Tunga as Shimoga (Mysore State) at an elevation of about 1,000 m (m.s.l.).

It has been reported that in the upper reaches of the rivers Ganga, Yamuna and Sarda in Uttar Pradesh, catla and other major carps occur for a part of the year in certain sections of the rivers. Temperature and not altitude or latitude was attributed by them to limit distribution of catla in these rivers. A temperature of 57° F appears to be the minimum temperature tolerated by catla.

However, the favourite habitat of catla is broad deep pools of the rivers, where they largely remain localised during winter and summer months, ascending, for local breeding migration, during the period of the south-west monsoon, June-September (Setna and Kulkarni, 1946). Catla is also able to live in slightly brackish waters (Raj, 1939; Devanesan and Chidambaram, 1948; Jones and Sujansingani, 1954), in the lower reaches of the rivers or lagoons, where there is slight tidal effect. The salinity of the relevant sector of the Chilka lake, where catla was reported to occur, ranges from 0.29 to 35.19 ppt during the year (Jhingran, 1963).

2.2 Differential distribution

2.2.1 Areas occupied by eggs, larvae and other junior stages: annual variations in these patterns, and seasonal variations for stages persisting over two or more seasons

The differential distribution depends upon the breeding habitat. Catla breeds during the south-west monsoon in shallow pockets in the marginal areas, in fields adjacent to the rivers which are inundated after heavy showers and in bundhs (Khan, 1924; Mookerjee, 1945; Ahmad, 1955; Khan, 1959; Dubey and Tuli, 1961). Spawning grounds are found in the middle reaches of most of the rivers, where flood water spreads in more or less limpid shallows over fertile flats, well above tidal reaches (Anon., 1962). The breeding in bundhs takes place in shallow marginal areas or flooded fields (Ghosh and Ghosh, 1922; Mookerjee, 1945a; Khan, 1947; Rai, 1948; Ganapati and Chacko, 1954; Saha et al., 1957; Khanna, 1958; Alikunhi et al., 1964). Ganapati and Chacko (1954) observed the depth at the spawning spot to vary from 0.5 to 1 m

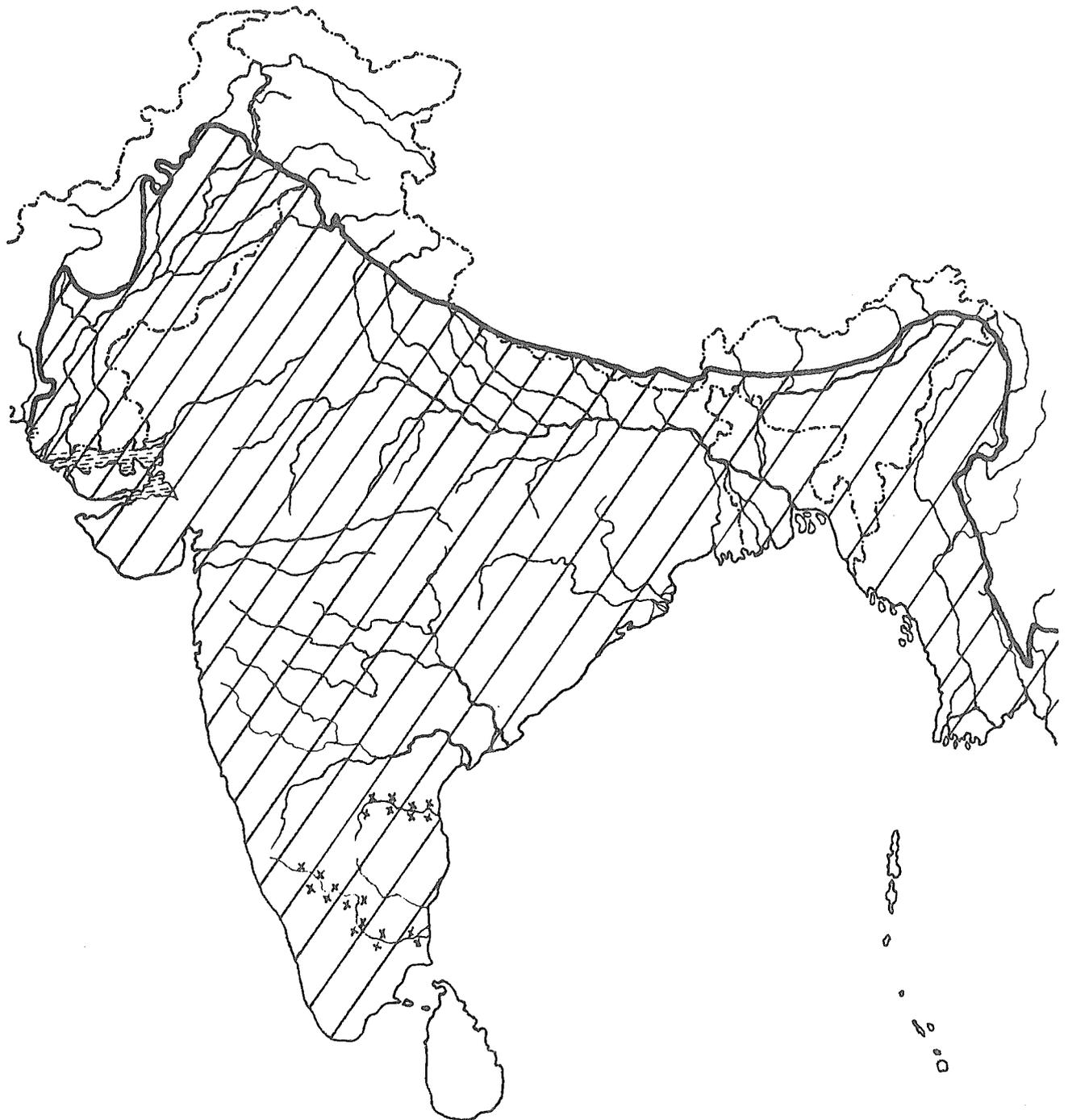


Figure 3. Geographical distribution of catla: crosses indicate areas where the fish has been successfully transplanted

Table IV
Distribution in rivers and lakes*

Habitat	Burma	India				Pakistan	
		Ganga River System	East Coast River System	West Coast River System	Brahmaputra River System	Indus River System	West Pakistan East Pakistan
Rivers and important tributaries	Pegu	Ganga Yamuna Ghaghra Gomti Rapti Sarda Ranganga Kosi Sone Damodar Chambal Betwa Ken	Mahanadi Godavari Manjra Krishna Tungabhadra Suvarnarekha Uraongarha South Koel Cauvery	Narbada Tapti Mahi Mindhola Hathmati Khari Vatrak Meshwa Padmavati	Brahmaputra Kalang Burhi Dhing Dhansiri Dhiko	Indus Sutlej Beas	Indus and its tributaries and other rivers of plains
Lakes	Indawgyi	Ranchi Bhopal lower	Sur(near puri) Pennar	Powai Bokh Bashan		Manchar	

*Only rivers have been mentioned from where catla has been reported in ichthyological literature. Relevant references are included in the bibliography.

in the bundhs of Bengal. In dry bundhs (bundhs which are completely dry for a part of the year), spawning sometimes takes place in deeper areas (Alikunhi et al., 1964). Dubey and Tuli (1961), while describing the spawning of major carps¹ in various environments in Madhya Pradesh, observed that catla, being a deep bodied fish, reaches the breeding ground when the rain fall raises the depth of water in the nullah (a small rivulet or a drain) to about 1 m or more. Spawning occurs

over hard or sandy soil and even on rocky embankments.

Eggs of catla are first demersal. They gradually become buoyant and eventually come to float at the surface (Mazumdar, 1957). Spawn² generally remain in surface or sub-surface waters while adult catla inhabit deep waters.

-
- 1/ The expression 'major carps' commonly includes four species, viz. Catla catla, Cirrhina mrigala, Labeo rohita and L.calbasu.
- 2/ Under 'spawn' are included hatchlings from 2.5-8 mm in total length.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality (hermaphroditism, heterosexuality, intersexuality)

Catla is heterosexual. Sexes are difficult to distinguish externally, except during the breeding season when mature females show a prominently bulging abdomen and a swollen reddish vent. According to Day (1878) the males ventral fin extends to the anal. Chaudhuri (1959a) stated that during the breeding season, the pectoral fin in mature males is slightly stouter and longer, extending farther towards the posterior end than in the case of mature females. In the few specimens examined by him, he found that the pectoral fin in males, when extended backwards and towards the dorsal side of the body, reaches the 8th and 9th lateral line scale, whereas in females, it reaches only the 6th or 7th lateral line scale. The pectoral fin in mature males, during the breeding season, has a very rough dorsal surface (i.e. the surface close to the body) which, in the case of females, is very smooth. According to him, the rough surface of the pectoral fin could be of help in gripping the female during courtship.

3.1.2 Maturity (age and size)

Catla attains maturity in the second year of life. Alikunhi (1957) mentioned that in ponds catla becomes mature when it is 22 months old. Natarajan and Jhingran (1963) estimated the maturity age of catla from the river Yamuna by plotting the length-weight relationship curves of sexed specimens. The length of which the two curves intersected fell under the size-range of the second year age-group.

The length at which catla attains its first sexual maturity has been stated by different workers as shown below:

Chacko and Kuriyan (1948a and 1950)	558.8	mm
Alikunhi (1957)	457.2	mm
Menon <u>et al.</u> (1959)	550.0	mm
Natarajan and Jhingran (1963)	441.595	mm

3.1.3 Mating (monogamous, polygamous, promiscuous)

Studies on ova-diameter and gonadosomatic index by Natarajan and Jhingran (1963) have revealed that catla has a single specific spawning, implying that each specimen spawns only once during the breeding season. The species appears to be promiscuous (Khan, 1924).

3.1.4 Fertilization

Fertilization is external. The fertilized eggs are abandoned by the parents and, depending on the location of the spawning ground, either drift to the edges of the bundh (Ghosh and Ghosh, 1922), or get washed down the nullah (Khan, 1959). In bundhs, a large number of eggs accumulate in shallow water, giving the latter a characteristic pale whitish appearance. When spawning is over, a thick blanket of eggs remains over the spawning ground (Alikunhi et al., 1964). The spent fish in natural riverine breeding grounds flounder about and start their homeward journey along with the receding water. Many are left behind, stranded amidst shallow pools and puddles, and ultimately die (Dubey and Tuli, 1961).

3.1.5 Fecundity

- Relation of gonad size and egg number to body size and to age

Khan (1924) found 400,275 eggs in a specimen weighing 5.1 kg. The number of eggs per kg body weight was estimated by him to be 77,832. Natarajan and Jhingran (personal communication) found the fecundity of catla to vary from 230,831 to 4,202,250, depending upon the length and weight of the fish and the weight of the ovary, as shown in Table V.

3.1.6 Spawning

- Spawning season

The spawning season of catla coincides with the south-west monsoon in North-eastern India and East Pakistan, where it lasts from May to August, and in North India and West Pakistan, from June to September. In South Indian rivers the spawning season appears to be somewhat variable as shown below:

<u>Authority</u>	<u>Spawning Season</u>
Chacko (1946)	July-September
Chacko and Kuriyan (1948a)	July-November
Chacko and Kuriyan (1950)	End of May-End of October
Alikunhi <u>et al.</u> (1952)	Twice a year, once each during south-west and north-west monsoons
Menon <u>et al.</u> (1959)	June-September
Ibrahim (1961)	July-October
Hora and Pillay (1962)	Twice a year during monsoons

- Frequency of spawning

Catla spawns only once a year (Natarajan and Jhingran, 1963). After one spawning the ovaries are in a spent condition; flaccid and blood-shot with a few dead detached ova lying in the lumen of the ovary.

- Spawning time of day

According to Chacko and Kuriyan (1949) and Khan (1959) catla generally spawn at night. The opposite was observed in a reservoir by Dubey and Tuli (1961) who found catla breeding during bright sun in the forenoon. Alikunhi et al. (1964) stated that unlike mrigal and rohu, which commenced breeding in the morning, catla were seen actively spawning only from about noon to evening. Because of their large size and deep body they remained in relatively deep water away from the marginal areas occupied by mrigal and rohu.

Dubey and Tuli (1961) differed from Chacko and Kuriyan (1949) and Ahmad (1955), and stated that celestial bodies, like the moon, have no effect on spawning. Ahmad (1955) observed spawning of major carps, in the river Halda, took place generally during the full or new moon. He felt, however, that there was not adequate evidence to correlate spawning with moon phases.

- Induction of spawning,
artificial fertilization

Attempts to induce catla to breed, by injecting fish pituitary hormone, have met with varying degrees of success in different parts of India (Chaudhuri, 1960, 1963 and 1964; Mammen and Sulochanan, 1962; Rajan and Madhusudhana Rao, 1962; Badami and David, 1964; Alikunhi et al., 1964; Anon., 1963-64 and 1964-65). Though experiments on induced breeding of catla were carried out during 1955, 1957 and 1958 at Cuttack (India), successful spawning was not achieved until May 1959 at Joyasagar in Assam. As a result of one pituitary injection one female catla, weighing 12.7 kg, released 11.0 lakhs of eggs, 32% of which hatched. A second catla, 5.9 kg in weight, laid over 7.0 lakhs of eggs and 90% hatched. From 1959 onwards, induced breeding of catla has been carried out on a large scale (Chaudhuri, personal communication). The largest fish so far bred was a catla female weighing 14.5 kg, which after one injection laid about 20 lakhs of eggs, 70% of which hatched. Mammen and Sulochanan (1962) successfully induced one pair of catla to breed at Mettur dam and obtained approximately 50,000 fertilized eggs. Rajan and Madhusudhana Rao (1962) successfully induced two sets of catla to breed and obtained 160,000 fertilized eggs from one set and two hatchlings and three wriggling stage eggs from the other set at Sunkesula Fish

Farm (Kurnool District) in Andhra Pradesh.

Badami and David (1964) conducted experiments at Tungabhadra dam and got as much as 62 percent hatchlings from one set. Alikunhi et al. (1964) were successful in inducing one pair of catla to breed under a controlled temperature of 28°C. Attempts to breed catla in Andhra Pradesh met with success only in 5.5 to 10.5% of the cases (Anon., op.cit.).

For administration of the pituitary hormone in catla, the pituitary glands were collected from fresh or freshly killed, fully ripe major carps, and were immediately preserved in absolute alcohol. The required quantity of gland was macerated with a little distilled water or 0.3 percent common salt solution. The gland suspension was then centrifuged and the supernatant fluid injected intramuscularly to the breeders. Usually, the glands from the same species as the recipient fish were used (Chaudhuri, 1960, 1963 and 1964; Das and Khan, 1962).

Vast gaps exist in our knowledge regarding the standardization of hormone dosage. Arbitrary dosages of pituitary glands were initially used to induce major carps to spawn. Das and Khan (1962) suggested a sub-dosage system, which they designated as 'Fish Units' (F.U.) and sub-classified them into 'Large Fish Unit' (L.F.U.), 'Medium Fish Unit' (M.F.U.) and 'Small Fish Unit' (S.F.U.). The equivalents of one fish unit in terms of the other are as indicated below:

1 L.F.U. \approx 2 M.F.U. \approx 4 S.F.U.

L.F.U., M.F.U. and S.F.U. are the units of pituitary glands of fish weighing 4,500, 1,800 and 900 g respectively.

Similar to the 'Loach Units' or 'Vy'un Units', based on the European weather fish, Misgurnus fossilis, used by Kazanskii and Persov (1948), Das and Khan (1962) advocated the use of 'Magur Units' (M.G. Units) which they defined as the amount of gonadotropin that would cause ovulation in 50 percent of mature magur (Clarias batrachus). The equivalents of F.U. in terms of M.G. Units are: 1 M.F.U. = 10-15 M.G. Units.

Chaudhuri (1963) obtained successful results in the induced breeding of major carps by administering 5-10 mg of pituitary gland (dried for two minutes) per kg body weight of female and 2-6 mg of gland per kg body weight of the male. Better results were obtained when a preliminary dose of 2-3 mg per kg body weight was given to the ripe female. After six hours, the regular doses were injected and the ripe breeders, of both sexes, were released together in water ranging in temperature from 24-31°C.

Alikunhi *et al.* (1964) gave a preliminary dose of 1 mg per kg body weight to the male breeder also, when it was not freely oozing. Artificial fertilization of catla has seldom been done in India. Chaudhuri (1959) and Alikunhi *et al.* (1964), however, had to resort to stripping of catla for artificial fertilization, after the breeders were administered hypophysial hormone.

3.1.7 Spawning grounds

Catla does not breed naturally in small confined waters. It breeds in rivers, reservoirs and 'bundh'- type tanks where fluvial conditions prevail during the spawning season.

Ghosh and Ghosh (1922) observed that in the bundhs of Midnapore, Bengal, Singhbhum and Bihar, hard and gritty beds with a gradually sloping bottom and a large catchment area, proved suitable for carp spawning. Khan (1924) observed carp spawning in flooded fields adjoining a nullah in the Punjab. Mookerjee (1945) found that catla spawned in shallow areas forming pockets adjacent to rivers. According to Chacko (1946), Chacko and Kuriyan (1948a) and Menon *et al.* (1959), sections of the rivers Godavari, Krishna and Cauvery, characterized by large submerged rocks or emergent vegetation, constitute the spawning grounds of catla. Job and Chacko (1948) described 22 breeding grounds of catla and other major carps in the rivers Godavari, Krishna, Tungabhadra and Cauvery. Khan (1959) recorded spawning of catla and other major carps in shallow areas adjacent to a nullah (Garua nullah off river Betwa, Bhopal) in Madhya Pradesh covered with a species of grass (*Vitiveria indica*). David (1959) stated that in Bihar major carps breed in a 647.5 sq.km area in an interlacing channel system of river Kosi in Saharsa and Darbhanga districts, near Muzaffarpur in river Burhi Gandak and in river Ganga near Sakrigalihat. Dubey and Tuli (1961) observed spawning of major carps both over hard and sandy soils and even on rocky embankments in rivers (several tributaries of river Chambal), reservoirs and bundhs of Madhya Pradesh. Alikunhi *et al.* (1964) reported carp spawning on muddy soil in bundhs of Madhya Pradesh and recommended a provision therein of levelled spawning grounds, at different elevations, with sparse or no growth of grass. Recently, spawning grounds of catla have been reported in the main Vedavathi river above Vanivilas Sagar in South India.

No single factor can be said to be responsible for spawning. The act involves fulfilment of a chain of interrelated conditions as a prerequisite to spawning

(Khan, 1942; Ganapati and Chacko, 1954). According to Hora (1945), Husain (1945) and Khanna (1958), heavy monsoon floods, capable of inundating vast shallow areas which form the breeding grounds of the fish stimulate spawning and are believed to be a primary factor for spawning. Khan (1947) and Ganapati and Alikunhi (1950), however, believed the availability of shallow spawning ground to be a deciding factor for spawning. Khan (1947) and Ganapati and Chacko (1954) observed that flooding in the early phase of the south-west monsoon is necessary and the fish do not spawn if rains are delayed.

The depth of water where breeding takes place has been stated to vary from 8 cm to 1.2 m (Khan, 1924; Ganapati and Chacko, 1954; Dubey and Tuli, 1961). However, Ganapati and Chacko (1954) concluded that sufficient depth of water which will enable the fish to swim to and from the spawning ground in the bundh will suffice for spawning.

The rise in the level of water, which may be caused naturally or artificially, has been observed by Khan (1942), Ganapati and Alikunhi (1950) and Ganapati and Chacko (1954) to bring about spawning. Studies conducted by the Central Inland Fisheries Research Institute, Barrackpore, (India), in 1955 revealed that spawning of carps was probably stimulated by sudden heavy rains resulting in abrupt rise of water level in the bundhs so as to submerge the contiguous shallow spawning grounds.

Opinions on the pattern of water current on the spawning ground are divided. A majority of the workers (Das, 1917; Khan, 1924; Mookerjee *et al.*, 1944a; Ganapati and Chacko, 1954; Dubey and Tuli, 1961; Alikunhi *et al.*, 1964) have stated that spawning occurs in still waters. Ghosh and Ghosh (1922), however, observed strong current on the spawning ground in the bundhs in Bengal and Bihar, while Khanna (1958) noticed moderate currents at the breeding site in a fish farm in the Punjab.

The colour of water on the breeding ground was found to be muddy by Khan (1924), brick-red by Mookerjee *et al.* (1944a) and of a hue corresponding to a mixture of tea and milk, but of varying shades, by Ganapati and Chacko (1954), both before and after spawning, indicating high turbidity in all the cases. Ganapati and Alikunhi (1950) found eggs and hatchlings in clear water as well. Ganapati and Chacko (1954) presumed that the colour of water depends on the nature of the particular area and the amount of rainfall and that the colour has no independent influence on spawning.

Table V
Relation of egg number to body size and age

Estimated age of fish in years	Total length of fish (mm)	Weight of fish (g)	Weight of ovary (g)	Number of ova	Number of ova per g wt of	
					body	ovary
III+	783	11,329.0	301.1	230,831	20.	767
III+	795	10,875.4	424.4	348,220	32	821
III+	795	14,373.4	3,005.1	2,348,351	163	781
IV	840	13,013.4	3,118.5	2,963,125	228	950
V	923	11,772.6	2,239.7	2,073,065	176	926
V	925	17,095.0	4,422.6	4,202,250	246	950
V	935	18,909.4	2,608.0	2,432,390	126	933
V+	950	18,455.8	3,118.5	3,077,800	167	987

The optimum temperature of water at the spawning ground, according to Khan (1942), is 24-31°C; according to Chacko and Kuriyan (1950) 22-28°C and according to Dubey and Tuli (1961) 26-33°C. Saha *et al.* (1957) observed no specific influence of temperature on spawning, and stated that cloudy days, accompanied by thunderstorm and rain, seem to have some influence on spawning. Alikunhi *et al.* (1964) observed spawning both in cool and warm weather.

Other factors like high pH and high O₂ content of water are incidental to floods and are not essential in themselves for spawning (Mookerjee *et al.*, 1944a; Mookerjee, 1945a). Low alkalinity (Saha *et al.*, 1957), minerals either in solution or in suspension (Raj, 1945) and low salinity (Rai, 1948) do not seem to play any significant part in the spawning of carps.

Major carp spawn prospecting investigations carried out by the Allahabad Substation of the Central Inland Fisheries Research Institute (India) in eight riverine stretches in the states of Uttar Pradesh and Gujarat revealed that widespread rains flooding the breeding grounds, high turbidity

and slightly lower temperature (by 1°C than in the pre- and post-spawning periods) stimulated carps to breed. Generally, intensive major carp spawning occurred in floods II to IV in the Indo-Gangetic plain in the middle and later parts of the monsoon, rather than its commencement or the terminal phase (Anon., 1965). These observations corroborate Mitra's (1958) findings, that in river Mahanadi, major carps spawn after 22-40 days of the onset of monsoon, and spawn has never been recorded till silt-laden flood water entered the river. In river Warbada, it was observed that carp spawning occurred only when the flood level attained a particular height, signifying a 'table land' at which elevation important breeding grounds lie (Anon., 1965).

3.1.8 Eggs: structure, size, hatching type, parasites and predators

Fertilized eggs of catla are mostly spherical, but some are oval in form. They are transparent, light red in colour, non-floating and non-adhesive. The yolk sphere contains no oil globule (Mookerjee, 1945). They have a large perivitelline space,

measuring 3 mm in width (Chacko, 1946). The diameter of the fully ripe ovarian egg has been recorded as 2.22 mm (Mookerjee, 1945) and 2.0-3.2 mm (Anon., 1962). The fertilized eggs, after being laid in water are reported to swell to 5.3-6.5 mm (Mookerjee, 1945), 4.1 mm (Anon., 1962), 6.0 mm (Mazumdar, 1957), 4.0-5.2 mm (Hora and Pillay, 1962), 4.3-5.1 mm (Chacko and Kuriyan, 1948a and 1950) and 4.6 mm (Chaudhuri, 1963). The embryo becomes prominent 10 hours after fertilization and measures 2.1 to 2.5 mm in length (Chacko and Kuriyan, 1948a). No information is available on the parasites and predators of catla eggs in nature. During experiments in induced breeding it has been observed that mortality may occur due to fungal infection.

3.2 Larval history

3.2.1 Account of embryonic and juvenile life (prelarva, larva, postlarva, juvenile)

The developmental features of fertilized eggs according to Mookerjee (1945) are given in Table VI.

Table VI
Development of fertilized eggs
(after Mookerjee, 1945)

Time after fertilization	Developmental features
35 - 40 min	Segmentation commences, regular
1h 29 min	8 celled stage
1h 45 min	16 celled stage
2h 19 min	32 celled stage
6h 30 min	Completion of yolk invasion and formation of blastopore
8h 50 min	Appearance of embryonic rudiment
11h 5 min	Appearance of optic rudiment
12h 45 min	Appearance of median fin fold
14h 30 min	Appearance of heart and otocyst rudiments
15h 0 min	Beginning of pulsation of heart
16h 0 min	Beginning of gill rudiments
16h 10 min	Beginning of pectoral fin buds
16h 40 min	Period of incubation

The incubation period, observed by different authors, is as shown below:

Mookerjee (1945)	16 h 40 min
Jagannadhan (1947)	16 - 24 h
Chacko and Kuriyan (1948a)	16 - 18 h

The newly hatched larva measures 4.2 to 4.7 mm (Mookerjee, 1945) or 4.38 to 5.25 mm (Chacko and Kuriyan, 1948a) or 4.5 to 5.3 mm (Anon., 1962).

It has a transparent, laterally compressed body and is characterized by the presence of conspicuous eyes, otocysts, rudiments of gill slits, pectoral fin and median fin fold (Mookerjee, 1945; Chacko and Kuriyan, 1948a).

The different stages in the larval development of catla are presented in Table VII and Fig. 4.

The pulsation of the heart begins 13 h after fertilization according to Chacko and Kuriyan (1948a) and after 15 h according to Mookerjee (1945). Menon *et al.* (1959) described the fry, 8-10 mm in length as having a large head, red-tinged operculum and a wide mouth. Mookerjee (1945) stated that catla fry have a large head, transparent opercular flaps, long snout, compressed chin, anterior mouth without teeth and barbels and a body with scales. Kamal (in press) while studying the differentiation of alimentary canal and associated structures in catla hatchlings, from the day of their hatching till the 19th day, observed that the alimentary canal appeared on the third day after hatching, and thence the fry (7.2 mm in length) started feeding.

Details of development and the stages of coiling of the alimentary canal, formation of gill rays, gill filaments and gill rakers, from the first day after hatching till the 19th day are presented in Table VIII.

Catla attains its adult characteristics in about six weeks after hatching (Chacko and Kuriyan, 1948a and 1950).

- 27.4
(Figure 4.5) Colour of body along dorsal side mignonette green and that of ventral side including isthmus white or grey; black colour noticeable on dorsal, anal and caudal fins. With further growth colour of body becomes golden yellow or dark olive-buff and red colour of gills becomes more intense (Mookerjee et al., 1944b).
- 30.0 Fry attain this size in five weeks, mouth upwards, body greenish-brown in colour, with golden tinge over the head region (Chacko and Kuriyan, 1948a).
- 44.0-44.2
(Figure 4.6) Jaws and mouth same as in previous stage, no taste buds, gape of mouth 8 mm, lips not continuous, eye 2.5 mm, opaqueness of opercula makes the red tinge of gills in opercular region quite indistinct (Mookerjee, 1945; Mookerjee et al., 1944b).
- 57.0-100.0 Large head, lips thick but not fringed, no distinct spot on body or at caudal peduncle, colour of back gradually becomes deep chrysolite green and that of belly greenish white, colour of fins a mixture of grey and light red or black alone or dark greenish. (Mookerjee et al., 1944b).

less, thereby showing the preference of the fish for zooplankton (Kamal, in press).

The food consumed by catla fry during various stages of development, as stated by Alikunhi (1957), is given in Table IX.

According to Mookerjee (1944, 1945) 5 to 10 mm long fry feed exclusively on unicellular algae, 10-20 mm long ones on protozoa of various kinds and 20 to 100 mm long individuals on unicellular algae (10%), protozoans and rotifers (6%), crustacea (80%), sand particles (1%) and unidentified mass (3%). Kamal (in press) observed that catla fry in the length-range 7.2 to 16.5 mm feed mainly on zooplankton. According to Alikunhi (1952), zooplankton, particularly Entomostraca and rotifers, appear to constitute the 'main food' of carp fry, while planktonic algae could only be considered as 'emergency food'. The young fry, with a short straight intestine, appear to be incapable of digesting, at least, some of the algae consumed.

Catla fry, 15-20 mm long, are apt to digest zooplankton, particularly cladocerans, in about an hour after ingestion. Alikunhi (1957) stated that catla fry from 11.0 to 101.0 mm mainly feed on animalcules and water fleas.

- Rates of development and survival

In a continuous flow system, the larvae and fry of catla up to 8 cm and fingerlings 10-15 cm long can live for 24 hours or more in water containing 0.5 and 1.0 ppm O₂ respectively, other conditions remaining optimum, but die within a short time below the above stated concentrations of O₂. Experiments on the effects of various combinations of O₂ and CO₂ concentrations on larvae, fry and fingerlings of catla show that the larvae (4-5 mm) cannot stand 0.5 ppm O₂ with 2.5 ppm CO₂, but with 1-4 ppm O₂ they can stand up to 7.5 ppm CO₂. The fry (1-2 and 4-8 cm) can stand 0.5 ppm O₂ with 15 ppm CO₂, but die in 0.5 ppm O₂ with 17.5 ppm CO₂. When O₂ is increased from 1 up to 4 ppm, the fry can stand 125 ppm CO₂, while half of them die in 150-175 ppm CO₂ and all die between 175-250 ppm. The fingerlings (10-15 cm) can stand 1 ppm O₂ with 2.5 and 5.0 ppm of CO₂. With further increase in the concentration of CO₂, O₂ remaining the same, they die at 7.5 ppm CO₂, indicating that fingerlings have a minimum and maximum CO₂ tolerance optima, which is absent in the case of larvae and fry up to 8 cm (Basu, 1950 and 1950a). In experiments performed for 72 and 56 hours, in environments with 5.2 to 6.0 and 1.76 to 2.8 ppm O₂ and 100-150 ppm and 75-110 ppm CO₂ respectively, catla fingerlings were found to utilize 14.63 mg O₂.

- Feeding

Figure 5 shows the development of mouth parts of catla fry from the day of its hatching to the 5th day when the alimentary canal and the associated structures are fully formed and the fry start taking their natural diet. They begin feeding on plankton from the third day after hatching while the rudiment of the yolk sac still persists. The fry are planktophagic. The mouth, to start with, is sub-terminal, but later moves to a slightly dorsal position. The gill filaments and the gill rakers increase in number with the size of the fry, the latter straining the ingested food items. The fry measuring 5.2 to 7.9 mm have a relatively short and straight intestine, characteristic of carnivores, and the coiling of the alimentary canal commences on the 6th day after hatching (Fig. 6). In catla fry 16.5 mm long, which feed on zooplankton, the intestine is short, about 67.9% of the body length, while in adult catla (500 mm in total length), it is 2½ times the body length. The degree of coiling of the alimentary canal in catla fry, as compared to other major carps, is

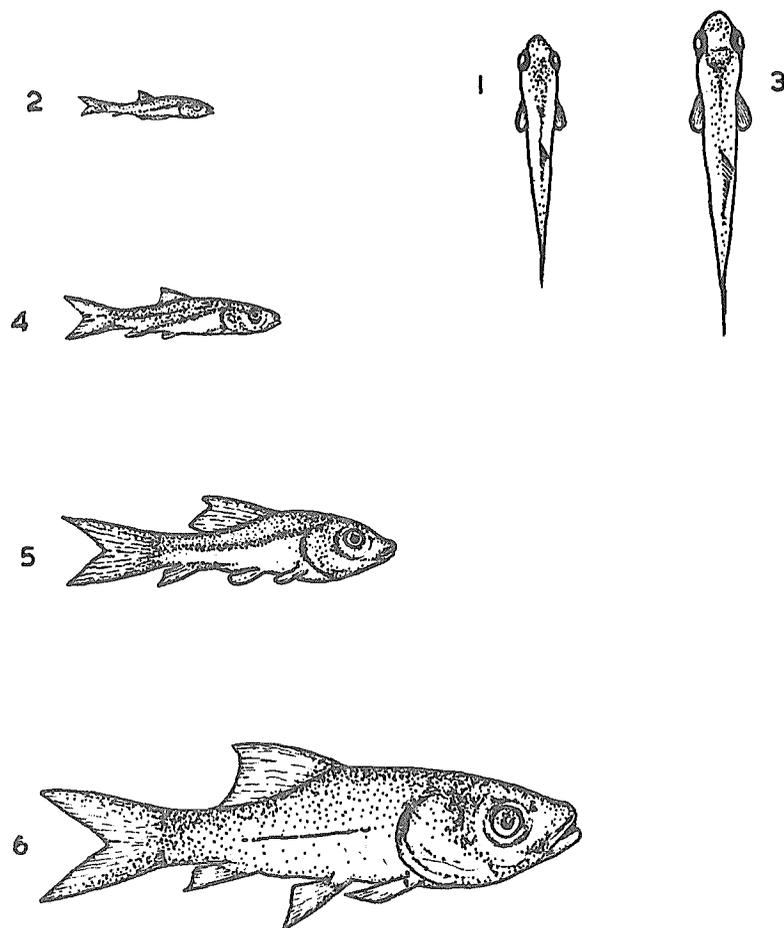


Figure 4. Developmental stages of catla

- | | | | |
|-----|--------------------|------|--|
| (1) | 10.0 mm long stage | (X5) | (After Devasundaram, 1952) |
| (2) | 11.2 mm long stage | (X2) | (After Mookerjee <u>et al.</u> , 1944) |
| (3) | 13.5 mm long stage | (X5) | (After Devasundaram, 1952) |
| (4) | 17.8 mm long stage | (X2) | (After Mookerjee <u>et al.</u> , 1944) |
| (5) | 27.4 mm long stage | (X2) | (After Mookerjee <u>et al.</u> , 1944) |
| (6) | 44.2 mm long stage | (X2) | (After Mookerjee <u>et al.</u> , 1944) |

Table VIII
Development of alimentary canal, gill rays, gill filaments and
gill rakers (after Kamal, in press)

Age in days after hatching	Average total length (mm)	S.D.	Average length of intestine (mm)	S.D.	Ratio of alimentary canal to total length	Stage of coiling	No. of gill rays	No. of gill filaments	No. of gill rakers
0	5.2	± 0.2372	3.0	-	0.576	-	-	-	-
1	6.5	± 0.1466	3.0	-	0.461	-	-	-	-
2	6.0	± 0.3000	3.0	-	0.500	-	4	10	-
3	7.2	± 0.1888	3.4	± 0.1251	0.472	I	4	10	-
5	7.9	± 0.1000	3.6	-	0.455	I	4	14	9
7	11.3	± 0.4715	5.3	± 0.4715	0.469	III	4	23	10
9	12.2	± 0.2359	7.0	-	0.573	IV	4	23-24	10
11	13.7	± 0.2359	8.0	± 0.8165	0.583	IV	4	22-23	10-13
13	16.5	± 0.3497	10.0	± 0.8165	0.606	V	4	31-32	16-18
15	16.3	± 0.9429	10.3	± 2.0548	0.631	VII	4	30-31	17-21
17	15.8	± 0.2359	10.2	± 1.6477	0.645	VII	4	32	20-21
19	16.5	± 0.5282	11.2	± 0.2359	0.678	VII	4	31-32	19-21

Table IX
Food consumed by catla during various stages of its life
(after Alikunhi, 1957)

Length (mm)	Average percentage of items of food generally encountered in the stomach and gut					
	Unicellular algae	Filamentous algae	Vegetable debris	Animalcules and water fleas	Insects	Sand or mud
11-20	10.0	-	3.0	87.0	-	-
21-40	9.9	-	2.5	87.6	-	-
41-100	10.0	-	18.5	70.0	-	1.5
100 and longer	8.3	0.7	38.0	44.1	-	8.9

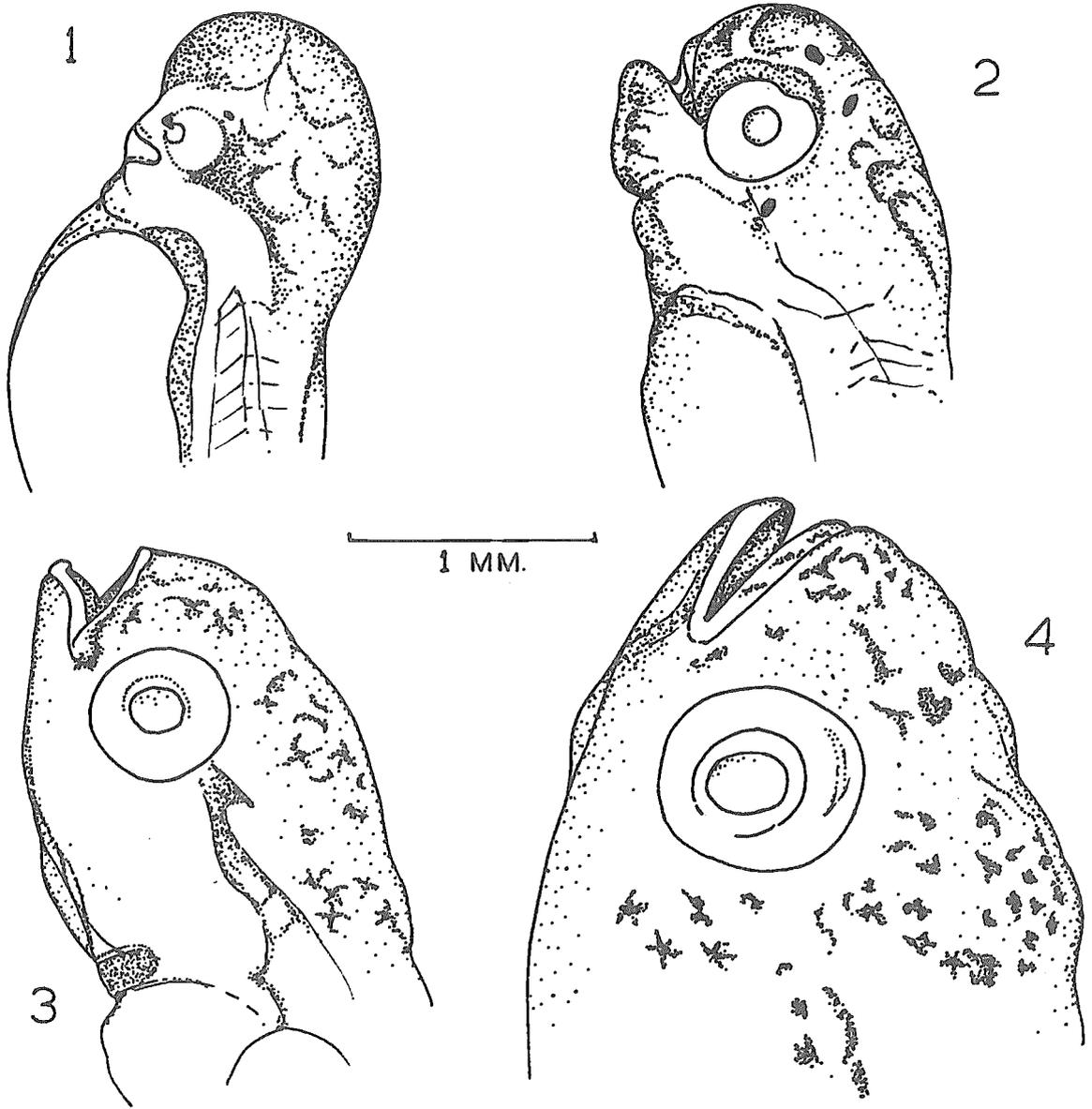


Figure 5. Development of mouth parts of catla (after Kamal, in press)
(1) Newly hatched larva (2) 2nd day after hatching
(3) 3rd day after hatching (4) 5th day after hatching

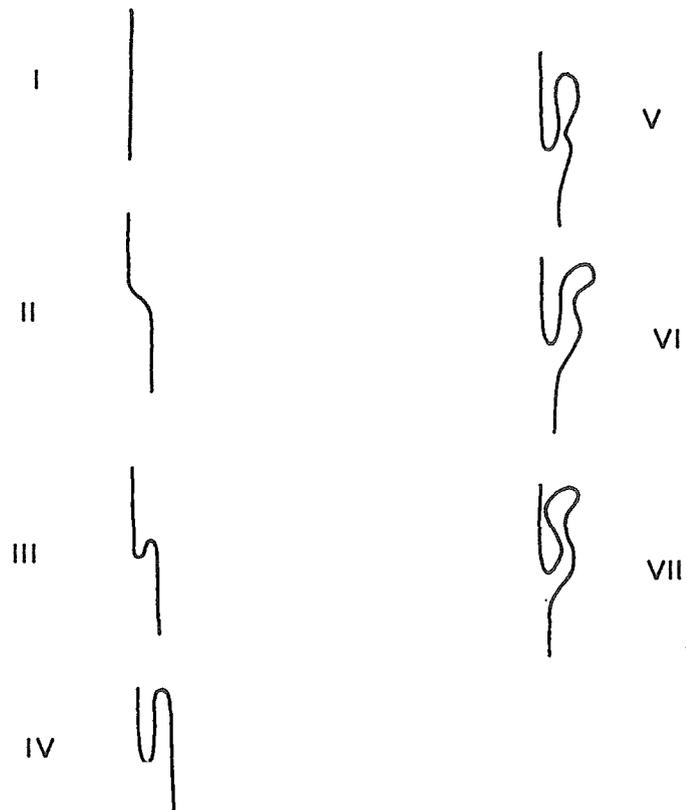


Figure 6. Diagrammatic representation of the stages I to VII of the coiling of alimentary canal of catla (after Kamal, in press)

Table XI
Survival of catla fingerlings at various temperatures
(after Mookerjee et al., 1946)

Length (mm)	Temperature (°C)	Period of survival (minutes)	Remarks
70	12.0	4	Survival period very short; temperature unsuitable
65	16.8	No mortality	No mortality, but when kept in this temperature for 15 days, a decrease in body weight takes place
65	18.3	"	No mortality or decrease in weight
70	37.8	"	--do--
65	38.9	"	Marked decrease in weight when kept in this temperature for 15 days
70	39.5	375	Mortality begins
70	41.1	8	Survival period decreases rapidly

3.3 Adult history

3.3.1 Longevity

Aging of catla, based on scale studies, was done by Natarajan and Jhingran (1963) who observed up to 5 + age-groups of catla in the commercial catches of river Yamuna at Allahabad, the maximum total length of fish in their samples being 123 cm. However, the length of the largest recorded catla is approximately 180 cm (Day, 1871, 1878 and 1889; Raj, 1939; Chacko and Kuriyan, 1950).

3.3.2 Hardiness

Catla is a hardy fish which, when young, stands transportation well over long distances involving considerable time. The species is very strong and active and often leaps over the seine. Consequently the fishermen usually follow the net in canoes (Hamilton, 1822; Day, 1889; Thomas, 1927; Devanesan and Chidambaram, 1948). The transfer from lotic to lentic waters and the change in the environmental factors involved, do not ordinarily affect the young catla. Transplantation to the lentic habitat does not adversely affect catla in respect to growth and development of gonads, though the fish does not ordinarily breed in confined waters (Alikunhi et al., 1952). Regional transplants of catla, described under section 2.3, have proved successful mainly because of the hardiness of the fish.

Mammen and Sulochanan (1962) described successful transportation of catla breeders tied with a nylon rope through the nares, in a tow-box behind a motor launch, moving at 3-4 knots over a distance of ten miles and over a short distance. The salinity tolerance of catla in Chilka Lake is 0.29‰ and in Khakhra Dhand in the Punjab, 0.28 to 2.2‰ (Rai, 1948). The limits of tolerance of different physico-chemical factors by fry and fingerlings of catla are described under 3.2.1.

3.3.3 Competitors

Catla faces different types of competition in natural and artificial habitats. During fry stage in both the habitats, almost all the inhabiting species of fish are planktophagic and there occurs an interspecific competition of a high degree. Catla fingerlings and adults continue to remain predominantly plankton feeders and, with age, the degree of competition declines as other species take to feeding in different niches. The competitors of catla are all plankton feeders, notably a number of clupeoids and minnows.

3.3.4 Predators

No information is available on predation by other animals on adult catla. Advanced finger-

Table XII
 Predatory and weed fishes
 (after Das Gupta, 1957; Alikunhi, 1957; Karamchandani, 1957 and
 Anon., 1965)

Predatory fishes	Weed fishes
<u>Channa marulius</u>	<u>Ambassis ranga</u>
<u>C. punctatus</u>	<u>A. nama</u>
<u>C. striatus</u>	<u>Aspidoparia morar</u>
<u>C. gachua</u>	<u>Puntius chagunio</u>
<u>C. stewarti</u>	<u>P. phutunio</u>
<u>Anabas testudineus</u>	<u>P. sarana</u>
<u>Nandus nandus</u>	<u>P. sophore</u>
<u>Glossogobius giuris</u>	<u>P. ticto</u>
<u>Notopterus notopterus</u>	<u>P. conchoniis</u>
<u>N. chitala</u>	<u>Rohtee cotio</u>
<u>Heteropneustes fossilis</u>	<u>Laubuca laubuca</u>
<u>Clarias batrachus</u>	<u>Rasbora daniconius</u>
<u>Lates calcarifer</u>	<u>Amblypharyngodon mola</u>
<u>Wallago attu</u>	<u>Barilius barila</u>
<u>Ompok pabo</u>	<u>B. bendelisis</u>
<u>Silonia silondia</u>	<u>B. bola</u>
<u>Ailia coila</u>	<u>B. vagra</u>
<u>Clupisoma garua</u>	<u>Esomus danrica</u>
<u>Eutropichthys vacha</u>	<u>Oxygaster bacaila</u>
<u>Gagata cenia</u>	<u>O. phulo</u>
<u>Glyptothorax sp.</u>	<u>Chela gora</u>
<u>Mystus seenghala</u>	
<u>M. aor</u>	<u>Hilsa ilisha</u>
<u>M. cavasius</u>	<u>Gudusia chapra</u>
<u>M. bleekeri</u>	<u>Corica soborna</u>
<u>Pama pama</u>	<u>Ilisha motius</u>
<u>Pseudocaciaena coitor</u>	<u>Pellona sp.</u>
<u>Mastacembelus pancalus</u>	<u>Gonialosa manmina</u>
<u>M. armatus</u>	<u>Setipinna phasa</u>
<u>Macrognathus aculeatus</u>	<u>Rhinomugil corsula</u>
<u>Anguilla bengalensis</u>	<u>Sicamugil cascasia</u>
<u>Amphipnous cuchia</u>	<u>Kenentodon cancila</u>
<u>Garra sp.</u>	<u>Colisa sp.</u>
	<u>Tetrodon cutcutia</u>
	<u>Botia dayi</u>
	<u>Nemachilus zonatus</u>

lings and yearlings of catla encounter many predators, notably Wallago attu, Channa marulius, C. striatus, Notopterus notopterus, N. chitala, Silonia silondia and Mystus sp. among fish; crocodiles, cormorants, gulls king-fishers, kites, crows, herons, storks ducks and otters etc., among other animals (Alikunhi, 1957).

3.3.5 Parasites and diseases

Parasitism, often resulting in mortality among catla, prevails particularly during the summer months when the water level in ponds is low (Alikunhi, 1957). A great variety of parasites and diseases may afflict catla (Southwell and Prashad, 1918; Chakravarty, 1943; Hora, 1943 a and b; Chakravarty and Basu, 1948; Thapar, 1948;

Basu, 1950b; Gnanamuthu, 1951 and 1951a; Karamchandani, 1952; Sarkar, 1954; Tripathi, 1954, 1955 and 1960; Ganapati and Rao, 1954; Alikunhi, 1957; Chauhan and Ramkrishna, 1958; Gopalakrishnan and Gupta, 1960; Gopalakrishnan, 1961 and 1962; Hora and Pillay, 1962). Heavy mortalities of catla, caused by diseases and parasites, have been reported (Chacko and Job, 1948; Ganapati and Rao, 1954; Gopalakrishnan and Gupta, 1960; Gopalakrishnan, 1961) in various parts of the country.

A disease, symptomised by the presence of gas bubbles in gill filaments, heart, blood vessels and gut with bursting of the air bladder through the peritoneum, causing heavy mortality among young catla in a pond in Madras, was reported by Chacko and Job (1948). Ganapati and Rao (1954) reported on black-grub disease in catla in a pond in Samalkot caused by black, ovoid, irregular metacercaria of Diplostomum sp.. Gopalakrishnan and Gupta (1960) and Gopalakrishnan (1961) reported on a new epidemical eye disease, commonly affecting 35-85 mm long catla, the etiological agent being a variant of Aeromonas liquefaciens. Among major carps, catla was observed to be most susceptible to a bacterium, tentatively identified as Aeromonas sp., which caused dropsy.

The following parasites have been recorded from catla.

- Bacteria:** Aeromonas liquefaciens (from eye)
Aeromonas sp. (from body cavity, scales, eye and intestine)
- Fungi:** Saprolegnia parasitica (from any part of the body)
Branchiomyces sp. (from gills)
- Protozoa:** Myxobolus catlae Chakravarty (from gills)
M. bengalensis Chakravarty and Basu (from gills)
Thelohanellus catlae Chakravarty and Basu (from gills)
T. seni (Southwell and Prashad) (from gills)
Bodominous rebae Tripathi (from gills)
Trichodina indica Tripathi (from gills)
Scyphidia pyriformis Tripathi (from gills)
Ichthyophthirius multifiliis Fouget (from skin, gills and fins)
Costia necatrix (from skin)
- Copepoda:** Argulus foliaceus Linnaeus (from body and fins)
Eragasilus bati Karamchandani (from gills)
Lernaea chackoensis Gnanamuthu (from gills)
Catlyphilla elongata Tripathi
- Trematoda:** Paradactylogyrus catalius Thapar (from skin and fins)

Dactylogyrus catalius Jain (from gill filaments)

Isoparorchis sp. (from air bladder)

Diplostomum flexicaudum (from muscles beneath the skin)

Cestoda: Ligula intestinalis (from intestine)

Acanthocephala: Acanthogyrus acanthogyrus Thapar (from intestine)

3.3.6 Greatest size

Next to Mahseer, catla is the largest carp in India (Raj, 1939; Menon et al., 1959). Hamilton (1822) reported that catla grows to about 92 to 122 cm in length. Day (1871 and 1878), Raj (1939) and Chacko and Kuriyan (1950) observed that catla attains a maximum length of about 180 cm. Rao and Prasad (1953) recorded the maximum size of catla as 152 cm. Menon et al., (1959) observed catla attaining a length of 112 cm in reservoirs. Natarajan and Jhingran (1963) observed that catla reaches asymptotic growth when it attains 127.5 cm in length. The maximum length of catla in the commercial catches from river Yamuna was observed by them to be 123 cm. The maximum weight of catla recorded by Raj (1939) and Devanesan and Chidambaram (1948) was about 63 kg. Thomas (1927) mentioned a catla weighing ca. 45 kg caught with a hook in a Calcutta pond.

3.4 Nutrition and growth

3.4.1 Feeding (time, place, manner, season)

According to Mookerjee (1945), Mookerjee and Ganguly (1948) and Misra (1953), catla is a surface feeder. Chacko and Kuriyan (1948a and 1949) described it as a surface and mid-water feeder, occasionally browsing on marginal substratum, and Alikunhi (1957) designated the species to be a surface and column feeder. Natarajan and Jhingran (1963) observed that while catla is primarily a surface feeder it is prone to explore all layers and sections of the river. According to them, though dominant occurrence of zooplankton in the gut primarily indicates a surface feeding propensity of the fish, the occurrence of organic detritus mingled with sand, mud and rooted aquatics, indicates a bottom browsing habit as well. The presence of certain unattached submerged floating vegetation indicates that the fish also explores the middle layers of water.

Mookerjee and Ganguly (1948) described catla as a sight-feeder, possessing large

eyes and a big upturned mouth without sensory papillae and barbels. The slightly upturned mouth of catla enables it to gulp in large quantities of water which is filtered through its gills retaining all the particulate organisms in the buccal cavity (Alikunhi, 1957). According to Natarajan and Jhingran (1963) each branchial arch in catla bears gill rakers in two rows in the form of long slender processes which act as strainers. The gill rakers project into the pharyngeal cavity and serve to filter the water that passes out into the branchial chamber.

The feeding intensity of catla and the gastrosomatic index during various months of the year were examined by Natarajan and Jhingran (1963). In the female, a gradual drop in feeding intensity during the maturation phase (April to June) and somewhat subdued feeding, extending into the post-spawning phase until October, were noticed, after which the gastrosomatic index shot up. In the male, the feeding intensity was not seen to be affected during maturation phase, but the index did drop in the post-spawning phase between August and October. Das and Moitra (1963) observed an annual variation in the diet of catla, according to the periodic abundance of the organisms in the environment.

3.4.2 Feed (type, volume)

While casual and cursory references to food of catla have been made by many workers, detailed analyses of food have been done only by a few. The food items, in their order of preponderance, encountered in the gut of catla in different localities, as reported by different workers, are shown in Table XIII.

Thomas (1887 and 1897) observed that large-sized catla feed on fish fry but no other worker has substantiated this observation. Raj (1931) observed remarkable growth of catla in weedy ponds with plenty of snails, and Menon and Chacko (1956) suggested culture of catla in rural areas for controlling molluscs which act as intermediate hosts to many a helminth parasite. Natarajan and Jhingran (1963) noted the presence of gastropods (*Melanoides* sp.), though sparingly, in the diet of catla juveniles, but none whatsoever in that of the adult fish. As next to crustacea and algae, plant matter forms the important food of catla, utilizing this propensity of the fish, thick growths of *Hydrilla*, *Oscillatoria* and *Spirogyra* have been successfully removed in the Chetput fish farm, Madras (Menon and Chacko, 1956). George (1963) observed that catla consumed large quantities of crustaceans and rotifers which were found to be completely digested. Intake of algal food was far less in quantity and algae, which have a resistant continuous cell-wall or a covering sheath of mucilage, seemed difficult or impossible to digest.

Natarajan and Jhingran (1961) proposed an index of preponderance for grading the food items encountered in the stomachs of fishes and the index was applied in food studies of juvenile and adult catla. The new index of preponderance synthesises "occurrence" and "volumetric" methods of food analysis and is defined by the authors as:

$$I_i = \frac{100 V_i O_i}{\sum V_i O_i} \times 100$$

where V_i and O_i are volume and occurrence indices of food item i and I_i , the index of preponderance of the food item i . Based on this method the indices of preponderance of different food items met within the guts of juvenile and adult catla are as given in Table XIV.

Table XIV
Indices of preponderance of different food items of juvenile and adult catla (Natarajan and Jhingran, 1961)

Food item	Index of preponderance	
	Juvenile	Adult
Crustacea	79.68 (1)	64.20 (1)
Algae	9.68 (2)	30.06 (2)
Plants	1.03 (5)	2.41 (3)
Rotifers	5.66 (3)	1.19 (4)
Insects	2.87 (4)	0.99 (5)
Protozoa	0.50 (6)	0.01 (8)
Molluscs	0.03 (9)	-
Polyzoa	0.02 (10)	-
Decayed organic matter	0.13 (8)	0.60 (6)
Sand and mud	0.40 (7)	0.54 (7)

As seen in Table XIV, while crustacea and algae occupy (1) and (2) ranks both in juvenile and adult catla, the (3), (4) and (5) positions are held respectively by plants, rotifers and insects in adults and by rotifers, insects and plants in juveniles.

3.4.3 Relative and absolute growth patterns and rates

Catla is the fastest growing of the indigenous Indian carps. Numerous workers have made passing remarks on its growth but few have furnished detailed biometrical data. Day (1889) cited an instance of growth of catla in a stocking tank (c. 19.8 X 17.7 X 4 m) near Calcutta, in which some fry of the species 12.7 to 25.4 mm or less in length were stocked in May 1875. On September 22, when the tank was netted and several dozens of fish captured, one of the largest weighed 396.9 g measuring 27.9 cm in length and the others were 28.3 to 56.7 g lighter. Raj (1931) indicated that 10.2 to 22.9 cm long catla fingerlings attain a length of 43.2 cm in four months. His observations (Raj, 1939) also indicate that catla fry, 12.7 to 25.4 mm in size, when stocked in weedy ponds with plenty of snails, attain a length of 30.5 cm in six months and

Table XIII
Food preponderance according to locality

Food items	Locality	Feeding type	Authority
Crustacea, rotten vegetation, algae, protozoa and rotifers, sand particles	Bengal	Generally surface feeder	Mookerjee (1945)
Vegetable matter, crustacea, diatoms and desmids, protozoa, sand particles, polyzoa, rotifers	South India	Surface and mid-water feeder, occasionally browsing along the marginal substratum	Chacko and Kuriyan (1948a)
Vegetable matter, diatoms and desmids, micro-crustacea	South India	Surface and mid-water feeder	Chacko and Kuriyan (1949)
Archigoniatas, diatoms, crustacea, algae, sand particles and small twigs, rotifers, protozoa, mollusca, polyzoa	South India (rivers Godavari, Krishna, Cauvery, Tungabhadra)	Surface and mid-water feeder	Chacko and Kuriyan (1950)
Algae, higher plants, crustacea, protozoa, mud and sand, molluscs	Madras	Surface feeder	Menon and Chacko (1956)
Diatoms, algae, protozoa, rotifers, crustacea, polyzoa, aquatic vegetation, molluscs, sand and small twigs	Madras	Plankton feeder, occasionally browsing on marginal bottom	Menon <u>et al.</u> (1959)
Crustacea, algae, plants, rotifers, insects, decayed organic matter, sand and mud, protozoa (mollusca and polyzoa in juveniles only)	Allahabad (river Yamuna)	Primarily a surface feeder but prone to explore all layers and sections of river	Natarajan and Jhingran (1961 and 1963)

45.7 to 61.0 cm in the first year of stocking. Bukht (1940) studied the growth of catla in experimental tanks in Bidyadhari spill area. Mitra (1942) studied variations in growth rate of catla in different districts of Orissa. Hora (1944) recorded an instance of very fast growth of catla to 30.5 cm (510.3 g) in just 2½ months. He further observed catla and rohu to attain a weight of 5.4 to 6.4 kg in one season. Chacko and Kuriyan (1948a, 1948b and 1950) reported the size of catla as 66.0 to 73.7 cm (weight c. 4.0 kg) in the first year of life and 0.91 to 1.8 m (weight 13.5 to 22.5 kg) in three years in various South Indian waters. Chacko (1948a and b) recorded growth of catla to be 25.4 cm in five months, 68.6 cm (weight 3.2 to 4.1 kg) in the first year and 91.4 cm (weight 15.7 kg) in three years in Madras waters. Chacko and Ganapati (1950) recorded a phenomenal growth of catla in two tanks in Kancheepuram, Madras, where the fish was observed to have grown at the rate of 7.6 to 10.2 cm per month during the first half-year of its life. Alikunhi *et al.* (1952), citing Moses (1940) mention that catla attains marketable size in six months and a weight of 10.9 kg in two years and 18 kg in three years. According to Alikunhi (1957), in normally stocked waters, a growth of 38.1 to 45.7 cm can ordinarily be expected in the first year. If understocked, catla grows to over 50.8 cm in length in the first year. Normal average growth (in weight) of catla in its first year of life is about 907 g. In Kurla tank, Bombay, catla attained c. 57.2 cm in length and 3.6 kg in weight in just about 9½ months (Hora, 1944). Rao and Prasad (1953) mention that catla fingerlings, 5.1 to 7.6 cm long, grow as much as 45.7 to 61.0 cm in the first year of stocking. Menon *et al.* (1959) recorded the growth rate of catla as shown below:

Table XV
Growth rate of catla (Menon *et al.*, 1959)

Year	Length in mm	
	in reservoir	in tank
I	600	320
II	950	530
III	1120	700

Das (1959) determined the differential growth rates of Indian carps. Samples from a population of carps of known age were weighed at regular intervals over a fifteen-month period and a second degree polynomial fitted to growth data over time, using log weights. For catla, the derived equation was:

$$\text{Log } W = 0.954457 + 0.006584 t - 0.00001123t^2$$

Natarajan and Jhingran (1963) studied the age and growth of catla from its scales. According to them the scales of catla show growth checks in the form of carved-out grooved rings, which were found to be annular and hence suitable

for age determination (Figure 7). Spawning stress was found to be the causative factor for ring formation. The first ring is laid in the second year of the life of catla when it attains maturity. These authors back-calculated sizes at different ages derived from scales, with the modal locations derived from Petersen's length-frequency distribution method, further dissecting multimodal distribution, following Harding (1949) and Cassie (1954). Von Bertalanffy's growth fit, according to them, describes the growth pattern in catla. The theoretical growth equation, applying to catla, was found to be:

$$L_t = 1275 \left[1 - e^{-0.28(t-0.11)} \right]$$

Table XVI
The lengths at different ages, against von Bertalanffy's growth fit

Age	Length at age (scale method) mm	Length at age (Petersen's method) mm	von Bertalanffy's fit mm
II	514	505	524
III	716	682	696
IV	823	800	846
V	917	900	951

Having derived lengths of catla at various ages (Figure 8), Natarajan and Jhingran (1963) further estimated the weights and the instantaneous rates of growth of the fish as shown in Table XVII.

Table XVII
Annual and instantaneous rates of growth of catla (Natarajan and Jhingran, 1963)

Age	Average length at age (mm)	Average weight at age (g)	Annual growth (%)	Instantaneous rate of growth
I	295	354	519	1.82248
II	514	2,193	196	1.08810
III	716	6,501	58	0.46044
IV	823	10,282	43	0.35577
V	917	14,665		

Ghosh and Bhattacharya (personal communication) observed catla to attain a length of 400 mm in the first eleven months of its life in the lower sector of the Ganga system.

Alikunhi and Sukumaran (1964) conducted an experiment of 4 months' duration in three nursery ponds, each 0.04 ha in area, to find out the growth of catla as compared with that of the silver carp, *Hypophthalmichthys molitrix*. (Table XVIII).

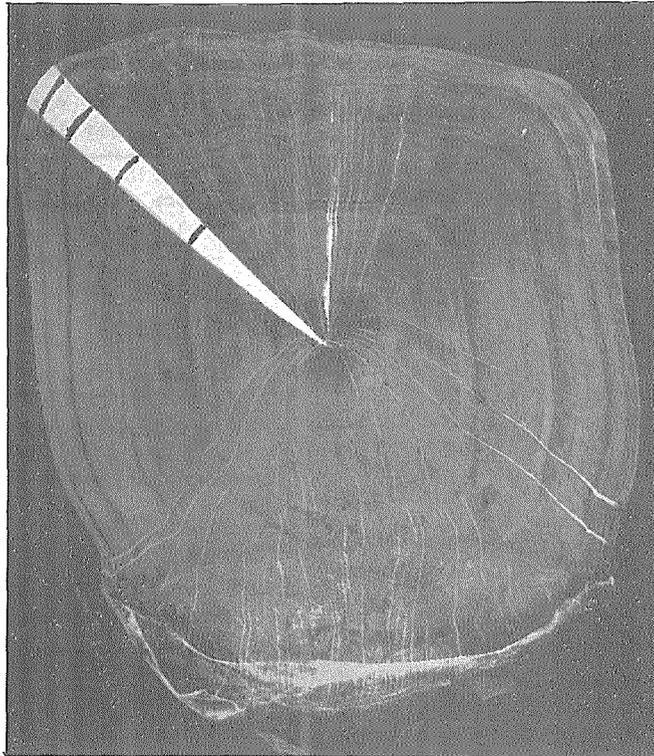


Figure 7. Scale of catla 935 mm in total length showing 4 age rings:
Scale length 28 mm: Estimated age 5+ years (Natarajan and
Jhingran, 1963)

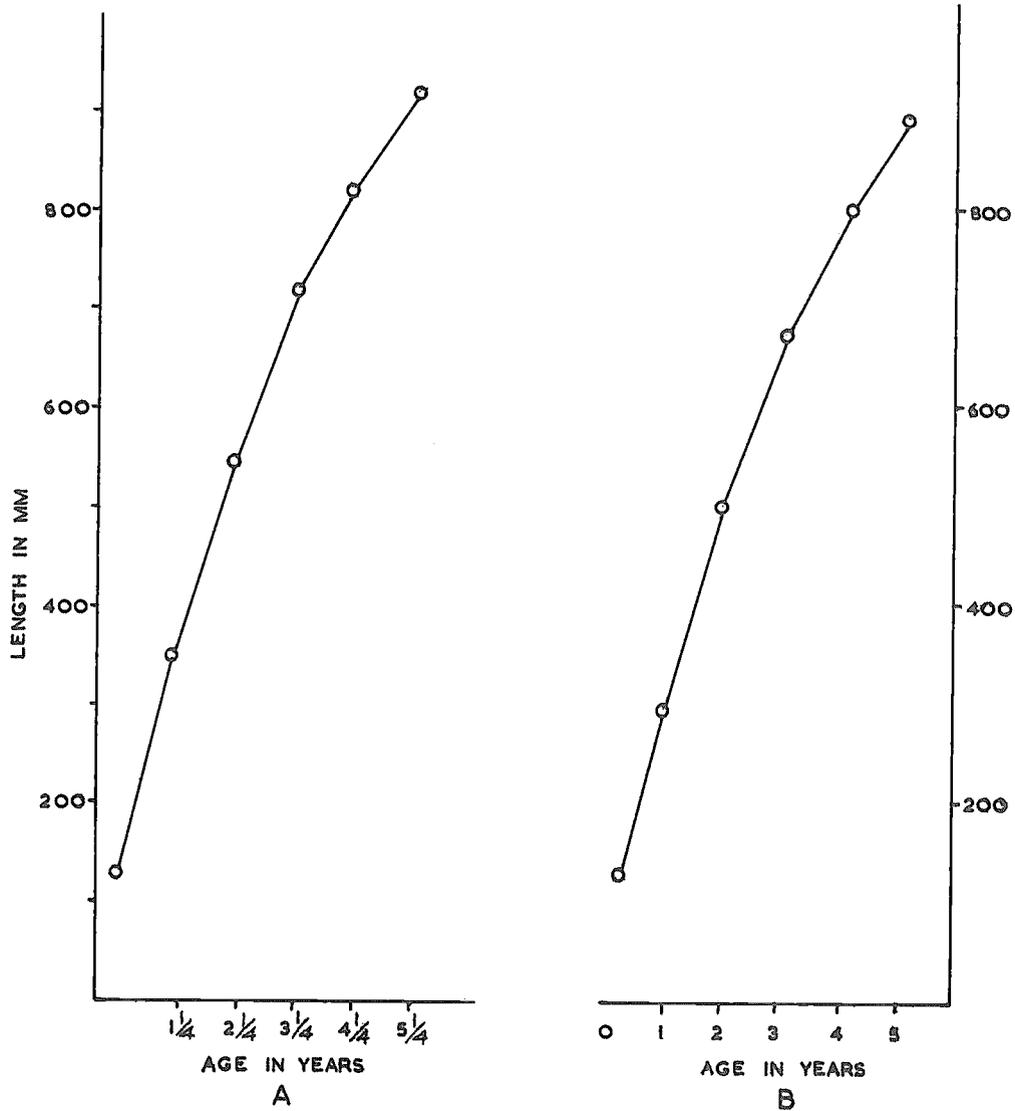


Figure 8. Age and growth of catla (Natarajan and Jhingran, 1963)

- (A) Curve depicting absolute values of length (mm) at ages derived from length frequency distribution
- (B) Absolute values of length against complete years

The data on growth, attained by both species, shown in Table XVIII (data in Table XVIII on *H. molitrix* also are presented in view of wide-spread interest attached to this problem) clearly reveals that growth of silver carp is faster than that of catla, under comparable conditions.

A 5-6 month-old specimen of catla, measuring 142 mm in total length, was tagged and released in the Ganga at Mirzapur (Uttar Pradesh, India) on 30.12.63. When recovered 301 days later, on 26.10.64, it measured 280 mm. Discounting the tagging shock, this recovery agrees fairly well with the data shown in Table XVII.

Jhingran (1952) studied the length-weight relationship of catla (Figure 9), ranging in furcal length from 41 to 405 mm and found it to be:

Weight = $0.8917 \times 10^{-5} \times \text{Length}^{3.15172}$
which in logarithmic form is:

Log weight = $-5.04976177242 + 3.15172 \log$ length, the standard error of estimate in terms of logs being ± 0.094257 .

Natarajan and Jhingran (1963) studied the length-weight relationship of catla separately for juvenile, male and female specimens. The equations derived by them are shown in Table XIX.

The exponential indices for length showed variability between male and female. The observed differences in the regression coefficient of male and female and between juvenile and female were not found to be significant. The difference in coefficient between juvenile and male was 1.89 times the S.E., having a probability of more than 5 percent. The authors pooled the entire length and weight measurements into a single equation, irrespective of size and sex, which was formulated to be:

Log W = $6.44009 + 3.28325 \log L$ (with S.E. ± 0.00755)

They indicated that the cube law is not statistically valid for catla.

3.4.4 Relation of growth to feeding, to other activities, and to environmental factors

According to Raj (1939), the growth of catla in brackish water is stunted and very poor. Chacko and Ganapati (1950) attributed the phenomenal growth of catla at the rate of 7.6 to 10.2 cm per month in two tanks in Kancheepuram, to the presence of abundant food and the large area, 2.8 to 5.7 ha, providing freedom for unrestricted movement. The tanks were rich in phyto- and zooplankton, though macrovegetation was poor. Basu (1950c) observed that in the course of a year, in sewage-irrigated fish farms near Calcutta, 1 cm long fry of catla attained

length of 40 cm, each weighing 793.8 g. Kulkarni (1952) observed that the growth of catla manifests an extremely wide range of diversity, depending largely on the ecological conditions of individual tanks. It grows fastest in the first three years and thereafter the growth slows down. Chacko (1956) reported that catla attains a length of 30.5 cm in six months and 45.7 to 61.0 cm in the first year of stocking, in temple tanks, where myxophyceae occur permanently. According to Alikunhi (1957) the growth of catla slows down when the stock exceeds c. 2,471 fingerlings per ha. The fish has been noted to grow very fast in highly alkaline waters containing large quantities of aquatic weeds (Menon *et al.*, 1959). Das (1960a) found growth of catla influenced by the volume of water available in the tanks or, conversely, the amount of crowding. Gopalakrishnan and Srinath (1963) observed that sludge appears to have a direct influence on the growth of catla and production of plankton due to release of nutrients. Fingerlings of catla responded positively to the three doses of sludge experimented with by the authors. The average increase in length of catla within a period of 71 days was as under:

Control	initial length	16.2 cm
	final length	23.1 cm
62.5 g sludge	initial length	11.7 cm
	final length	26.6 cm
125 g sludge	initial length	20.8 cm
	final length	35.5 cm
250 g sludge	initial length	13.7 cm
	final length	38.4 cm

Explaining the occurrence of certain ring-like markings (winter-rings) on the scales of catla-of-the-year, Natarajan and Jhingran (1963) remarked that the drop in temperature in winter months in river Yamuna at Allahabad caused a growth deceleration among the fish, which was not sufficient to evoke a similar response in older age-groups.

3.5 Behaviour

3.5.1 Migration and local movements

Catla is said to be a local migrant, undertaking short journeys in search of suitable spawning grounds in the breeding season. Khan (1924) observed that catla ascend rivers during monsoon rains in search of suitable spawning grounds, and after spawning return to the main stream. Groups of fish are seen at the water surface, splashing and apparently fighting with each other. Khan (1940) observed catla ascending a fish ladder in the Punjab only during July to September, when the difference between the

Table XVIII
Growth of silver carp and catla fingerlings in nursery ponds at Cuttack during 1960
(Alikunhi and Sukumaran, 1964)

Pond No.	Species	Date of sampling	Length (cm)		Average weight (g)	Total weight (kg)	Remarks
			Range	Average			
1	Silver carp alone	6.1.60	15.9-24.1	20.1	77.2	7.7	stock thinned out to half
		6.2.60	17.7-26.5	23.2	132.0	13.1	
		7.3.60	20.1-30.2	27.2	219.0	21.7	
		6.4.60	20.7-32.7	28.7	257.0	25.5	
		6.5.60	30.0-37.0	33.2	424.0	20.8	
2	Catla alone	6.1.60	13.5-26.6	17.7	74.9	7.5	allowing for mortality stock thinned out to one third
		6.2.60	14.5-27.8	19.7	104.6	8.2	
		7.3.60	15.7-27.2	21.6	125.4	9.8	
		6.4.60	17.4-32.2	22.5	179.0	14.0	
		6.5.60	22.7-30.7	26.4	253.2	7.1	
3	Silver carp	6.1.60	14.8-24.0	19.5	74.9	3.75	stock thinned out to half
		6.2.60	18.4-28.0	22.9	127.4	6.37	
		7.3.60	19.9-31.0	25.4	169.1	8.45	
		6.4.60	22.8-32.9	28.3	218.0	10.9	
	Catla	6.5.60	22.9-34.9	29.8	270.0	6.75	
		6.1.60	13.7-26.0	17.7	74.9	3.75	
		6.2.60	15.2-27.8	19.5	91.8	4.3	
		7.3.60	17.0-27.9	20.4	106.0	5.0	
		6.4.60	17.1-28.0	21.1	110.4	5.2	
		6.5.60	18.8-24.3	21.6	131.5	2.9	

Table XIX
Length-weight relationship in catla
(Natarajan and Jhingran, 1963)

	Equation	S.E.	Variance	S.D.	Regression coefficient at 95% confidence limit
Juvenile	$\log w = \bar{6}.17482 + 3.39826 \log L$	± 0.07	0.00405	0.06668	3.26106-3.53546
Male	$\log w = \bar{6}.49470 + 3.26446 \log L$	± 0.03253	0.00332	0.05768	3.20070-3.32882
Female	$\log w = \bar{6}.67243 + 3.19869 \log L$	± 0.01312	0.03429	0.18535	3.17295-3.22441

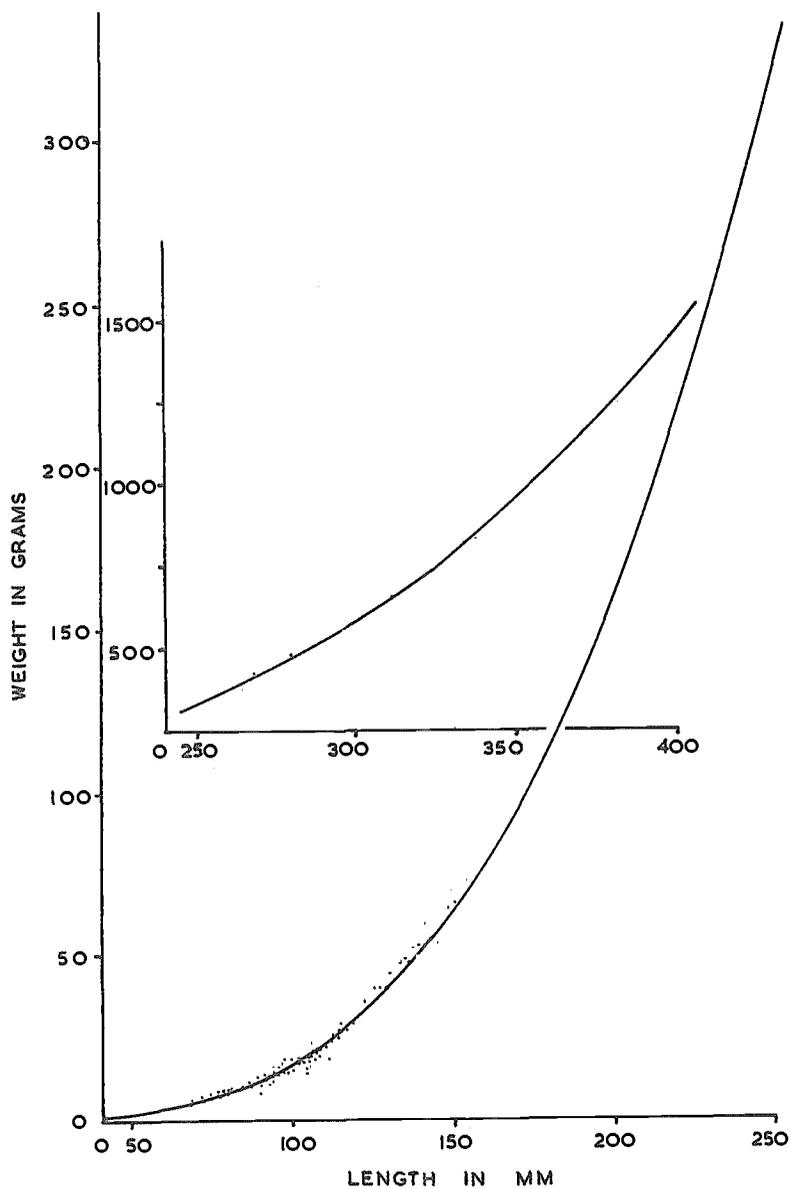


Figure 9. Curves depicting length-weight relationship of catla (Jhingran, 1952)

water level up and downstream of the weir was not great. Catla and other major carps are known to congregate in large numbers below dams, anicuts, weirs, etc., especially in the breeding season, and their occurrence in such situations has been reported by Chacko (1952) in a number of rivers in South India. According to Raj (1941) water-falls act as natural barriers to the distribution of the fish. Catla are sedentary by nature and breed, feed and live their lives within a limited range. The fish undertake only short journeys, to breed and feed, into the shallow tributaries or inundated banks. During the floods, however, they travel further afield wherever a flow occurs and push their way into even the shallowest water courses and drains in their search for new waters. Chacko (1946a) observed that catla move into the upper reaches of the river sections in small groups in search of favourable breeding grounds. Chacko and Kuriyan (1948a) reported that after the introduction of fish into the Kurnool-Cuddapah Canal by the Madras Fisheries Department, catla has migrated into the Pennar and other waters in Nellore district. Chacko (1949a) observed catla showing local movements within the Coleroon River. According to Menon *et al.* (1959) spawning migrations of catla are mainly restricted to the plains and migrations to upper reaches are seldom seen.

From recoveries of 63 specimens out of a total of 3,718 catla fingerlings tagged in the Ganga River systems in Uttar Pradesh, India, by the Allahabad Substation of the Central Inland Fisheries Research Institute during the years 1961-1965, it was revealed that the maximum distance travelled by them was only 16 km up- or down-stream in a maximum number of 301 days.

3.5.3 Reproductive habits

According to Ghosh and Ghosh (1922), 2 to 3 males to one female is the usual ratio in the breeding grounds. Khan (1924) stated that a female is often chased by three or more males, but the reverse has also been observed by him. Rarely is a single couple seen. If a mate is separated from its companion, it has been heard to produce guttural sounds calling the other partner.

The mating behaviour of major carps has been described in detail by Dubey and Tuli (1961) and Alikunhi *et al.* (1964). The fish first indulge in a courtship. The males chase the female, darting about in the water. The female is then held by the male, the latter bending its body round the female, rubbing, knocking and nudging her. At the climax of this activity, the pairs are seen to be locked in embrace, their bodies twisted round each other with the fins erect and caudal fin quivering. Sometimes, the coiling of the male may be behind the dorsal fin of the female. In this posture mating occurs with vigorous splashing of water, wherein many fish lose a number of scales and also sustain other minor injuries.

The sex-play lasts for a short time. The coiling and intertwining of the two sexes exerts pressure on the abdomen of the mating pair, resulting in the extrusion of the ova and ejection of the milt. According to Ghosh and Ghosh (1922) the extent of the extrusion of ova and milt depends upon the rush of water into or out of the bundh; the greater the rush, the more complete the extrusion. All the eggs are not laid at one place and at one time, but at intervals, during which the pair keeps on moving (Khan, 1924).

4 POPULATION (STOCK)

4.1 Structure

4.1.1 Sex-ratio

The sex-ratio of the species, as evidenced by samples from river Yamuna, was found not to differ significantly from 1:1 (Natarajan and Jhingran, 1963). Alikunhi et al. (1964), recording carp breeding in bundhs, have recommended a release of breeders of catla in the ratio 1:1 by weight and one female to two males by number.

4.1.2 Age composition

Detailed data on age composition of catla are not available in the literature except for the river Yamuna at Allahabad furnished by Natarajan and Jhingran (1963). According to them the fish-of-the-year show up first in the commercial fishery in September. Age groups I and II (see also Table XX) formed 43.97% (by number) of the total landed, in the years 1959 and 1960.

Table XX

The percentage composition of the numbers of catla of age groups I-VI (Natarajan and Jhingran, 1963)

Age group	1959	1960
I	9.45	33.95
II	24.74	20.64
III	13.96	12.23
IV	26.93	21.10
V	19.61	10.09
VI	5.36	1.83

The higher percentage in the first-year class in 1960 was attributed to greater abundance of the fish-of-the-year in the catches of that year, and, when the 0-year class was eliminated, the combined numerical strength of first and second age groups was reduced to 31.83% in 1959 and 42.51% in 1960.

4.1.3 Size composition (see Table XXI)

The size composition of catla, as revealed from random samples from the catches of River Yamuna at Allahabad (Natarajan and Jhingran, 1963) is given in Table XXII.

4.3 Natality and recruitment

4.3.1 Natality

Alikunhi et al. (1964), setting an arbitrary production target of 50 lakhs of spawn in one breeding in a small bundh of 0.12-0.20 ha area, allowing for 100% breeding, 90% fertilization of eggs, 60% recovery and 50% hatching and survival up to spawn stage, recommended the following

breeders to be introduced in the bundhs: average weight of female (kg) - 8-10; number of females to be introduced - 12-15; number of males to be introduced - 20-30.

4.3.3 Recruitment

The natural spawning of catla may commence early or late depending on the onset of the south-west monsoon.

4.4 Mortality, morbidity

4.4.1 Rates of mortality

Mortality rate between the fingerling and yearling stages of all the species of major carps in a 208 km stretch of river Ganga was determined by Jhingran and Chakraborty (1958).

4.4.2 Factors or conditions affecting mortality

High fishing mortality of catla and other major carp fingerlings has been described by Jhingran and Chakraborty (1958) in a section of the middle reaches of river Ganga. Natarajan and Jhingran (1963) have briefly discussed the intensive exploitation of catla of the first and second year-groups, from river Yamuna at Allahabad, when the fish is undergoing its fastest growth rate.

See: 2.2.1, 3.2.1, 3.3.4 and 3.3.5

Large-scale mortality of fishes caused by oxygen deficiency has been observed in lakes, ponds and tanks, usually in summer when continuous sultry weather is followed by sudden showers (Moitra, 1955; Alikunhi, 1957).

Severe fish-mortality, occurring in the Shahdra fish farm, Delhi, was attributed by Chaturvedi (1962) to the highly alkaline condition of the water (570 ppm) which exceeded the tolerance limit of 500 ppm (Alikunhi, 1957) of the Indian major carps. Chaturvedi (1964) observed 28% mortality of catla fingerlings in Shahdra tank, Delhi, caused by a drastic fall in temperature. The author remarked that the water temperature in Delhi goes as high as 36°C in summer and down to near freezing point in winter. As these fishes are used to high temperature, any drastic fall in temperature seems sufficient to cause gross mortality.

4.4.3 Factors or conditions affecting morbidity

Khan (1939 and 1943) reported mortality of fish in ponds and tanks and Malden (1943) in the river Sohan in the State of Punjab. Hora and Nair (1944) discussed the effects of effluents of the quinine factory at Mungpoo in Bengal. Bhimachar and David (1946) described the deleterious effects of the

Table XXI
Size-group frequency distribution of catla and other major
carps landed from the river Ganga at Buxar during the years
1952-1954 (Jhingran 1956)

Size category	Size-range in mm	Approximate age	Percentage frequency	Period of abundance
Juvenile	71-160	0 age group	7.7	September to November
Small	161-340	6-18 months	66.0	September to December
Medium	341-790	3-4 years	19.0	November
Large	791-1060	Older than 4 years	7.3	March

Table XXII
Pooled percentage length-frequency distribution of catla for the years
1959 and 1960 (Natarajan and Jhingran, 1963)

Class-range (mm)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
100-149	-	-	-	-	-	-	-	-	2.09	0.70	1.63	1.66
150-199	-	-	10.53	-	1.61	-	-	-	-	14.08	8.13	19.92
200-249	1.33	-	15.79	-	11.29	1.17	-	-	1.26	8.45	5.69	29.46
250-299	-	-	-	-	-	1.75	2.44	1.75	7.53	3.52	3.25	21.16
300-349	1.33	-	-	-	1.61	0.58	1.22	0.88	14.23	4.23	5.69	5.39
350-399	5.33	2.44	-	-	3.23	-	1.22	6.14	12.55	3.52	5.69	3.73
400-449	6.67	4.88	-	-	1.61	-	4.88	17.54	5.86	6.34	4.88	3.73
450-499	7.80	4.88	-	-	3.23	-	6.09	10.53	7.53	3.52	1.63	0.41
500-549	7.80	-	-	2.94	1.61	-	4.88	12.28	7.53	5.63	2.44	0.41
550-599	9.33	-	2.63	14.71	6.45	-	-	5.26	2.51	3.52	0.81	2.90
600-649	7.80	2.44	-	14.71	4.84	-	4.88	5.26	2.92	11.97	3.25	2.07
650-699	6.67	7.32	5.26	2.94	4.84	1.75	4.88	8.77	8.79	11.27	4.88	2.07
700-749	2.67	21.95	10.53	8.82	3.23	2.34	8.54	9.65	10.04	10.53	10.57	0.41
750-799	19.20	21.95	15.79	20.59	4.84	4.09	9.76	11.40	5.02	5.63	17.87	2.90
800-849	6.67	19.51	21.05	11.76	11.29	26.90	12.20	0.88	1.26	3.52	4.88	0.83
850-899	7.80	2.44	5.26	8.82	9.68	25.15	12.20	2.63	1.67	2.82	10.57	1.24
900-949	5.33	7.32	10.53	8.82	17.74	24.56	17.07	6.14	3.35	0.70	5.69	1.24
950-999	1.33	4.88	2.63	5.88	9.68	8.77	9.76	0.88	0.42	-	2.44	0.41
1000-1049	1.33	-	-	-	3.23	2.92	-	-	-	-	-	-
1050-1099	-	-	-	-	-	-	-	-	0.42	-	-	-
Number sampled	75	41	38	34	62	171	82	114	239	142	123	241

wastes from Mysore Paper Mills and Mysore Iron Works on the fisheries of Bhadra river. Mookerjee and Bhattacharya (1949) reported on asphyxiation of catla and other major carps, resulting in mortality in two tanks near Calcutta, caused by the presence of sulphuretted hydrogen and high alkalinity in combination with organic matter. Ganapati and Alikunhi (1950a) and Menon *et al.* (1959) reported on the toxic effects of the factory effluents from Mettur Chemical and Industrial Corporation, Madras, on the fisheries of river Cauvery. Seth and Bhaskaran (1950) studied the effects of the disposal of industrial wastes on the sanitary condition of the Hooghly river in and around Calcutta; Ganapati and Chacko (1951) and Menon *et al.* (1959) studied the pollutional effect on fish life of the effluents from a paper mill at Rajahmundry, discharged in River Godavari; Srinivasan and Ganesan (1955) and Menon *et al.* (1959) investigated pollution in river Cauvery caused by the effluents from the Erode Cauvery Textiles, Bhavani; Motwani *et al.* (1956) studied and reported on the pollutional effects of the factory effluents of the Rohtas Industries at Dalmianagar on river Sone and Banerjee *et al.* (1956) observed a case of heavy fish mortality in the same river at Dehri-on-Sone. David (1956) studied the pollution of the Bhadra river at Bhadravati caused by industrial wastes; Saha *et al.* (1958) reported on the inimical effects of raw sewage (if in high concentration) on fish-life due to the presence of CO₂, H₂S, NH₃ and suspended solids. Menon *et al.* (1959) observed considerable dwindling of the fishery of Chandriya Kalwa, in which catla formed an important component due to pollution by the effluents from a cane sugar factory at Vuyyur. Qasim and Siddiqi (1960) recorded a case of mortality among fish caused by wastes from sugar and textile mills and a distillery discharge in river Kali in West Uttar Pradesh, due to increase in the B.O.D. load, depleting the dissolved oxygen in river water; Banerjee and Motwani (1960) reported on the pollutional effects of the wastes from a sugar factory at Balrampur on the fish and fishery of river Suvaon, a tributary of river Rapti, caused by creation of anaerobic conditions and low red-ox potential; David and Roy (1960) studied pollution of river Ganga at Kanpur, caused by wastes from textile mills and leather tanneries but reported that the discharged liquids undergo high dilution first in the city sewage and later in the great volume of river water, losing their individual harmful effects. These waters, when discharged into small river systems and ponds or reservoirs, cause ill effects on aquatic life. Ray (1961) evaluated the toxicity of the effluents from sugar, pulp and paper factories and distilleries on fish by bio-assay experiments. Normal sugar wastes proved lethal to fish due to absence of oxygen which can be remedied by saturating the water with oxygen. Distillery wastes need a dilution of at least 12-17 times, and those from pulp and paper factories 4-5 times, to render them innocuous. The effluents from the pulp factories clog the gills of the fish

and bring about synergetic action after the suspended matter enters the gastrointestinal tract. The suspended colloids of the pulp effluent accelerate the toxic effect of chlorine. Ray and David (1962) observed a case of fish mortality caused by the precipitation of ferric iron in the river Daha (N.Bihar) polluted by sugar and distillery wastes. Ray (1963) showed, in a stream polluted by sugar factory and distillery wastes, that an absolute increase either in organic matter, carbon or nitrogen does not indicate pollution and that C/N ratio is the crucial factor. Gopalakrishnan and Srinath (1963) reported considerable mortality of fish, including catla, when the dose of activated sludge exceeded 312.5 g per 240 l of water.

4.5 Dynamics of population

There is a belief among the fishing community, especially of the Ganga river system, that the major carp fishery including that of catla, is dwindling year after year. This belief is based on vague memories of the fishermen of past heavy landings but has no scientific basis. Rai (1948a) stated that in Pakistan abundance of catla has been greatly reduced in rivers Ravi and Chenab and their tributaries after the construction of weirs at the headworks of numerous canals. Studies of the dynamics of catla populations of the different river systems have not been attempted so far.

4.6 Relation of population to community and ecosystem, biological production etc.

To utilize the food available in different strata and zones in a body of water, mixed farming of carps of different feeding propensities is practised in various tropical countries. The Indian major carps catla, rohu and mrigal are often co-stocked with varying numbers of kalbasu, bata and reba in ponds in Bengal, Bihar, Orissa, Punjab, Assam etc. Hora (1947) advocated a ratio of 50 percent catla, 30 percent rohu and 20 percent mrigal, bata and kalbasu in mixed farming of carps. Alikunhi (1957) recommended stocking of catla, rohu and mrigal in the ratio of 30, 30 and 40 percent respectively. However, he obtained satisfactory growth when these species were stocked in equal numbers. Ling (1961) stated that the most profitable combination of major carp species in mixed farming is 30 percent catla, 60 percent rohu and 10 percent mrigal. Hora and Pillay (1962), while recommending the same ratio as suggested by Ling (1961), further stated that if kalbasu is included, the percentage of rohu may be decreased to 50 percent and the difference made up with kalbasu.

In recent years, the compatibility of catla and other Indian major carps with Tilapia mossambica, Cyprinus carpio, Hypophthalmichthys molitrix and Ctenopharyngodon idellus has been studied.

Catla fry, along with those of other major carps, have been found to be incompatible with tilapia, since the latter feeds extensively on carp fry and its young directly competes with them for food. Such a competition results in poor survival and growth of carp fry.

Catla and other major carps, when stocked with the Bangkok strain of Cyprinus carpio var. communis, have been found to form a highly compatible community, resulting in high productivity.

Alikunhi and Sukumaran (1964) carried out an experiment to elucidate compatibility of catla and silver carp, H.molitrix and found that the pond in which silver carp and catla were stocked together yielded less than the one with silver carp alone and a little more than that with catla alone. Although the production of silver carp alone was over double that of catla, the presence of the two together seemed to have affected the growth of both species adversely. Though both species are plankton feeders, differences in feeding habits are structurally

indicated. Catla is predominantly a zooplankton feeder and H.molitrix a phytoplankton feeder. As stated already (3.4.3), under comparable conditions, silver carp was found to grow faster than catla.

The Indian major carps do not compete for food with the grass carp, C.idella, since the latter feeds mainly on aquatic macrovegetation.

It is hoped that the silver carp, the grass carp and the common carp, when cultured together with the Indian major carps will help increase fish production and prove welcome additions to pond culture in India.

Sreenivasan (1963) studied primary production in three upland lakes of Madras by the light and dark bottle method and found the occurrence of cyanophyceae associated with high productivity. The same author (1964), adopting the same method in the study of a tropical pond in Madras, found that there was a conversion of 1.65% of the primary production to fish, catla being a major plankton feeder among them.

5 EXPLOITATION

5.1 Fishing equipment

5.1.1 Fishing gear

The common type of gears viz. drag, gill, drift, purse, cast and scoop nets along with traps and hook and line are all employed to take catla (Table XXIII). The gear which goes by the name of 'Karal' or 'Katla jal', used in rivers (Anon., 1962) and deltaic regions (Anon., 1949), is a type of drift net and does not catch catla specifically as may be supposed, but is reported to catch carps in general in rivers and bekti; catla and other fishes in deltaic area. Gulbadamov (1961; 1962), who carried out experimental fishing operations in several water bodies in India, viz., Mettur dam in Madras, Krishnarajesar in Mysore, Maithon, Panchet, Tilaiya and Konar reservoirs under Damodar Valley Corporation in Bihar and West Bengal, recommended the introduction of certain gill nets tested and developed by him. These are "Gulbanet" types I and II and "Sebgul" nets which are described in Table XXIII. Observing the capture of catla by indigenous gears, especially 'rangoon' and 'catla' type of nets, Gulbadamov (1961) and FAO/UN (1962) remarked that larger specimens of commercial fishes such as Catla catla, Cirrhina mrigala and Mystus aor seem to occur singly and mainly at a depth between 1.5 to 11 m depending on the time of day and area. As the 'rangoon' and 'catla' type nets are only about 3.6 to 4.2 m deep and are operated with floats on short strops of 0.5 to 1.2 m length, they fish a depth range from about 0.5 to 5.5 m, while a good deal of the commercial fishes are found deeper.

Catla has a habit of leaping, while being fished with a drag net. Taking advantage of this, the escaping fish are taken by hand by fishermen following the net (Ahmad, 1954).

Catla, being also a game fish and good fighter (McDonald, 1948), is sought by anglers. Thomas (1927), McDonald (1948) and Goldschmidt (1953) have described the methods of angling catla. McDonald (1948) stated that foul hooking of catla is a common feature. Goldschmidt (1953) claimed to have hooked catla successfully in Powai lake, Bombay, with modified hooks and baits. A common method of hooking catla in Bengal is called 'arah' and 'jhima' fishing. In the former, a joint of bamboo is split into broom-like splinters, stuffed with ground bait and made into a small football-like mass (called 'arah'), with a central core of a length of thin bamboo which is driven into the bottom of the tank. Catla is in the habit of sucking through the 'arah'. A few 'catla' hooks kept close to the 'arah' and touching the bottom take catla successfully. In shallow tanks, the 'jhima' method is more successful, especially from a raised platform called a 'machan'. In this method of fishing, which is said to be effective

for hooking catla (Thomas, 1927), the ground bait is flung far out and one of the three hooks is baited with a big lump of paste.

5.1.2 Fishing boats

The type and number of boats used for the operation of different nets that catch catla are shown in Table XXIII. In the mid-alluvial zone of the Ganga river system, fishing is done from small, light boats, known as 'dongi' which are usually about 6 m long, 1.5 m wide and 45 cm deep. A big boat, known as 'katra', about 10 m long, 3 m wide at the stern and 90 cm deep, is generally used to operate the bigger drag nets, mahajal, darwari, karia etc.

Fishing in river Narbada is done from boats 6 to 9 m long operated by 3 or 4 men. These, like most of the other riverine craft, are flat bottomed. In the river Godavari, open, plank-built, undecked boats (called 'nava') of about 7.3 m in length and 1.2 m in width, are used. In West Bengal and Assam different types of 'dinghies' and plank-built 'chandi nauka' are used for fishing. In Assam, the shallow, plank-built riverine fishing boats, largely used for operation of clap and dip nets, vary from 3 to 9 m in length and 0.9 to 1.8 m in width. These pointed and elongated boats are variously designated locally, as 'dinghi', 'jale dinghi', 'jalia dinghi' or 'pansi nauka'.

5.2 Fishing areas

5.2.1 General geographic distribution

See: Table IV under 2.1

5.2.2 Geographical ranges (latitudes, distances from coast, etc.)

Latitudes 8°N to 32°N
Longitudes 68°E to 100°E

5.2.3 Depth ranges

In the rivers the nets are operated both in deep and shallow waters, depending upon the type of net used. Drag nets are paid out in the form of a semi-circle from the bank where the depth is only a few cm. They are also used in the deeper part of the river up to about 7 - 11 m. Bottom-set gill nets, kamal etc. are operated in even greater depths. In ponds and tanks, anglers generally prefer to cast their tackle in 1-2 m deep waters.

5.3 Fishing seasons

5.3.1 General pattern of fishing season

Catla is caught practically all the year round. However, fishing is practically suspended

TABLE XXIII
Fishing gear for Catla

English Name	Type of Gear Vernacular Name	Area of operation	Dimensions				Material	Number of men required	Number and type of boats required	Authority *	Remarks
			Length (m)	Breadth or depth (m)	Size of mesh (cm)	7					
1	2	3	4	5	6	7	8	9	10	11	
Dragnet	Mahajal	Ganga River system Indus River system	7-14	3.8	5.8-6.5	Hemp	12-16	2 (1 Katra and 1 Dongi)	Saxena(1965) Faruqui and Sahai(1943) Anon.(1949) Dubey and Mehra(1959)	All the major carps and catfishes	
	Darwari or Poorai	Ganga River system	5-9	5-11	2.4-3.8	Cotton	12-16	2 (1 Katra and 1 Dongi)	Saxena(1965)	---do---	
	Karia	---do---	9-15	6-11	16	Hemp	20-22	2 (1 Katra and 1 Dongi)	Saxena(1965)	---do---	
	Chondhi	Chambal River	-	-	-	-	-	-	Dubey and Mehra(1959)	---do---	
	Do-dandi	Ganga River system	9.6	4.35	2	Cotton	2	-	Saxena(1965)	---do---	
	Chhanta	---do---	9.3	3.57	7	Cotton	3-4	1 (Dongi)	Saxena(1965) Faruqui and Sahai(1943) Hornell(1923) Anon.(1949)	---do---	
Bill net	Tiar	Ganga River system	39	2	18	Hemp	2	1 (Dongi)	Saxena(1965)	Faruqui and Sahai(1943) have described this under fixed net	
	Gocheil	---do---	41	3	26	Hemp	2	1 (Dongi)	Saxena(1965)		
	Rangoon net	Marbade and Tapi rivers; Mettur Dam; Bhavanisagar and Panchet dams	-	-	-	-	-	-	Gulbadamov(1961 and 1962)		
	Uduvalai	Mettur Dam	-	-	-	-	-	-	---do---		

1	2	3	4	5	6	7	8	9	10	11
Gulbanet I	Mettur Dam, Krishnaraja-sagar, Maithan and Paunchet Hill Reser-voir	75	6	5-8	Synthetic	-	-	-	Gulbadamov(1961 and 1962)	
Gulbanet II	---do---	75	6	8-13	---do---	-	-	-	---do---	
Sebgul	---do---	50	2	5-6.5	---do---	-	-	-	---do---	
Drift net Karel or Katla jal	Deltaic area of Mahanadi, Ganga and Brahmmaputra	-	-	13-15.5	Hemp	-	-	-	Hornell(1923); Anon.(1949)and Anon.(1962)	
Peripatra	---do---	7	3	13-18	Hemp	-	-	-	Hornell(1923); Anon.(1949)and Anon.(1962)	Used in Baker-ganj estuary
Purse or Clap net	Gange River system	-	-	14	Cotton or nylon	2	1 (Dongi)	-	Sarena (1965)	Primarily Hilsa net, but this net with the mesh size mentioned catches catla and other carps. In the lower reaches of Ganga River this net is known as Shangla (Hornell, 1923 and Anon.1949)
Cast net	Bhawanar jal	-	-	2.5	Cotton	1	-	-	Sarena (1965)	Generally fingerlings of catla and other carps are caught
Chagaria	---do---	-	-	-	-	-	-	-	Faruqui and Sahai (1943)	
Khepla jal	Estuaries of Mahanadi, Ganga and Brahmmaputra	-	-	Variable	Cotton	-	-	-	Anon.(1949) Hornell(1923)	
Bechhari or othar jal	---do---	-	-	-	Hemp	4-6	1	-	Anon.(1949)	Large-sized catla, rohu, catfishes, coekup etc.,are caught

1	2	3	4	5	6	7	8	9	10	11
Scoop or dip or hand net	Jali	Ganga River system	-	-	1-1.6	Cotton	1	-	Saxena(1965)	These three nets are synonymous
	Hela jal	--do--	-	-	-	Cotton	-	-	Hornell(1923) Anon.(1949)	Small-sized carps are caught
	Kharrajel	--do--	-	-	-	-	-	-	Anon.(1949)	--do--
	Bhesaljal	--do--	-	-	-	-	-	-	Anon.(1949) Hornell(1923)	--do--
	Kochbi	Indus River system	-	-	2.5-10	-	-	-	Anon.(1949)	Catches spawners and small fishes
Hook and line	Jor	Ganga River system	155 (about 150 hooks)	-	-	-	-	-	Saxena (1965)	May occasionally take catla
	Borshi	Deltaic area	300-800	-	-	-	-	-	Anon.(1949)	
Fish traps	Kurjar	Ganga River system	variable	-	9-9.5	Bamboo and cotton	1	1 (Dongi)	Saxena (1965)	
	Chakjal	--do--	-	-	-	-	-	-	Hornell(1923)	Same as Kurjar
	Polo or Tappu	--do--	-	-	-	Bamboo	-	-	Anon. (1949)	
	Chip	Indus River system	-	-	-	Bamboo splinters	-	-	Anon. (1949)	Carps which have spawned and are returning to the main stream
	Mudgi	Hyderabad (Manjra River)	-	-	-	-	-	-	Job and Pantulu (1953)	
	Closing screen	Orissa	-	-	-	-	-	-	--do--	Pond fishes like carps, catfishes, murrels, feather-backs etc.
	Leap pocket	Orissa and Madras	-	-	-	-	-	-	--do--	
	Cheatam	Malabar	-	-	-	-	-	-	--do--	Used in paddy fields of Malabar. Fair-sized murrels, carps, mullets, prawns etc. are caught

1	2	3	4	5	6	7	8	9	10	11
Hocha	Bengal, Bihar, Assam and Kumaon	-	-	-	-	-	-	-	Job and Pantulu (1953)	Usually fry and fingerlings are caught
Mavulu	Madras and Andhra Pradesh	-	-	-	-	-	-	-	Jagannadha (1947), Menon et al. (1959)	Fingerlings of catla and other carps etc. are caught
Fixed net	Ganga River system	-	-	-	-	-	-	-	Sarena (1965)	
Chanchi or Pati	Ganga River system (tidal areas and bheels)	-	-	-	-	Slender bam-boo rods woven into screens	-	-	Anon. (1949)	Carp, catfishes, mullets and murrels are caught
Fish-spear	Konch (Tidal areas and bheels)	-	-	-	-	-	-	-	Anon. (1949)	Large-sized carps and catfishes are speared
Ek-Katya	--do--	-	-	-	-	-	-	-	Anon. (1949)	--do--
Spawn collection nets of various types	-	-	-	-	-	-	-	-	-	(See: 5.6.1)

* The authority against gear is stated in the order of importance of publication describing the gear and not chronologically

in the main rivers during the south-west monsoon (May-October) because of excessively strong current and greatly increased depths. The fishing venue in the monsoon is shifted to small tributaries, creeks, nullahs, drains etc., where adult carps migrate for spawning and the juveniles for shelter. Juveniles of 0 age-group of size range 71-160 mm are taken in large numbers, often alive, for culture operations by fine meshed drag-nets, in shallow inundated areas from September to December. Fishing in the main rivers is greatly accentuated during the winter (November to February) and spring (March-June), especially in the latter. Tanks and ponds provide a regular source of catla throughout the year, irrespective of seasons.

5.3.2 Duration of fishing season

See: 5.3.1

5.3.3 Dates of beginning, peak and end of season

See: 5.3.1

5.3.4 Variation in time or duration of fishing season

A significant cyclic feature of the waters of the Indian sub-continent is the great fluctuation in their depth. In summer the level runs extremely low and most of the streams are reduced to a mere trickle. The south-west monsoon brings heavy rainfall and flooding. The rivers often overflowing their banks and inundating vast areas. This phenomenon determines fishing activity considerably. At low stages, fishing nets can be easily operated in rivers and reservoirs and, consequently, in summer there is usually more intensive fishing.

In India and Pakistan there is a general dearth of cold storages, especially in the rural areas, and fresh fish is preferred by the consumers. These factors, combined with extremely high demand for freshwater fish in the eastern states of India, especially Bengal, also influence the time and duration of fishing operations. Fishing activity in different parts of India and Pakistan is suspended on certain religious festivals and ceremonious occasions.

5.4 Fishing operations and results

5.4.3 Catches

In the years 1958-60, 23 urban fish assembly centres were covered in a market sampling programme. In 1961 it was felt desirable to confine sampling work to the more important urban markets which are fed throughout the year, and the number of towns covered was reduced to eight. Table XXIV shows the annual landings of catla at five urban assembly centres situated on river Ganga and two on river

Yamuna.

Table XXV shows the monthly landings of catla at Sadiapur (Allahabad), one of the important assembly centres on river Yamuna.

5.5 Fisheries management and regulations

The Indian Fisheries Act came into being in 1897 as it was considered expedient to provide for certain matters relating to fisheries as a whole. Section 6 of this Act empowers local governments to frame rules applicable to their waters as and when found necessary. These rules may prohibit or regulate all or any of the following matters:

- (a) the erection and use of fixed engines
- (b) the construction of weirs
- (c) the dimension and kind of the net to be used and the mode of using them, and
- (d) all fishing in any specified water for a period not exceeding two years.

Thereafter, from time to time, most of the states of India framed rules and regulations to suit their needs.

In 1956, the Punjab State Government prohibited catching of rohu, mrigal, mahseer and catla smaller than 25.4 cm long. In Delhi, the capture and sale of these species below 20.4 cm in length has been prohibited since 1948. The State of Uttar Pradesh has prohibited, since 1954, the capture and sale of fry and fingerlings of major carps, 5.1-25.4 cm in length, from 15th July to 30th September, and of breeding fish from 15th June to 30th July in the prohibited areas, except under a licence issued by the proper authority. The areas where fingerlings and breeding fish occur have been defined and published. In Madhya Pradesh a size limit of 22.9 cm was imposed in 1953, for the capture of rohu, mahseer, mrigal and catla. In Bihar fishing is prohibited in specified areas of river Sone.

5.6 Fish farming, transplanting and other intervention

See: 2.1

5.6.1 Procurement of stocks

Despite the development of induced breeding technique by pituitary hormone administration in India since 1956, the mainstay of the major carp seed industry in India and Pakistan continues to be the collections from natural sources. Eggs, fry and fingerlings constitute the stocking material much needed throughout the country for culture of fast-growing major carps.

Table XXIV

Annual landings of catla at selected centres on the Ganga river system (in tons)

Year	Ganga					Yamuna	
	Kanpur	Varanasi	Ballia	Patna	Bhagalpur	Agra	Allahabad
1958	7.4	7.8	3.2	3.0	11.1	8.5	10.3
1959	7.6	3.5	4.8	5.6	3.6	23.9	15.4
1960	11.6	1.8	2.3	4.1	5.9	2.5	15.1
1961	4.2	0.6	0.5	4.6	3.2	2.6	18.4
1962	4.0	1.1	1.3	7.1	4.4	2.7	14.5
1963	3.0	0.9	2.3	3.0	7.2	2.7	17.4
1964	1.2	1.4	1.0	2.9	-	2.2	25.5

Table XXV

Monthly landings of catla at Sadiapur (Allahabad) Centre (in tons)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1958	1.03	0.96	0.41	0.17	0.40	0.50	0.97	1.25	2.08	1.35	0.57	0.63
1959	0.92	0.88	0.56	0.70	0.92	3.64	0.99	0.90	1.35	1.04	1.77	1.68
1960	0.63	0.77	0.73	0.19	1.02	2.48	3.15	0.73	1.60	1.67	1.20	0.91
1961	1.90	2.27	1.88	0.49	1.48	1.84	1.15	0.64	2.46	2.33	0.86	1.07
1962	0.58	1.18	1.50	0.83	1.21	0.96	1.31	0.75	1.15	2.63	1.12	1.22
1963	0.80	1.83	1.33	0.73	1.01	3.15	0.68	0.82	2.30	1.58	1.92	1.21
1964	1.63	1.74	3.06	2.36	1.30	3.97	1.35	1.31	3.19	2.79	1.13	1.62

River meanderings in plains result in a serpentine course with the cutting off of oxbow lakes. The bend and curves of various shapes in the river course often show a precipitous fast eroding bank on one side, and a flat, gently sloping bank exactly opposite. Both these banks are unsuitable for spawn collection. The best collection sites generally lie on the side of the gently sloping bank, but at a spot where the current just diverges, casting off spawn to the sides, as if by centrifugal force. At such sites a large number of spawn collection nets can usually be fixed.

Current velocity and turbidity appear to affect mesh selectivity of the spawn collection nets. While pH, dissolved O₂ and plankton are unimportant factors in riverine spawn collection, some of them constitute important pre-conditions for major carps to breed in their natural breeding grounds (Anon., 1965).

Riverine fish seed collection is done by special funnel-shaped nets (Figure 10) consisting of two parts, namely, the net proper and a detachable tail piece called 'gamcha', fixed to the cod end. The 'gamcha' is stitched to the main net in some varieties thereof. The net proper is of variable dimensions and, at times, two lateral wings are attached to it for coverage of a wider area. The rear of the net tapers to a narrow end, where a cane or a bamboo ring is placed to give it a stable round shape. The 'gamcha' is sometimes a rectangular open piece of cloth, but, more often, has the shape of a monk's hood. It is tied round the ring at the cod end of the main net. Such nets are operated with the mouth facing the current. Fry are caught by the stationary net and collect in the tailpiece. The net is fixed in the river bed in 1-3 m deep water with the help of two poles each at the mouth and the cod end and one or two poles for keeping the tailpiece in position. Batteries of nets are at times fixed in the river bed.

The dimensions of spawn collection nets used in different parts of India and Pakistan are not standardized. The fishermen of the eastern districts of West Bengal and East Pakistan use benchi jal (Rahman, 1946), a net made of cloth of 12½ counts yarn of the following dimensions: length 5-7 m, circumference 8-11 m, 'gamcha' length 1.22 m and width 91 cm.

In Midnapore district of West Bengal the dimensions of the prevalent nets are: length of net proper 320 cm, width at mouth 312 cm, height at mouth 61 cm, ring diameter 23 cm, length of 'gamcha' 168 cm, height of 'gamcha' 62 cm and width at rear end 44 cm.

In Delhi, Uttar Pradesh, Bihar, Orissa, Gujarat and Andhra Pradesh, a considerable amount of fry are collected by gear similar to the 'benchi jal' of West Bengal but, of variable dimensions, adapted to collect riverine spawn either in somewhat deeper waters or in shallow flats.

Not only are the net dimensions unstandardized, the mesh is also highly variable. The material of the net often consists of plain cloth, mosquito netting or other fine meshed materials of cotton yarn. The tail piece almost invariably consists of plain mill or handloom cloth. Experiments conducted by the Allahabad Substation of the Central Inland Fisheries Research Institute (India), with nets of the dimensions used by Midnapore fishermen stated above, but of 3 meshes, viz., 1/8", 1/16" and a combination of 1/8"-1/16", (front half of 1/16" and rear half 1/8" mesh) revealed that 1/8" meshed net was the most efficient. Its catching efficiency was at times as high as 14 times as compared to nets under local use. There were, however, indications that 1/8" meshed nets were more effective in slow current and high turbidity and 1/16" meshed nets in faster current and low turbidity (Anon., 1965).

An attempt at standardization of spawn collection nets was made by the Allahabad Substation of the Central Inland Fisheries Research Institute, Barrackpore (India) and 1/8" meshed net of the dimension used by Midnapore fishermen was taken as a standard for comparison with other spawn collection nets. New measures of spawn abundance and indices of spawn quantity and quality were developed to render spawn catches taken by a standard net at centres located on different rivers, mutually comparable, and to make an assessment of the spawn yielding potentiality of the centres. Catch per net-hour was the unit of effort derived and the whole season's catch of spawn, taken by one standard net, represented the index of spawn quantity available at a centre. The index of spawn quality was an expression of seasonal percentage of major and minor carps and other fishes (Anon., 1965).

Fingerlings are collected from riverine back waters, paddy fields, irrigation channels, tanks, etc., connected with the main river, generally with drag and cast nets. In Cauvery delta, fingerlings are captured by regulating the flow of water through irrigation sluices into puddles, from where they are collected with

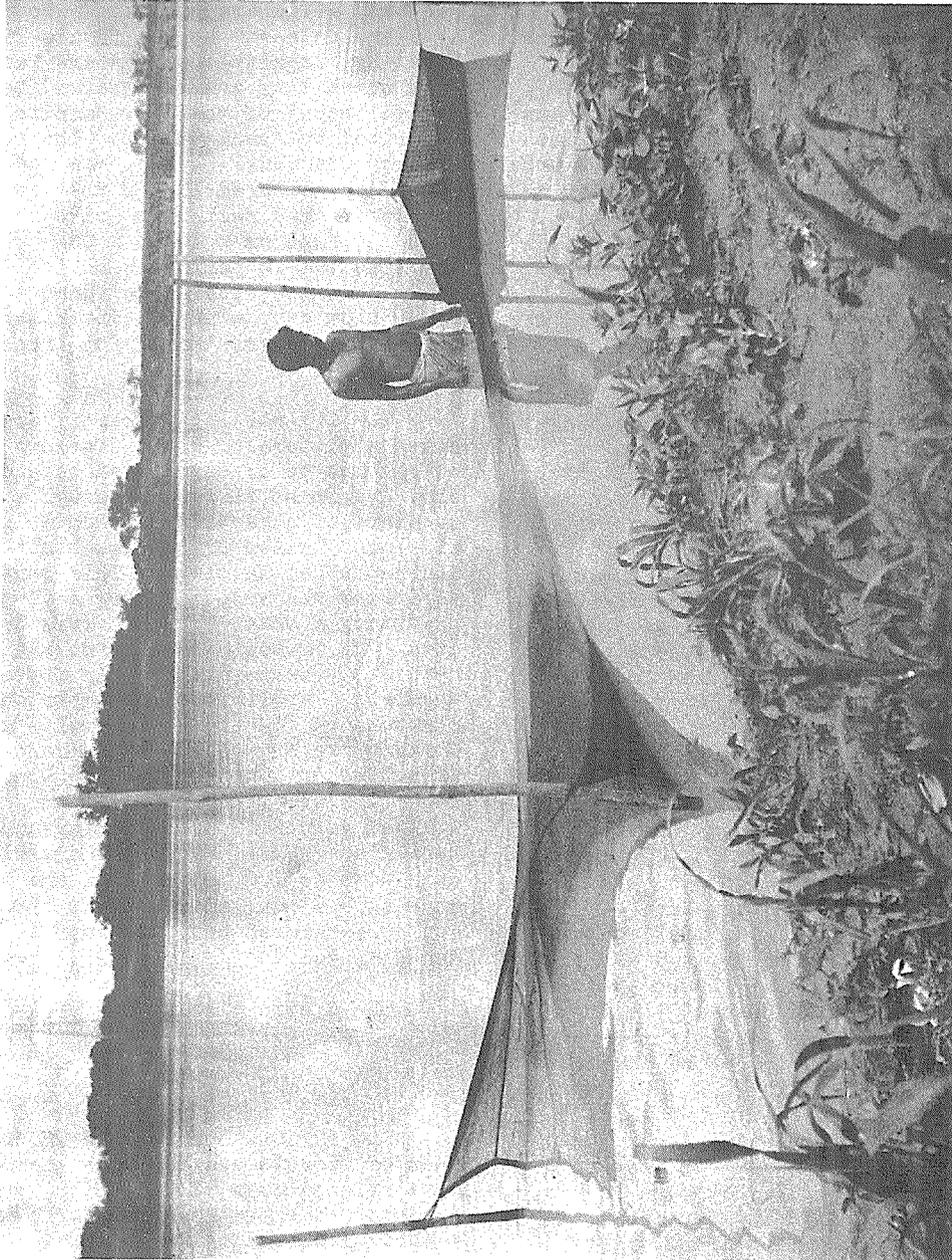


Figure 10. A net used for collection of carp spawn in rivers

fine meshed nets and transported for stocking. Dip nets and basket traps called 'mavulu' are used especially in the rivers Godavari, Krishna and Cauvery (Jagannadhan, 1947, and Menon *et al.*, 1959).

The fry and fingerling collection season in North-Eastern India and East Pakistan lasts from May-September, in North India and West Pakistan from June-October, and in South India from July-November.

In river Halda (Chittagong, East Pakistan), eggs are collected 12-14 hours after fertilization, close to the tidal zone, and hatched under protected conditions. The collection gear consists of a rectangular piece of mosquito netting cloth, 11-12 m long and 2.7 m wide, strengthened marginally with ropes and tied at each end to a bamboo pole about 2.4 m long. Two men operate the net either from a boat, or by wading in water, or by tying the net to poles fixed in the river (Ahmad, 1948).

The eggs thus collected in various stages of development are put into a portion of a boat, partitioned off with clay, for hatching. A better method is to hatch the eggs in nets suspended by bamboo frame-work, through which flows a gentle current of river water; in bamboo baskets, lined inside with fine cloth, moored in the river and in hatching pits (each c. 448 cm x 244 cm x 46 cm in size) excavated on the bank with arrangement for the supply of river water through pipes or hollow palm trunks. Each pit contains about 120 to 300 kg of eggs numbering about 900,000 to 2,200,000. Usually 25 to 50% hatching is obtained by this method (Ahmad, 1948 and 1948a). Ahmad (1948) suggested improvements in hatching techniques and proposed the use of a double walled rectangular tank-like structure, comprising one inner tank, made of netting, called the inner 'hapa' and the outer of fine cloth, called the outer 'hapa'. The corners of the inner 'hapa' are tied to the corresponding ones of the outer, and the whole device suspended in water with bamboo poles. The eggs are spread on the base of the inner 'hapa' and the hatchlings pass into the outer. The larvae thus obtained, are cared for till they are transformed into fry and have become 4-5 days old. It may be mentioned here that the same type of hatching device is now used to hatch eggs secured from induced breeding operations. Kaushik (1962) has described a hatching method which employs a series of tubs placed on sloping ground with a current of water flowing through them. Inside each tub are fitted two small 'hapas',

one inside the other in the same pattern as described above. The fertilized eggs collected in bundhs are usually hatched in improvised pits filled with bundh water. However, elaborate hatching arrangements are made in advance when major carps are to be induced to breed. Das and Khan (1962) and Chaudhuri (1964) have described in detail the field techniques they adopted, which are similar. To begin with, eggs are released by the female fish in the breeding 'hapa' where they are fertilized and from which they are transferred to the double-walled 'hapa' of the above-mentioned type, described by Ahmad (1948). The outer 'hapa', used by Chaudhuri (1964), was made of ordinary cloth and measured 182 cm x 91 cm x 91 and the inner of round meshed mosquito netting, measuring 152 cm x 76 cm x 46. These 'hapas' are laid out in perfectly horizontal position, one within the other, the inner submerged in 23 - 31 cm deep water. The hatchlings are kept in the outer 'hapa' for three days before stocking.

The fry collected from rivers usually comprise a mixture of a wide variety of species which have to be segregated before stocking. They are first filtered through a sieve which consists of a rectangular wooden frame with a wire mesh bottom or through bamboo grills or a coarse meshed netting. This contrivance separates the somewhat larger young forms of the predatory fishes, advanced fry, debris, trash etc. At present there is no satisfactory method of segregating early fry of different species. Preliminary attempts were made by Alikunhi *et al.* (1951) to evolve a technique of sorting the fry of the major carps of India, following the Chinese method (Lin, 1940). A known number of fry (5.0-7.0 mm) were kept in a limited volume of water in earthen vessels and tall glass jars. When the dissolved O₂ value came down to 1.0 ppm or less and the free CO₂ rose to 8.8 ppm, 60 to 96% of the catla fry could be skimmed off the surface where they had concentrated.

The distinguishing features of catla eggs, fry and fingerlings are described under 3.2.1.

5.6.2 Conditioning

The fry are conditioned in order to rid them of excreta and to inure them to subsist in a restricted area to which they are inevitably subjected during transport. The most common method of conditioning is to store fry in a cloth 'hapa' (Figure 11) in a still part of the river. Saha and Chowdhury (1956) stated that the depth of water where a conditioning



Figure 11. 'Hapa' in which fry are temporarily stored

enclosure is to be installed should be 30.48 to 35.56 cm. The period of conditioning depends upon the size and health of the fry and fingerlings. Jagannadhan (1947) stated that catla fry need 48 to 72 hours of conditioning. Saha and Chowdhury (1956) stated the same, but with reference to major carps in general. Alikunhi (1957) mentioned that about 6 hours of conditioning were required before fry are packed for transportation. Menon *et al.* (1959) mentioned that catla fingerlings have to be conditioned for 48 hours before transport. Srivastava and Karamchandani (in press) observed that when catla fry (8-23 mm) are conditioned for 24 hours prior to transport in a limited volume of water (1.8 to 2.0 ml of water per fry) a minimum of 0.88 ppm of O₂ was sufficient for their survival.

While conditioning, involving starvation and evacuation of faecal matter is considered to be a desirable practice, it was reported by Alikunhi (1957) that the fry stand the strain of long distance transport better if they are fed on animalcules like cladocerans during conditioning and while under transport.

Various types of conditioning containers are used, namely boxes made of wire meshes, bamboo or cane wicker work; barrels or boats with perforated bottoms; temporary enclosures made of netting or bamboo matting; pits and cloth 'hapa' etc. Clean, natural water at an optimum temperature of 26.5°C is suitable to condition the catla fry (Jagannadhan, 1947). During conditioning and transportation, fry and fingerlings should not be handled with bare hands lest the slime and scales covering the body be removed and thereby render them vulnerable to fungal and bacterial infection (Jagannadhan, 1947). Fry collected from the nurseries are kept in nets fixed in ponds, on which water is splashed from all directions, and the frightened fry pass excreta and vomit. After the fish have been properly conditioned they are ready to be transported (Hora and Pillay, 1962).

5.6.3 Transport

Fry and fingerlings are generally transported in open earthen vessels called 'hundies', metal carriers and sealed bags or containers under oxygen, as a head load for short distances or by rail, road, water and air over longer distances. Saha and Chowdhury (1956) have described the traditional method of transporting fry and fingerlings in 'hundies' as practised in Bengal. Though the 'hundies' are of variable size, they are generally of two types, one small of 20 cm diameter and 23 l capacity carried as a head load and, the other, larger, of 23 cm diameter and 32 l capacity, used for transport by rail. The 'hundies' are filled with water from the same source as the fry and the latter released therein at the rate of 50,000 in the

smaller and 75,000 in the larger ones. About 58 g of finely pulverised red soil is sprinkled over the water surface and during transport the 'hundies' are subjected to periodic shaking (see Tables XXVI and XXVII).

As earthen 'hundies' are liable to be easily broken during transport, improved open metal containers are often used and, at times, preferred. The latter are round vessels with a wide mouth, which can be closed with perforated pressed-in lids, the larger typed being 9.53 cm in diameter at the base, 9.20 cm at the mouth and 9.38 cm high. According to Jagannadhan (1947), 50-60 catla fingerlings can be transported in a tin container of 45.4 l capacity. Menon *et al.* (1959) remarked that 120-150 catla (of 20-30 mm length) per tin can be transported to a distance of 720 km (the duration of the journey is not mentioned by the authors). To prevent denting and effect insulation, woollen covers are used on the metal containers (Jagannadhan, 1947), or the vessel is crated and kept wet during the journey (Anon., 1962). Jagannadhan (1947) remarked that some air space should be left above the surface of water. A better container, with a small semi-rotary pump, has been devised by the State Fisheries Department of Orissa. The delivery tube of the pump carries two rows of holes at 45° to each other so as to produce two oppositely directed sprays over the entire surface of water. By the use of this pump, fish fry can be transported in semi-insulated road vans up to a distance of 9.483 km with as low a mortality as 5%. Sealed metal containers with oxygen have successfully been employed for transportation involving longer durations. Khan (1939a and 1946a) described a type of oxygenated container for transporting fish seed. This was made of galvanized iron and measured 45.72 x 35.36 cm, with two air-tight openings at the top, one to let oxygen in and the other to let out the displaced water. The fish thus got an atmosphere of oxygen while under transport. According to Khan (1946a), for a journey of 12 hours' duration in winter, each container can accommodate about 200 fry 2.54-5.08 cm long, or 100 fingerlings of 7.62-10.16 cm, or 30-50 fingerlings 12.70-20.32 cm long. Mookerjee (1940) devised a cheap method for oxygenation. Mitra (1942a) described the advantages of sending fish fingerlings in a suitably designed container with oxygen which could be despatched through rail as an ordinary parcel. Ganapati and Chacko (1951) made a comparative study of the transport of fish seed in ordinary tin carriers with or without oxygen. Ranade and Kevalramani (1956) conducted experiments on the air transport of carp fry packed in plastic bags and observed that approximately double the quantity of fry, transportable in a 'hundi' by rail, can be shipped by air in a plastic bag (duration 12 hours). Alikunhi (1957) mentioned the use of 18.2 l kerosene tins fitted with air-tight screw-capped lids for filling and with

Table XXVI
Number of fry to be transported in earthen hundies
of 27.3 l capacity
(Alikunhi, 1957)

Length of fry (mm)	No. per hundi	Maximum duration of transport (hours)	Percentage of mortality
12.7-19.05	1,500	24	2-5
	1,200	36	2-5
19.05-25.4	1,000	20	2-5
	800	30	2-5
25.4-50.8	500-800	24	10.0
50.8-76.2	200	8	10.0

Table XXVII
 Number of fry to be transported in closed containers
 of 22.7 l of water
 (Alikunhi, 1957)

Initial dissolved oxygen content (ppm)	Size of fry to be transported (mm)	No. of fry to be put in each container	Approximate safe period in minutes during which transport can be effected
4	6-7	50,000	19
4	6-7	30,000	31
4	6-7	20,000	47
4	15-20	1,000	40
4	15-20	500	80
4	30	300	120
4	30	150	240
5	6-7	50,000	25
5	6-7	30,000	42
5	6-7	20,000	62
5	15-20	1,000	60
5	15-20	500	120
5	30	300	165
5	30	150	330
6	6-7	50,000	31
6	6-7	30,000	51
6	6-7	20,000	77
6	15-20	1,000	75
6	15-20	500	150
6	30	300	207
6	30	150	414

Table XXVIII

Number of fry to be transported in 18.2 l kerosene tins under oxygen
(After Alikunhi, 1957)

Length of fry (mm)	Number per tin	Duration of transport by air (hours)	Mortality (percent)
12.7-19.05	800-1,000	12	5-12
39.0-50.8	400	24	30
25.4-31.8	325	16	3

tubes for drawing in oxygen from a cylinder. The number of fry that can be safely transported, when the tin is filled two-thirds with water and one-third with oxygen, is given in Table XXVIII. Saha and Sen (1958) described three types of containers, viz. glass carboys, specially designed containers of aluminium and galvanized iron sheet and latex-rubber and plastic bags for transport of spawn and fry under oxygen pressure. They found the specially designed aluminium containers were the most efficient but, considering the relative costs of different types of containers tried, recommended the latex-rubber bags for commercial use. Another type of container, popular in the Indo-Pacific region, has a capacity of about 0.18 l, with three apertures at the top, two of which are fitted with metal tubes, one for O₂ supply, another for discharge and the third (provided with a strainer without rough edges) to eliminate excess water (Anon., 1962). Hora and Pillay (1962) stated that 18 l cans were used at the Central Inland Fisheries Research Institute, Barrackpore, India, for the transport of fry of the Indian major carps with about 6 l of free oxygen. Such cans hold 900-1000 fry, 1-2 cm long (about 285 g in weight) and can be safely transported by air for over 20 hours. Alkathene bags of 74 x 46 cm, and of capacity 3 l, are widely used currently for transport of major carp fry under oxygen. The bag is one-third filled with river water and packed with oxygen and 30,000 fry (5.5-7.5 mm) for transport over a period exceeding 24 hours, and 60,000 fry of the same size for journeys up to 24 hours.

The role of O₂, CO₂ and pH on the survival of fry and fingerlings during transport has already been discussed under 3.2.1. Basu (1951b) studied the effect of additions of red soil to the transport medium of Indian carp larvae, referred to earlier in this section, and reported that the added soil particles, by virtue of their positive electric charge, help in attracting the negatively charged dead fry (infected with bacteria) to the bottom of the container, getting them buried in the soil. The extent of pollution by organic matter was kept localised by the deposit of red soil on the bottom of the container. Saha and Chowdhury (1956) observed that additions of red soil to the transporting medium, constant shaking of the carrier and changing its water do not extend the survival period beyond 30 hours. They also observed that the use of red or ordinary soil makes no

difference but addition of soil in a finely pulverized state increases the period of survival, as is evidenced from the fact that addition of soil to distilled water extends the life of fry from 10 minutes to 19 hours. Experiments conducted by Saha *et al.* (1956b) on the use of different absorbent substances showed that pulverized earth, activated charcoal and 'Amberlit' were found to absorb CO₂ and NH₃ from the medium, with a consequent increase in the period of survival of fry. Srinivasan and Chacko (1953) and Srinivasan, Chacko and Valsan (1955) observed that the addition of Na₂HPO₄ does not reduce carp fingerling mortality in open containers but does so in closed ones, possibly because of its ability to absorb CO₂ in the latter, which is not possible in open carriers. Saha *et al.* (1956b) found that addition of Na₂HPO₄ to the water containing fry was harmful after 40 hours, a finding different from that of Vaas (1951). Spawn was found to stand a concentration of 2.5 ppm of dissolved free ammonia and 15 ppm of dissolved ammonia in the form of inorganic salts (Saha *et al.*, 1956b). Saha *et al.* (1955), however, reported that sodium amytal, a synthetic hypnotic, at c. 21 to 28 mg per litre of water considerably lowered the metabolic rate of the fry and that 30 percent more fry could be transported in a given volume of water, thereby reducing the ultimate cost of transport.

Table XXIX

Minimum water volume required by fry of different size-groups
(Saha *et al.*, 1956a)

Length of fry (cm)	Av. wt. of fry (g)	Minimum water volume required by fry (cc)
4.93 - 6.60	1.91	25
3.12 - 4.74	0.92	15
2.62 - 3.60	0.35	8
2.03 - 3.43	0.25	7
1.77 - 1.91	0.076	2

While fry can now be safely transported, transport of fingerlings (50-100 mm) is still a problem. Effective methods of transporting these have been developed in Punjab and Madhya Pradesh in galvanized iron drums of c. 180 l capacity. In Madhya Pradesh, a sufficiently wide opening, 48 cm x 30 cm, is cut along the main body of the drum for providing aeration and sufficient space for the movement of the fingerlings. Four small iron brackets are fixed opposite to this opening on the outer side of the drum to prevent it from rolling during transportation. A mortality of about 5% has been observed during long distance transport of fingerlings in these drums (Anon., 1955). The transportation of breeders for dry bundh or induced breeding involves a great risk as, being active, they are often severely injured. Open canvas containers (1 m x 1 m x 1½ m), supported on a frame of galvanized iron pipes, introduced recently in Punjab and Madhya Pradesh, have been found to be very useful. Mammen (1962) has, however, recommended a splashless tank with attached aeration equipment for this purpose.

5.6.4 Holding of stock

The rate of stocking of spawn in nursery ponds of the Cuttack Substation of the Central Inland Fisheries Research Institute, ranged from c. 247,100-1,235,500 per ha. Alikunhi (1957) mentioned that under exceptional conditions it could be raised to as high as 21,527,352 per ha even in water as shallow as 30.48 cm. In cement cisterns, without artificial feeding, the rate of stocking can be 8,401,400 per ha but such heavy stocking necessitates thinning within 10 days. On attaining a length of 19-25 mm in the nurseries the fry are usually transferred to rearing ponds.

It was earlier held that 25.4 mm long fry should be stocked at 86,485-148,260 per ha in 15.24 m x 15.24 m x 3.04 m rearing ponds, but Alikunhi (1957) noted that such deep ponds are not suitable for the purpose. He advocated a stocking rate of 24,710 fry per ha in only 121.92 - 152.4 cm deep ponds, without artificial feeding. With artificial feeding, however, the stocking rate can be raised to 197,680 fry per ha. Carp larvae, being easily identifiable at 19-25 mm long stages, mixed farming is recommended from rearing pond stage onwards for better results (see 4.6). On attaining a length of 76.2 - 127.0 mm in rearing ponds, the fingerlings are commonly transferred to stocking ponds. The rate of stocking, along with the species composition advocated by different authors, is furnished in Table XXX.

Hora and Pillay (1962) stated that in a stocking pond, each carp fingerling should be provided with about 0.1 m³ of water in the first year, 0.23 m³ in the second year and 0.45 m³ in the third year. This is achieved by thinning the population at the end of each year. An allowance of 10 percent should be made in stocking ponds for natural mortality and also for losses by reduction in the volume of water in the ponds as a result of evaporation during summer.

5.6.5 Pond management (fertilization; aquatic plant control, etc)

Efficient pond fish culture entails special preparation of nurseries to receive the tender hatchlings and fry. This comprises adoption of a series of measures commencing with the draining out of nurseries to remove predatory fishes, insects and trash fish, drying, liming and ploughing the pond bottom. Liming is unnecessary in ponds situated on calcareous soils. In deeper perennial water bodies which cannot be drained out, as many unwanted fish as possible are removed by repeated netting and the rest poisoned. As a measure for increasing pond fertility, Hora and Pillay (1962) mentioned that a short-season crop of leguminous plants should be grown on the pond bottom, which thereafter, should be reploughed and levelled. Should the soil be acidic, its pH ought to be raised to 8 or 9 by reliming. The next step in nursery preparation consists of manuring, aimed at sustained production of zooplankton to serve as food to achieve a rapid growth of the fry. Details of manuring are described further in this

section. The nursery is then filled either with rain-water or with clear water from a nearby source. In certain nurseries near Calcutta domestic sewage in moderate doses is used for their enrichment. Bhaskaran (1952) advocated limitation of the sewage dosage so that the O₂ concentration in the pond does not fall below 3 ppm.

Mention has been made above of poisoning for removal of unwanted fish. A large number of piscicides, of plant origin, are used for this purpose. Some of the more common ones are: safed siris (Albizia procera); nagdona tithwan (Artemisia vulgaris); dar-hald (Berberis aristata); tuba (Derris spp.); banalu (Dioscorea spp.); chaulmugra (Hydnocarpus kurzii); akhrot (Juglans regia); Millettia spp.; hazarmani (Phyllanthus urinaria); Rhododendron spp.; kuchla (Strychnos nuxvomica); sarphonka (Tephrosia purpurea) and ban tambaku or gidar tambaku (Verbascum thapsus). Derris powder, with 5 percent rotenone, is perhaps the commonest pond poison used. This should be administered at least a month before the anticipated date of fry release. For application, the required quantity of derris powder is mixed with water and sprayed over the surface of the nursery pond, keeping it well stirred during the process. Depending upon the dosage used, which may vary from 4-20 ppm, the poisonous effect of derris powder wears out in 2-12 days. Hora and Pillay (1962) remarked that large perennial waters are apt to be slightly acidic, which should be rectified by liming at the rate of 300-500 kg per ha either together with derris powder application or separately. Due to non-availability of derris powder, endrine at 0.1 ppm is now being commonly used to eradicate unwanted fish (Anon., 1964).

Initially, pond manuring should be carried out 7-10 days after poisoning. The manures commonly used are fresh or semidried cow-dung, stable refuse, oil-cake, municipal compost, decaying vegetation and inorganic fertilizers. Little information exists on the relative utility and doses of different manures, and further experimentation is needed. Inorganic fertilizers are known to increase the production of phytoplankton which the carp fry are mostly unable to digest and assimilate. Food of carp fry has been mentioned under 3.2.1. Various combinations of cow-dung, mustard oil cake and aquatic weeds such as Eichhornia, Hydrilla, Najas, etc., at c. 555 to 832 kg/ha have been suggested by Saha (1953). Alikunhi et al. (1955) manured the ponds of the Cuttack Substation of the Central Inland Fisheries Research Institute (India), with cow-dung at the rate of c. 11,208.26 to 22,416.52 kg per ha. Basing their observations on experimental ponds, cement cisterns and pots, they observed that heavy manuring with cow-dung colours the water dark brown, and, while during the first 8-10 days of manuring, the phytoplankton content (net

plankton) of the water is remarkably poor, from the 9th to 10th day onwards, the water teems with zooplankton, particularly rotifers, cladocerans and copepods, the crop of animalcules lasting from 7-10 days. Alikunhi *et al.* (1955) further reported that the average production of plankton in ponds, manured at the rate of 11,208.26 kg per ha, was more than in those manured at the rate of 16,812.38 kg per ha. It was also observed that when manured with cow-dung, at the rate of 16,812.38 kg per ha, the average production of fish flesh per day per pond amounted to about 459 g, a yield more than from ponds manured with either 11,208.26 or 22,416.52 kg per ha. The manure should be applied 15-20 days before the anticipated date of fry release.

It has recently been observed that the release of soluble salts other than nitrogen and phosphorus is not as high in the case of cow-dung as in poultry manure (Ray and David in press). When poultry manure was applied along with cow-dung manure in cement cisterns, catla was found to grow at 1.1 mm per day even at the exceedingly high rate of stocking of c. 16,575,000 to 28,050,000 larvae/ha, the rate of survival being 50 percent (Banerjee, Singit and Ray, in press).

Alikunhi (1956) stated that, if the initial dose of manure does not result in the desired level of plankton production, supplementary manuring should be done which may not exceed 2,510.6 kg per ha but may have to be repeated every 4-5 days till production level of plankton is satisfactory. A bloom of phytoplankton, should it develop in the pond, can be controlled by spraying liquid cow-dung or some other organic matter or dye, or by covering the surface of the pond with the duck weed, Lemna (Alikunhi *et al.* 1952), both causing the bloom to die within 4-5 days by preventing light penetration. Alikunhi (1956) stated that chemicals (algacides) should not be used to control algal blooms, as they are likely to be harmful to animalcules, the main food of growing carp fry. In manured nursery ponds, weeds, particularly the submerged ones, grow very rapidly utilizing the readily available rich nutrients and thus adversely affect plankton production. The weeds also offer shelter to predatory insects. Alikunhi (1957) stated that mechanical removal of weeds at regular intervals with human labour or with weed cutting machines is perhaps the most practical method of removing them in shallow nursery ponds.

Insects predate heavily on carp fry and special care is therefore taken to control them before releasing fry in nurseries. The control measure consists of spraying an emulsion of 56 kg mustard or coconut oil and 18 kg washing soap per ha, on the water surface 12-24 hours before releasing the fry (Pakrasi, 1953). The emulsion can be applied with a sprayer or sprinkled by hand. A still day should be chosen for spraying lest the oil film gets blown to one side of the pond.

The quantitative abundance of zooplankton in a nursery can be estimated by adopting appropriate limnological methods. A rough method for estimation of plankton has been developed by Alikunhi (1956) for use by fish farmers. About 54,552 l of water, taken from different representative areas of the pond, are filtered through a muslin tow-net with a glass tube tied to the lower narrow end, the diameter of the glass tube being 2.54 cm. A pinch of powdered common salt is added to the water in the tube, when detached, to kill the plankton. Within 15-20 minutes of adding the salt, most of the organisms settle at the bottom of the tube. If the column of plankton sediment is 6.35 to 8.5 mm high from the bottom of the tube, and is found to consist mostly of water-fleas and other animalcules, the water in the pond may be considered sufficiently rich in plankton to be stocked at the rate of 494,200 to 741,300 fry per ha. The animal or plant nature of the plankton sediment is roughly indicated by a pale brownish or greenish colour respectively. A minimum of 1.5-2.0 ml zooplankton in 45 l of water was observed by Alikunhi *et al.* (1955) to be essential for satisfactory stocking of the pond. Mitra and Mohapatra (1956) have also stressed the desirability of the initial availability of zooplankton at the rate of 0.1 to 0.33 cc per fry and opined that a higher concentration does not give appreciably better results. The number of fry to be stocked in nursery ponds, depending on the density of plankton, has been shown in Table XXX.

For stocking a nursery with spawn, the water in the fry container should be gradually but thoroughly mixed with pond water so that the temperature difference, if any, is homogenized. The fry container should then be slowly dipped and tilted in water so that fry are free to swim out of the container into the nursery. It is better to release the fry in different areas of the nursery. Alikunhi (1957) observed that stocking a nursery is best done late in the evening. This gives the fry time to acclimatize themselves during the ensuing night, relatively free from any predators.

Within 2-3 days after stocking the food available in the nursery often becomes very low. Alikunhi (1956) observed that for the first two days after feeding commenced, the fry do not take artificial food but depend almost completely on natural food. After this period, artificial food along with the natural food enhances the growth and survival of fry considerably. The commonly administered artificial foods are rice bran and oil cakes of ground-nut, coconut and mustard. Powdered oil-cakes and rice bran, which are to be given to fry as artificial food, should be

Table XXX
Rate of stocking in different kinds of ponds

Type of ponds and/or their areas	1	2	3	4	5
	Stage and/or size	Approximate number per ha of water surface	Duration of rearing in days	Authority	
Shallow, seasonal nurseries, 91.44-152.40 cm deep, 1.524 cm x 1,828.8 cm x 914.4 cm in area and paddy fields with a depth of over 30.48 cm.	fry up to 8.5 mm	741,300-1,235,500, depending on density of plankton available as food	15-30	Anon. (1956a)	
Seasonal nurseries 1,524-1,828.8 cm x 914.4 - 1,219.2 cm x 91.44-121.92 cm	do.	1,235,500 - 1,976,800	15	Alikunhi (1956)	
Seasonal, shallow nurseries 1,524 cm x 1,524 cm in size and 91.44 - 121.92 cm depth	fry few hours -3 days old	222,390 without feeding, 1,235,500 with artificial feeding	15	Alikunhi (1957)	
0.62 ha in size	-	-	30	Goodsell (1959)	
Seasonal nurseries, 0.9 - 1.5 m deep, 2.4 x 3 m in size or perennial ponds 1.8 - 3.6 m deep and 0.5 ha in area	fry	7,812,500	12-15	Hora and Pillay (1962)	
Perennial or seasonal rearing ponds, 121.92-182.88 cm deep, 0.62-1.24 ha in area and paddy fields with a depth of 45.72 cm or more	25.4-50.8mm	49,420 -74,130 without feeding, 148,260-197,680 with regular feeding	30-60	Anon. (1956a)	
Rearing ponds slightly larger than nursery ponds	25.4-38.1mm	98,840-123,550 without feeding, 148,260-197,680 with artificial feeding	60	Alikunhi (1956)	
Perennial or seasonal rearing ponds retaining water for a long period, but not deeper than 182.88 cm, long and narrow in shape for easy, inexpensive fishing operations and paddy fields 45.72-60.96 cm deep	19.0-25.4mm	24,710 without feeding 197,680 with artificial feeding	60-90	Alikunhi (1957)	
Rearing ponds	25.4-50.8mm	4,000-5,000	60	Goodsell (1959)	
Rearing ponds	35 mm	250,000-500,000	-	Hora and Pillay (1962)	
Stocking ponds 1.25 - 2.0 ha in area	Fingerlings 50-100 mm	5,000-8,000 (catla:rohu: mrigal: 3:6:1)	-	Lin (1951)	

1	2	3	4	5
Perennial stocking ponds 182.68 cm or more deep, 0.202 ha or more in area, preferably long and narrow in shape for easy, inexpensive netting operations and large water bodies	Fingerlings 102-153 mm	4,942-7,413 without feeding 9,884-12,355 with artificial feeding	180-240	Anon. (1956a)
do.	Juveniles, 254-305 mm	1,853-2,471 without feeding, 2,965-3,706 with artificial feeding	365 or more	Anon. (1956a)
Stocking ponds	Juveniles, 76.2-127.0 mm	3,706 without artificial feeding (catla: rohu: mrigal 3:3:4)	-	Alikunhi (1956)
Perennial stocking ponds over 182.88 cm deep, 0.134 ha or larger in area (preferred area: 0.809 - 1.214 ha) preferably long and narrow in shape for easy, inexpensive netting operations	-	2,471 catla, 3,296 rohu, and 4,492 mrigal + 5-10% of each species as allowance for natural mortality (if individual species alone are stocked)	-	Alikunhi (1957)
do.	-	1,023 catla, 1,023 rohu and 1,364 mrigal + 10% of each species as allowance for natural mortality (catla: rohu: mrigal: 3:3:4)	-	Alikunhi (1957)
Stocking ponds	-	3,000	-	Goodsell (1959)
Stocking ponds	8-13 cm	1,875 catla, 3,750 rohu and 625 mrigal	-	Hora and Pillay (1962)

Table XXXI

Rates of feeding during 15 days in nursery ponds
(Alikunhi, 1957)

First 5 days after stocking	Daily, double the weight of fry at the time of stocking
6th to 10th day after stocking	Daily, triple the weight of fry at the time of stocking
11th to the 15th day after stocking	Daily, four times the weight of fry at the time of stocking

Table XXXII

Volume of artificial food to be given to fry for 15 days
in nursery ponds
(Alikunhi, 1956/1957)

Days	Volume of fry (in bati*)	Quantity of daily feed in bati			
		Mustard oil cake	Ground nut oil cake	Coconut oil cake	Rice bran
2nd to 5th day	1	1.0	1.25	2.0	2.0
6th to 10th day	1	1.5	2.50	3.0	4.0
11th to 15th day	1	2.0	3.75	4.5	6.0

* Bati - a small cup-like measure usually of 130-150 cc capacity

sifted through a fine meshed sieve to remove the husk and to ensure uniformity in the size of particles. Daily doses of artificial food in the first 5 days of stocking should be equal (Hora and Pillay, 1962) or $1\frac{1}{2}$ -2 times (Anon., 1956a and Alikunhi, 1957) the weight of fry at the time of stocking; double (Hora and Pillay, 1962) or triple (Alikunhi, 1957) the weight of fry as at the time of stocking for the next 5 days; and triple (Hora and Pillay, 1962) or $4-4\frac{1}{2}$ times (Anon., 1956a and Alikunhi, 1957) the weight of fry at the time of stocking, during the following five days (see Table XXXI). A fry of 6-6.5 mm length weighs about 0.0014 g on an average (see Table XXXII). The average production of early fingerlings in the first 15 days of rearing is shown in Table XXXIII. The highest rate of survival was observed in the pond to which rice bran was added daily at twice the initial weight of the fry.

After about 15 days of nursing, when the fry have grown to 25.4 - 38.1 mm in length, they are transferred to rearing ponds. The fry should not be fed for two days in the nursery immediately preceding netting for their transfer into rearing ponds. A nursery can be used to raise several crops of fry in a season (Anon., 1956a). Alikunhi (1957) was able to produce 94,000 fry and early fingerlings in a 0.25 ha pond in two crops within a period of five weeks.

Rearing ponds should, as far as possible, be prepared in the same manner as nursery ponds. The essential steps in the preparation of rearing ponds are, as in nursery ponds, the elimination of all predatory and trash fishes and manuring prior to stocking with fry. With proper care the young fish attain fingerling size of 76.2 - 127.0 mm within 2 months in the rearing ponds. They are then ready for the stocking ponds.

The stocking ponds should also be prepared in advance for reception of fingerlings. The first step is to drain them, if possible, and to remove the accumulated bottom deposits. If draining is not possible, the bottom deposits can be collected by means of long scoops, operated from the bank or a boat, or by repeated netting. Lime is then added to ponds which have acidic water or a low alkaline reserve, or in which there has been a fish disease. Slaked lime or quicklime should, as far as possible, be applied to the pond bottom after draining and sediment removal, or it may be released at the pond inlet, or spread on the water surface. Hora and Pillay (1962) suggested that for complete disinfection of ponds a dose of about 10,000 kg per ha of lime is necessary, but, if the liming is done regularly every year for fertilization purposes, 100-200 kg per ha should suffice for soils which are not very acidic or poor in carbonates. A lime dressing of 1,000 to 1,500 kg per ha is required for ponds with acid soil and water. The authors also stated that the alkaline reserve of pond water can be brought to the desirable level with about 2 kg per ha of lime, but much larger quantities of lime are required to neutralize acidic pond substrata. It is necessary to bring the pH of the soil to about 6.5 to prevent a sudden fall in the pH of the pond water.

Hora and Pillay (1962) have recommended a dose of over 1,000 kg of cattle or horse manure, about 560 to 1,200 kg of poultry manure and 5,000 kg of green compost per ha for manuring stocking ponds. These ponds, like nurseries, may also be manured with compost, green grass, cow-dung and oil cake. These authors observed that a mixture of organic and inorganic fertilizer, consisting of 3 parts of animal manure and 1 part of superphosphate,

Table XXXIII

Production of early fingerlings in the first 15 days
(Alikunhi, 1957)

Artificial food provided	No. of ponds used for rearing	Percentage of survival range	Average	Average production number per ha
Rice bran	4	47.0-99.0	77.2	953,633
Ground nut oil cake	5	13.2-71.8	36.6	477,076
Mustard oil cake	4	4.5-51.0	28.2	348,460
Coconut oil cake	2	47.8-61.0	54.4	672,409

applied at the rate of about 500 kg per ha per annum, is also quite effective.

Stocking ponds often get choked with aquatic weeds which deprive the pond soil of its nutritive elements, restrict the movement of fish, interfere with netting operations and harbour predators, insects etc. Philipose (1964) has briefly described the methods adopted for eradication of weeds in ponds.

Floating weeds like Eichhornia and Pistia are best removed by manual labour. Chemicals like 2,4-D are quite effective and economical against Eichhornia, though not frequently against Pistia. Saha, Sen and Muhury (1958) worked out economics of the process of destruction of Eichhornia by using 'CIDICO' containing 80-82 percent sodium salt of dichlorophenoxy acetic acid at e. 4.2 kg/ha, without affecting the major carp stock. Actual spraying was carried out with a power sprayer, covering on an average about $\frac{1}{2}$ hectare per day with the help of one mechanic and three labourers. In Assam, spraying with 2,4-D at 8.4 kg/ha (in 1,125 l aqueous solution) with the aid of Knap-sack sprayers, was found to be the most effective method for mass clearance of Eichhornia in a bheel, Ramachandran (1963a). 2,4-D, when mixed with a common domestic detergent, acts effectively on weeds like Pistia, Nymphaea and Nelumbo in which leaves are either hairy or waxy. Simazine WP-50, applied at 5.6-11.2 kg per ha, has been found to kill Pistia, Eichhornia and Colocasia completely within 2-3 weeks even during rains. Laboratory experiments conducted at the Cuttack Substation of the Central Inland Fisheries Research Institute, India, showed that Simazine 25 percent paste, sprayed in aqueous solutions at 22 kg/ha killed 80 percent of Pistia and 70 percent of Eichhornia in 15 days, with the remaining plants also showing deterioration. Taficide-80 has been successfully used at a dose of 2.2 kg/ha for the control of Eichhornia.

Marginal weeds like Typha, grasses, sedges, rushes, Ipomea, Jussiaea, Sagittaria and Colocasia are best controlled, under Indian conditions, by ploughing-in, grazing by live-stock, burning during dry season, or repeated cutting and deepening of marginal shelves.

Rooted emergent weeds like Limnanthemum, Trapa, Myriophyllum etc. are successfully removed by repeated weekly cutting of leaves before fruiting, for about 6-8 weeks. Alternatively, spraying once or twice with 2,4-D (at 5.6-11.2 kg/ha) kills some of these plants. In field experiments, CuSO_4 when applied as crystalline lumps at 140 kg/ha to ponds infested with the weed Limnanthemum cristatum, uprooted nearly 95 percent of the plants without any adverse effects on the plankton and fish populations of the treated water areas.

Rooted submerged weeds are cleared by a number of simple, manually operated devices like bottom rakes, log weeders, metal spikes with or without barbed wire attachment, forks, drag chains or a bamboo pole fixed with a cross piece at the lower end followed by repeated netting with strong wire or rope nets. Other methods employed include shading by floating plants like Pistia or Salvinia for a period of 8-10 weeks or by creating algal bloom or algal mats by repeated fertilization with N.P.K. Some of the fishes known to feed on weeds are Ctenopharyngodon idella (Chinese grass carp), Puntius javanicus, Tilapia mossambica, T. melanopleura and Cyprinus carpio (common carp). Of these, grass carp is known to feed voraciously on Hydrilla and, to a lesser degree, on Lagarosiphon, Najas, Lemna and Azolla, and can be used for effective biological control of some of these aquatic weeds (Alikunhi and Sukumaran, 1964). Philipose (1964) stated that sodium arsenite at 5-6 ppm is very effective against submerged weeds but cautioned against its frequent use due to its highly poisonous properties. Banerjee and Mitra (1954) applied CuSO_4 of 10 ppm concentration in nursery ponds heavily choked with Ottelia alismoides, Limnanthemum cristatum and Najas foveolata, after the pH of the pond water was first lowered to 6 by the use of 10 ppm H_2SO_4 . Visible signs of withering of the weeds appeared in 3-4 days, and all the vegetation died in about 25 days. CuSO_4 alone has very little effect on the submerged weeds. Fish, however, are fatally affected by the above-stated dose of CuSO_4 . Superphosphate or urea, at 150 ppm or above, kills most of the submerged weeds, usually producing an algal bloom and probably serving as a fertilizer as well. Ramachandran (1963b) observed that anhydrous ammonia gas has been found effective for controlling weeds like Hydrilla, Najas, Wolffia, Nymphaea and Nelumbium, when injected into the subsurface layer of water by means of an applicator at 112-334 kg/ha or 6.4-18 ppm of Ammonia N. The unwanted fish are also killed by this method. Simazine WP-50, applied at 3-5 ppm has been found to suppress Hydrilla under laboratory conditions.

Algal blooms and mats can be controlled by maintaining a thick cover of Lemna for 2-3 weeks (Alikunhi et al., 1952); Simazine WP-50, applied at 1 ppm, has been found to control algal growth without killing fish. Field trials have yet to be carried out.

After the pond is stocked, the condition of the fish should be periodically checked by netting at regular intervals to ensure that they are thriving. Control measures to check disease are discussed under 5.6.7. Shade is

provided in shallow ponds by planting trees on the embankment, taking care to periodically remove the leaves which fall into the water. Treatment of acidic waters by lime at rates up to 10 ppm, and of foul water by $KMnO_4$ in doses not exceeding 1.5 ppm, has been recommended by Hora and Pillay (1962). Basu (1950d and 1958) stated that Bengal fish farmers float cut banana stems on the ponds to adjust its pH. Although banana stem juice is acidic in reaction (pH 5.2-5.7), it contains a considerably alkaline reserve which is beneficial to the pond. The bottom of the pond is frequently raked to remove noxious gases often found accumulated there. Minute doses of alum help to settle the suspended or colloidal matter and thus to control high turbidity of the pond water. Sugar-cane jaggery (gur) is sometimes employed for clearing pond water, but it should be used with care as it is lethal to fish even at 1 percent concentration. The inlet and outlet of the stocking pond should be protected by wire screens.

5.6.6 Paddy-cum-fish culture

Alikunhi (1961) has briefly described fish culture in paddy fields in India. In certain districts of Andhra Pradesh, millions of early fry of Catla catla, Cirrhina mrigala and Labeo fimbriatus enter the irrigated paddy fields during June-July. They grow to early fingerling size of 4-6 cm by September-October when they are caught in traps set at the inlets and outlets of terraced fields and across the connected ditches and drains. An experiment was carried out in the 24 Parganas districts of West Bengal in 1945. Fingerlings of major carps, 19.05 - 63.5 mm long, were stocked in about 238.765 ha of paddy fields at 1,478 per ha. The growth of fingerlings in 3-4 months was recorded as 12.7 - 30.48 cm without artificial feeding and the production was c. 112.08 kg per ha. Further experiments on a larger scale have been undertaken by the Madras Fisheries Department. Hora (1951) observed the annual average yield of fish cultured in rice fields without artificial feeding to be 104.2 kg per ha. Paddy-cum-fish culture is commonly practised in the deltaic

areas of the rivers Godavari, Krishna and Cauvery and the "Kole" cultivation fields in South Malabar (Chacko and Ganapati, 1952).

5.6.7 Diseases and parasite control

See Table XXXIV

5.6.8 Harvest

No definite information is available on the best size at which catla, raised in culture operations, should be harvested. In most cases, the entire crop of fish in the pond is harvested regardless of size, although, in some well organized fisheries, fishes below a particular size are not captured for food. Catla attains its maximum rate of growth in weight probably in the second or third year of its life. Seasonal ponds have to be completely fished out in summer when the yearlings are transferred to permanent waters, if available. However, depending on the local demand for fish, the yearlings can also be profitably marketed.

Catla as a species is not ordinarily cultured alone but jointly along with other carps. Fish production in pond culture operations in India and Pakistan varies widely. An unattended wild crop does not ordinarily exceed an annual production level of c. 112 kg/ha. In cultivated waters, without any artificial feeding, a production of 300 to 900 kg/ha is achieved annually (Lin, 1951). With artificial feeding the annual production can be increased to c. 2802 kg/ha (Alikunhi, 1956). In a pond culture experiment with catla and the silver carp, Hypophthalmichthys molitrix, lasting four months, Alikunhi and Sukumaran (1964) computed an annual production of 1328 kg/ha. When catla was cultured alone, they estimated a production of 1193 kg/ha annually.

Table XXXIV

Diseases and their control measures

Disease	Control measures	Authors
Gill rot	5-10 minutes' bath in 3-5% salt solution or in 5 ppm KMnO ₄ solution.	Alikunhi (1957)
Saprolegnia infection	Dip in 3% common salt solution or in 1:2,000 solution of CuSO ₄ , or in 1:1,000 solution of KMnO ₄ for 5-10 minutes, or until fish show distress. Dip for 1 minute in 1:3,000 CuSO ₄ solution once daily for 3-4 days. In laboratory conditions dip treatment for 3 seconds in 1:10,000 solution of Malachite green was found effective.	Hora and Pillay (1962) Gopalakrishnan (1964)
Dye disease	One hourly treatment with Chloromycetin for 2-3 consecutive days, or treatment with 1 ppm KMnO ₄ .	Gopalakrishnan (1962)
Fin rot	Bath for 1-2 minutes in 1:2000 solution of CuSO ₄ . Treatment to be stopped when fish show distress.	Hora and Pillay (1962)
Ichthyophthiriasis	Dip for hourly durations in 1:5,000 formalin solution for 7-10 days, or 2% common salt solution for more than 7 days.	Gopalakrishnan (1964)
Costiasis	10-minute baths in 3% common salt solution or in 1:2,500 formalin solution.	Hora and Pillay (1962) and Gopalakrishnan (1964)
Argulosis	Application of lime in the pond at 0.1-0.2 g per l after all fish are removed, the pond bottom exposed to sun for at least 24 hours before application of lime. Pond treatment with gammexane at a concentration of 0.2 ppm repeated twice or thrice at weekly intervals.	Hora and Pillay (1962) Saha and Sen (1955) and Gopalakrishnan (1964)
Ligulosis	No chemical method yet devised. Partly controlled biologically by the destruction of permanent host.	
Gyrodactylosis	5 minutes' dip in 5% common salt or 5-10 minutes' dip in 1:5,000 formalin solution.	Gopalakrishnan (1964)
Dropay	Treatment with Chloromycetin at a concentration of 60 mg in 4.545 l of water. No food to be given during treatment.	van Duijn (1956)

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SYNOPSIS OF FISHERIES BIOLOGICAL DATA

This is one of a series of documents issued by FAO, CSIRO and USFWS concerning species and stocks of aquatic organisms of present or potential economic interest. The primary purpose of this series is to make existing information readily available to fishery scientists according to a standard pattern, and by so doing also to draw attention to gaps in knowledge. It is hoped that synopses in this series will be useful to other scientists initiating investigations of the species concerned or of related ones, as a means of exchange of knowledge among those already working on the species, and as the basis for comparative study of fisheries resources. They will be brought up to date from time to time as further information becomes available either as revisions of the entire document or their specific chapters.

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FRm/S38	Synopsis of biological data on <i>Ascophyllum nodosum</i> (Linnaeus) Le Jolis. Provisional version	August 1968
FRm/S39	Synopsis of biological data on <i>Monostroma latissimum</i> Wittrock in Japanese cultivation. Provisional version	August 1968
FR/S32 (Rev. 1)	Synopsis of biological data on <i>Catla Catla catla</i> (Hamilton, 1822)	November 1968

