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SYNOPSIS OF BIOLOGICAL DATA ON THE MRIGAL
Cirrhinus mrigala (Hamilton, 1822)

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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SYNOPSIS OF BIOLOGICAL DATA ON THE MRIGAL

Cirrhinus mrigala (Hamilton, 1822)

Prepared by

V.G. Jhingran and H.A. Khan

Central Inland Fisheries Research Institute

(I.C.A.R.)

Barrackpore, West Bengal

India

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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PREPARATION OF THIS SYNOPSIS

The present document was included in the FAO Species Synopsis Series in view of the growing importance of *Cirrhinus mrigala* in fish culture, especially on the Indian subcontinent.

The details set out in this paper are based on data collected by the authors in the course of their personal research work on the species and also on information compiled from various sources, most of which are included in the reference list.

Distribution

Authors
FAO Department of Fisheries
FAO Regional Fisheries Officers
Regional Fisheries Councils and Commissions
Selector SI

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Synopsis. Biological data. Freshwater fish. Taxonomy. Vernacular names. Morphology (organisms). Geographical distribution. Hybridization. Sexual reproduction. Life cycle. Development (biological). Autecology. Population characteristics. Inland fisheries. Fishing gear. Fishing grounds. Fishery regulations. Habitat improvement. Stocking (organisms). Fish culture. Freshwater aquaculture. Pond culture. *Cirrhinus mrigala*. Asia.

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* These items have been omitted in the text as, either no information is available to the authors on them, or they are inapplicable to mrigal, the fish being exclusively a freshwater species.

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1 IDENTITY

1.1 Nomenclature

1.11 Valid name

Cirrhinus mrigala (Hamilton, 1822), Fig. 1
Smith, Bull. U.S. nat. Mus., 188, 1945

1.12 Objective synonymy

Cyprinus mrigala Hamilton, Fish Ganges, pp. 279, 389, pl. 6, fig. 79, 1822 (type-locality : ponds and freshwater rivers of the Gangetic provinces). McClelland, Asiat. Res., 19 (2), pp. 275, 350, 1839; Bengal and Assam.

Cirrhina rubripinnis Valenciennes, Hist. Nat. Poiss., 16, p. 288, 1842; type-locality, ponds in Calcutta.

Cirrhina plumbea Valenciennes, Hist. Nat. Poiss., 16, p. 289, 1842; type-locality, R. Irrawady.

Cirrhina mrigala Valenciennes, Hist. Nat. Poiss., 16, p. 294, 1842; Günther, Cat. Fish. Brit. Mus., 7, p. 35, 1868; Day, J. Asiat. Soc. Bengal, p. 135, 1871; Day, Fish. India, p. 547, pl. 129, fig.4, 1877; Day, Fauna Brit. India, Fish., 1, p. 278, 1889. Shaw and Shebbeare, J. Asiat. Soc. Beng., 3, p. 45, fig. 41, 1937; Siliguri Bazar. De Witt, Stanford Ichth. Bull., 7 (4), p.84, 1960; Nepal. Menon, A check-list of fishes of the Himalayan and the Indo-Gangetic plains, p.24, 1974.

Cirrhinus mrigala Smith, Bull. U.S. nat. Mus., 188, 1945; Mitra and Ghosh, Zool. Ans., 100, p.67, 1932; Misra, Rec. Indian Mus., 57 (1-4), pp.157, 158, text-fig.80, 1959; Srivastava, Fishes of Eastern Uttar Pradesh, p. 35, fig.18, 1968; Ponds in Gorakhpur.

Cirrhinus chaudhryi Srivastava, Fishes of Eastern Uttar Pradesh, p.30, fig.17, 1968; (Synonymised by Dutt and Murty, Bull. Dept. Mar. Biol. Oceanogr. Univ. Cochin, 5 : 39-48, 1971.

1.2 Taxonomy

1.21 Affinities

– Suprageneric

Phylum Vertebrata
Subphylum Craniata
Superclass Gnathostomata
Series Pisces
Class Teleostomi
Subclass Actinopterygii
Order Cypriniformes
Division Cyprini
Suborder Cyprinoidei
Family Cyprinidae
Subfamily Cyprininae
Genus Cirrhinus (Oken) Cuvier (1817)

– Generic

Cirrhinus (Oken) Cuvier, 1817, Règne Animal, 2, ed.1, p.193 (type-species: Cyprinus cirrhosus Bloch).

Cuvier (1817) established the genus with Cyprinus cirrhosus Bloch as the type-species and called this genus Les Cirrhines, since he used only French names for many of his genera. Oken, immediately following the publication of the "Régne Animal", recapitulated Cuvier's Les Cirrhines as Cirrhinus giving it the Latin form. The name was spelled as Cirrhina by Valenciennes (1842), which was accepted by Gunther (1868) and used as such by several other workers. Smith (1945) reverted to the original name Cirrhinus and this was subsequently followed by other workers.

Snout depressed and obtusely rounded, with soft thin covering. Mouth broad, transverse. Upper lip fringed or entire and not continuous with lower lip. Lower lip sharp, without any horny covering and either with or without a thin lip but having a small knob above mandibular symphysis. Barbels small, in two pairs, one pair or none. Gill rakers short. Pharyngeal teeth, plough-shaped, arranged in rows of 5, 4, 2/2, 4, 5. Abdomen rounded. Scales large, small or moderate. Lateral line continuous, passing to centre of base of caudal fin. Dorsal fin short or of moderate length and destitute of osseous rays; its origin in advance of pelvics . Anal short.

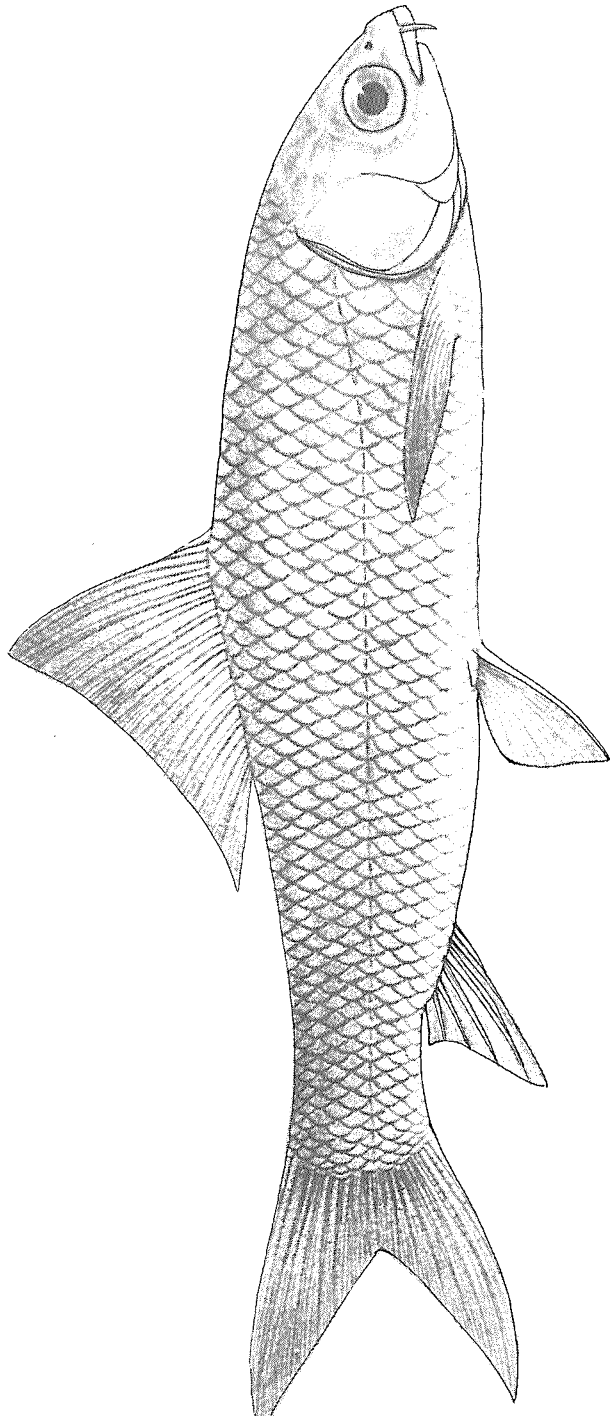

Figure 1 Cirrhinus mrigala (Hamilton)

- Specific

Cirrhinus mrigala (Hamilton, 1822). Gangetic provinces.

Fins: D.15-17(2/3-4/12-13); P.18-19; V.9; A.8(3/5), C.19. Origin of dorsal fin nearer end of snout than base of caudal, height less than depth of body, upper edge concave. Pectoral shorter than head, not reaching pelvic fin which is separated from anal by considerable distance. Anal fin not extending to caudal fin. Caudal deeply forked and is contained 2.8-3.2 times in standard length.

Barbels: A single pair of short rostral barbels.

Lateral line: Complete having 40-45 rows of scales.

Measurements: Depth of body 3.6-3.8, length of head 3.7-4.3 times in standard length, width of head 1.4-1.6 in its length and 0.9-1.2 times in its height. Eye diameter contained 4.9-5.5 times in length of head, 1.0-1.3 times in length of snout, 2.0-2.8 times in interorbital width. Interorbital space flat, snout with or without pores, two pairs of nostrils, gape of mouth contained about 2.5 times in length of head, upper lip entire.

Colouration: Usually dark grey above, silvery beneath, dorsal fin greyish, pelvic and anal orange tipped especially during breeding season.

Distribution: Throughout Northern India, Bangladesh, Burma, Pakistan. Introduced into South India for cultural purpose.

1.22 Taxonomic status

Cirrhinus mrigala is a morpho species

1.23 Subspecies*

1.24 Standard common names, vernacular names

TABLE I

Standard common names, vernacular names

Country	Standard common name	Vernacular name
Burma		Nga-Kyin, Nga-gyin
Bangladesh	Mrigal	2/ Mrigal (Bengali)
India	Mrigal	1/ Mrigal (Assamese, Bengali, Gujarati) Nain, Nainee (Hindi, Urdu) Morahkee (Kutch) Mrigal or Mirga (Marathi) Mirrga, Mirgali (Oriya) Mori (Punjab) Yerramosu, bellala mosu (Telegu)
Pakistan		Naini (North-west Frontier Province, in Hindi) Morakha (Panjabi) Morahkee (Sindhi) Naini (Urdu)
Nepal	Mrigal	Mrigal

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

TABLE II

Meristic counts of Cirrhinus mrigala

B	D	P	V	A	C	L.l.	Ltr.	Vert.	Barbels	Authors
3	15	18	10	7	19+	-	-	-	One pair	Hamilton (1822)
-	16	17	9	7	19	-	-	-	-	McClelland (1839)
-	16	17	9	7	19	-	-	-	-	Valenciennes (1842)
-	15-16	-	-	8	-	42-43	7/9	-	-	Günther (1868)
3	3/15	17	9	2/5	19	40-43	8-9/9	-	-	Day (1869)
3	3/12	15	9	3/5	19	40-43	$6\frac{1}{2}/8\frac{1}{2}$	-	-	Day (1871)
3	15-16(3/12-13)	15	9	8(3/5)	15	40-45	$6\frac{1}{2}$-$7/8\frac{1}{2}$	-	-	Day (1878, 1889)
-	3+12 or 13	-	-	-	-	42-43	16	-	One pair (Lower pair rudimentary or absent)	Beaven (1877)
-	3/12-13	15	9	3/5	15	40-45	-		One pair	Shaw and Shebbeare (1937)
-	15-16(3/12-13)	15	9	8(3/5)	15	40-45	-	-	-	MacDonald (1848)
3	3/12-13	15	9	3/5	19	40-45	$6\frac{1}{2}$-$7/8\frac{1}{2}$	-	-	Misra (1959)
-	16(3/13)	18	9	8(2/6)	15	40-44	$6\frac{1}{2}/6\frac{1}{2}$	-	-	Scrivastava (1968)

1.3 Morphology

1.31 External morphology

Meristic counts of mrigal, as described by various authors, are presented in Table II. Khan (1972) carried out meristic studies of mrigal, obtained from two different environments i.e. from moats and from the Rivers Ganga and Yamuna around Aligarh. According to him, morphometric comparisons of different body measurements revealed a significant difference between the fishes from moats and rivers, while the differences between the fishes of different years of sexes were insignificant. He suggested that mrigal from the two environments belonged to two different stocks

1.32 Cytomorphology*

1.33 Protein specificity
- Results of comparative serology

In the absence of gastric glands in the intestinal bulb, the digestive function is performed by bile and pancreatic juices released in the anterior part of the intestinal bulb. The intestinal fluid has a pH ranging from 6.8-7.1 in the intestinal bulb but shows a decrease to a range of 6.2 to 6.5 in the hind gut under different conditions of starvation and artificial feeding. Protein digestion occurs under pH 7.0-7.1. The digestive coefficient and biological values of proteins at 10% level have been observed to be 92.16% respectively.

Das (1958) carried out haematological studies of mrigal and found average r.b.c., and haemoglobin contents to be 468, 500, 6 400 and 9.25 g respectively. The specific gravity of the blood of mrigal is 1.06. The various physiological characteristics of the blood of the species are presented in Table III. The erythrocytes of mrigal are elliptical in shape with centrally situated nuclei. The mean size of erythrocytes and nuclei are 12.6 μ x 6.9 μ and 6.4 μ x 2.8 μ , respectively.

The biochemical and electrophoretic measurements and densitometric curve for plasma proteins are shown in Table IV and Fig.2. Electrophoretic studies have shown the presence of a third lipoprotein fraction designated as a_F and occurrence of only one band (based on the qualitative analysis of the haemoglobin) in mrigal (Das, 1961).

TABLE III

Packed cell volume (PCV), haemoglobin, sedimentation rate (SR), and clotting time determination: erythrocyte and leucocyte counts on Cirrhinus mrigala (Qayyum and Nasim, 1967).
(Number of fish in parentheses: range - R, mean - M)

	PCV (%)		Haemoglobin (gm)		Erythrocyte (Million)		Leucocyte (thousand)		SR (mm)		Clotting time (seconds)	
	R	M	R	M	R	M	R	M	R	M	R	M
1	2	3	4	5	6	7	8	9	10	11	12	13
Male and female combined	31.0-49.5	38.92 (36)	7.1-11.3	9.1 (36)	1.93-2.69	2.21 (36)	6.0-8.2	7.26 (12)	0.05-0.40	0.186 (23)	40-65	52.5 (8)
Male	31.0-44.0	39.9 (15)	7.8-10.6	9.23 (15)	1.93-2.64	2.33 (15)	6.0-8.2	6.91 (7)	0.08-0.30	0.167 (11)	40-44	42 (2)
Female	32.0-49.5	38.2 (21)	7.1-11.3	9.04 (21)	1.97-2.69	2.22 (21)	7.4-8.0	7.36 (5)	0.05-0.40	0.204 (12)	42-65	53.5 (6)

TABLE IV

Mean and standard deviation of weight, biochemical tests, and electrophoretic measurements of blood of Cirrhinus mrigala (Das, 1961)

Measurement	Mean	Standard deviation
Weight (g)	521.00	201.77
Blood sugar (mg/100 ml)	92.96	9.12
Total plasma protein (g/100 ml) (micro-Kjeldahl)	2.69	0.34
Plasma albumin (%)	44.67	11.80
a_1 plasma globulin (%)	32.59	11.03
a_2 plasma globulin (%)	13.67	9.06
β plasma globulin (%)	5.50	4.31
β plasma globulin (%)	3.58	1.93
a_F lipoprotein (%)	7.17	3.24
a lipoprotein (%)	38.33	8.21
β lipoprotein (%)	54.50	6.96
Plasma albumin (g/100 ml)	1.12	0.65
a_1 plasma globulin (g/100 ml)	0.80	0.42
a_2 plasma globulin (g/100 ml)	0.33	0.26
β plasma globulin (g/100 ml)	0.13	0.08
γ plasma globulin (g/100 ml)	0.09	0.06
Total plasma protein (electrophoresis)	2.47	1.13
a_F lipoprotein (g/100 ml)	0.14	0.05
a lipoprotein (g/100 ml)	0.83	0.46
β lipoprotein (g/100 ml)	1.15	0.49
Total lipoprotein (electrophoresis)	2.12	0.92

Naseem and Siddiqui (1970) studied seasonal variations in organic phosphorus, calcium, total protein, cholesterol and iron contents in the blood serum of mrigal (Table V). They found that the phosphorus content showed a gradual increment from summer (May and June) to early winter (December). During summer, females showed higher values of phosphorus tan males. The Maximum level of Ca in the blood serum of mrigal is found in the first transitory period (October and November) and falls down by 12% in early winter, remains uniform till summer and then shows a further decline in the monsoon period. Males show a higher value of Ca than females in all seasons. The protein content of blood serum shows seasonal fluctuations in mrigal, with the highest values occurring in winter and summer and lowest values in the first transitory period. Maximum values of cholesterol are recorded in the first transitory period. Males and females do not show any marked difference in their cholesterol contents. There is not much seasonal variation in the iron content of the blood of mrigal, though males generally show higher values than females except in summer. Higher alkaline phosphatase values are observed during the post-spawning period when fishes start feeding actively.

Hasan and Jafri (1964) carried out studies on the biochemical composition of the ova of mrigal and reported the following characteristics: colour of the ova, ivory; specific gravity, 1.104; dry matter, 41.984%; moisture, 59.016%; fat, 4.179%; fat (as % of dry matter), 9.953; fat of water, 63.195%; protein, 35.0%; ash, 1.60%; phosphorus, 0.785%; calcium, 8.0 mg/100 g and iron, 32.50 mg/100 g.

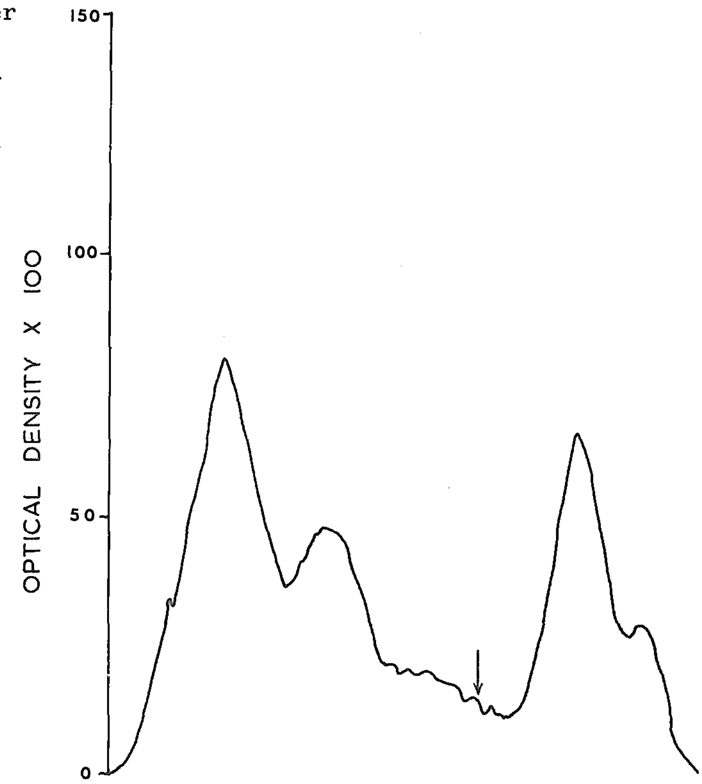

Figure 2 Densitometric curve for plasma protein fraction of mrigal. The albumin fraction and globulin fractions a_1, a_2 β and γ appear when the graph is read from left to right (Das, 1961).

TABLE V

Seasonal Changes in the biochemical constituents in the blood serum of Cirrhinus mrigala
(Naseem and Siddiqui, 1970)

Seasons	Sex	Length range (cm)	Weight range (g)	Alkaline Phosphatase (B.U.)		Phosphorus (mg/100 ml)		Calcium (mg/100 ml)	
				Range	Mean	Range	Mean	Range	Mean
1	2	3	4	5	6	7	8	9	10
Summer	M & F combined	35.4-45.5	365.0-505.0	0.63- 7.12	3.60	7.20- 8.54	7.60	7.30- 9.85	8.65
	Male	35.5-43.5	365.0-485.0	2.90- 7.12	5.96	7.20- 8.00	7.00	7.35- 9.75	8.50
	Female	36.0-45.0	378.0-505.0	0.63- 1.60	1.25	7.86- 8.54	8.20	7.55- 9.85	8.80
Monsoon	M & F combined	36.0-45.5	390.0-495.0	0.43- 1.54	0.87	7.20- 9.40	8.30	6.54- 9.65	8.15
	Male	42.0-45.5	460.0-495.0	1.44- 1.25	0.86	7.20- 9.40	8.30	7.70- 9.65	8.80
	Female	36.0-43.0	390.0-475.0	0.43- 1.54	0.88	7.40- 9.40	8.30	6.54- 8.40	7.50
First transitory period	M & F combined	42.0-62.0	445.0-1685	0.75- 4.08	2.71	7.20-10.85	8.80	7.30-11.50	9.15
	Male	42.0-59.0	445.0-1650	0.80- 4.08	2.45	7.75-10.85	9.05	8.20-11.50	9.60
	Female	42.5-62.0	465.0-1685	0.76- 3.06	2.98	7.20- 9.90	8.54	7.30-10.20	8.70
Winter	M & F combined	42.0-61.0	509.0-2268	4.32-10.52	6.25	8.50-13.20	10.59	7.35-10.00	8.66
	Male	42.5-61.0	504.5-2268	5.20-10.52	6.33	9.60-13.20	11.75	8.20-10.00	9.28
	Female	42.0-61.0	501.0-2268	4.32- 9.18	6.17	8.50-11.50	10.00	8.35- 9.20	8.04

Seasons	Sex	Protein (g/100 ml)		Cholesterol (mg/100 ml)		Iron (mg/100 ml)	
		Range	Mean	Range	Mean	Range	Mean
1	2	11	12	13	14	15	16
Summer	M & F combined	1.32-3.44	2.960	205.0-350.5	256.25	27.71-36.85	35.15
	Male	1.32-3.02	2.940	205.0-350.5	275.00	27.71-36.25	34.76
	Female	1.38-3.44	2.980	207.5-320.0	237.50	29.05-36.85	35.53
Monsoon	M & F combined	2.37-3.17	2.790	215.5-305.5	256.14	26.25-37.85	50.74
	Male	2.54-2.94	2.740	215.5-387.0	241.00	26.25-37.85	31.02
	Female	2.37-3.17	2.830	218.0-425.0	271.27	28.78-35.05	30.55
First transitory period	M & F combined	1.20-2.25	1.615	155.0-875.0	356.13	28.02-34.47	32.24
	Male	1.32-2.25	1.725	150.0-575.0	408.00	28.02-32.33	31.00
	Female	1.20-2.06	1.500	155.0-875.0	304.26	30.02-34.47	33.48
Winter	M & F combined	2.54-4.05	3.010	262.0-502.0	334.39	26.78-32.91	29.50
	Male	2.64-4.05	3.210	318.0-405.0	326.00	27.72-32.91	30.49
	Female	2.54-3.93	2.800	262.0-502.0	342.76	26.78-30.55	28.52

2 DISTRIBUTION

2.1 Total area

Day(1878, 1889) mentioned that mrigal inhabited rivers and tanks in Bengal, Deccan, North-West Provinces, Punjab, Sind, Cutch and Burma. Alikunhi (1948) recorded its occurrence in the Godavari and the same author in 1957 mentioned the distribution of mrigal in the major river systems of India as far south in the Godavari. However, the fish is more common in the plains of Northern India. Misra (1959) gave the distribution of the fish in India : river and tanks in West Bengal, Darjeeling district, Eastern Himalayas, East Punjab, Uttar Pradesh, Western Himalayas, Madras, Deccan, Bombay (introduced), Ahmedabad, Cutch; in Pakistan : rivers and tanks in West Punjab; in Bangladesh (formerly East Pakistan) and Burma. The fish has also been recorded from Nepal (De Witt, 1960).

Mrigal fry from Bengal were regularly introduced into Madras waters, including the Cauvery, from 1943 to 1947, and from Orissa in 1949 (Thyagarajan and Chacko, 1950). The Maharashtra Fisheries Department, Bombay, obtained this carp from Patna and introduced them into the Powai lake, where it has been reported to have bred (Kulkarni, 1947). David (1963) reported transplantation of mrigal in the lower reaches of the Godavari and the Krishna where the fish has established itself. The species has also been introduced in the Mettur reservoir, where it forms a lucrative fishery. However, because of successful transplantations, mrigal has now spread over whole of Peninsular India.

Mrigal is reported to have been transplanted to Sri Lanka, where it is believed not to have thrived. Mrigal fry and also rohu have been exported to Mauritius, Blantyre (Africa); Tokyo (Japan); Penang, Malacca and Sarawak (Malaysia); Nepal; Manila (Philippines); Moscow (USSR) and Norton (South Rhodesia) by M/s Fish Seed Syndicate, Calcutta. For details refer to Khan and Jhingran (1975).

Fig. 3 shows the geographical distribution of mrigal. Table Va gives the rivers and lakes from which mrigal has been reported according to the literature.

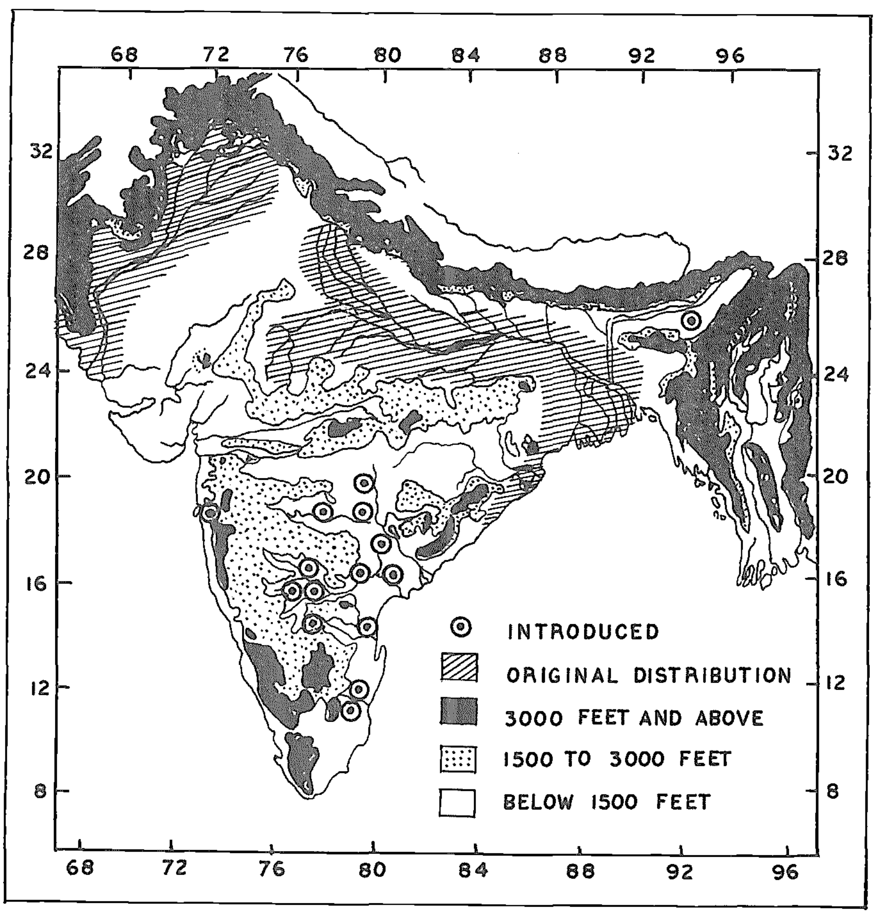

Figure 3 Geographical distribution of mrigal

TABLE Va

Distribution in river and lakes*

Habitat	Burma	India					Bangla-desh	Pakistan
		Ganga River System	East Coast River System	West Coast River System	Brahmaputra River System	Indus River System		
Rivers and important tributaries	Irrawaddy	Ganga	Mahanadi	Narmada	Brahmaputra	Indus	Padma and its tributaries	Indus and other rivers of plains
	Myintze	Yamuna	Godavari	Tapti	Kalang	Sutlej		
	Pan-Hlaing	Ghaghra	Krishna	Mahi	Burhi Dhing	Beas		
	Sittang	Gomati	Cauvery	Sisodra	Dhansiri			
		Rapti		Sabarmati	Dhiko			
		Sarda						
		Ramganga						
		Kosi						
		Son						
		Damodar						
		Chambal						
		Betwa						
		Ken						
Lakes	Indawgyi	Ranchi	Kolleru	Powai				
		Lower Bhopal		Bokh				

* Only such rivers have been mentioned from where mrigal has been especially reported in ichthyological literature.

2.2 Differential distribution

2.21 Spawn, larvae and juveniles

In natural open waters, mrigal breeds during the south-west monsoon in shallow pockets in marginal areas, in fields adjacent to the rivers which are flooded after heavy showers and in bundhs where riverine conditions are simulated. Spawning grounds are found along 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. Breeding in bundhs takes place in shallow marginal areas or flood fields. The depth at the spawning spot may vary from 0.5 to 1 m. Spawning occurs over hard or sandy or muddy soil and even on rocky embankments. When spawning is over, a thick blanket of fertilized egg is left over spawning site. Eggs of mrigal are non-adhesive and non-floating. Eggs hatch into larva within 16 to 24 hours depending on water temperature. Eggs and hatchlings drift along with the receding flood water in the main flow and are collected from rivers in especially made fry nets. Hatchlings generally remain in surface or subsurface waters, while fry and fingerlings show a tendency to move to deeper waters.

2.22 Adults

Mrigal thrives well in all fresh waters below an altitude of c. 549 m (Motwani, unpublished). The temperature seems to contribute to the limit of distribution of mrigal in rivers Ganga, Yamuna and Sarda in Uttar Pradesh. A temperature of 14°C appears to be the minimum tolerated by mrigal. Mrigal is a bottom dweller. Larger fish generally frequent deeper water but they also move into shallow water for feeding. During the south-west monsoon, mrigal migrates to breed in shallow recesses in the marginal areas and in flooded fields adjacent to the rivers. The fish also breeds in shallow marginal areas of bundhs on flood fields. Depth at the spawning spots may vary from 0.5 to 1 m.

2.3 Determinants of distribution changes

Sudden changes in ecological determinants may prove lethal to spawn, hatchlings, fry etc. Any abrupt rise or fall in water temperature, fall in the water level and depletion of oxygen in water caused by decaying organic matter adversely affect developing eggs, hatchlings, spawn, etc. When heavy rains occur, causing appreciable quantities of silt to be washed down over the spawning ground, the developing eggs are soon smothered by the fine silt settling over them. Other ecological determinants are mentioned in sections 3.16, 3.22, 3.33, 3.34 and 3.35.

2.4 Hybridization

2.41 Hybrids

A large number of intergeneric hybrids have been produced at Cuttack Pond Culture Division of the Central Inland fisheries Research Institute (Chaudhuri, 1959a, 1971). These are:

Male parent species	Female parent species	Hybrids
Catla catla	Cirrhinus mrigala	Catla-mrigal
Labeo rohita	C. mrigala	Rohu-mrigal
C. mrigala	L. rohita	Mrigal-rohu
C. mrigala	L. calbasu	Mrigal-Kalbasu

The first generation hybrids of male mrigal and female rohu were produced in 1958. Hamsa,N. (1971 reported that the fertile hybrid between male rohu and female mrigal could be popularly called "mrighu", deriving the new name from its parents. The hybrid has a deeper body than either of its parents, while the head is bigger than mrigal but smaller than rohu (Hamsa, N. 1971). Most of the body characteristics of offspring produced by crossing reciprocal hybrids - rohu-mrigal and mrigal-rohu were intermediate between those of the parents. Both types of hybrids matured fully in two years (Chaudhuri, 1971). Hybrid mrigal-kalbasu have a slightly fringed lower lip and 2 pairs of prominent black barbels (Chaudhuri, 1971). The colour of the body was intermediate between the species. Some male hybrids produced were observed to have matured in one year (Chaudhuri, 1973). In August 1960, two-year old, fully mature specimens of mrigal-rohu and rohu-mrigal hybrids were examined. Males were mostly in the oozing condition (Chaudhuri, 1973). The first generation of fully mature mrigal-Kalbasu female hybrids were successfully spawned by hormone injection and crossed with males of catla, kalbasu and mrigal and the following hybrids were produced.

Male parent species	Female hybrids	Hybrids
Catla catla	mrigal-kalbasu	catla-mrigal-kalbasu
Labeo calbasu	mrigal-kalbasu	kalbasu-mrigal-kalbasu
Cirrhinus mrigala	mrigal-kalbasu	mrigal-mrigal-kalbasu

A few males of these hybrids were reported to have attained maturity in one year (Chaudhuri, 1973).

Chaudhuri (quoted by Hickling, 1968) crossed male Ctenopharyngodon idella with female Cirrhinus mrigala in 1963 and 1965 and found that 95% of the eggs hatched but showed abnormal growth and died within a few days.

2.42 Influence of natural hybridization in ecology and morphology

Natural hybridization seldom takes place. Artificially produced hybrids are generally intermediate in character as in the parent species.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.11 Sexuality

Mrigal is heterosexual. Sex differentiation is possible only when ripe females show a fully bulged and soft abdomen with a slightly swollen, reddish vent. On being slightly pressed at the abdomen, the mature male exudes milt freely and the female releases eggs. According to Mookerjee (1938), during the breeding season, in West Bengal, the male mrigal has its pectoral fins bigger than anals, whereas in the female they are equal to the anals. Khan and Hussain (1954a) studied the secondary sexual characters of mrigal in Punjab and stated that male mrigals of the same size have their pectoral fins better developed and larger than the anal fin; whereas in females the pectoral fin is smaller than or equal to the anal. In a few females they found pectorals larger than the anal, but the former are always less developed when compared with those in male mrigal of the same size. Chaudhuri (1959b) studied 23 male and 32 female specimens of mrigal and inferred that the pectoral fins in mature males have a rough dorsal surface, and when extended backwards and towards the dorsal side of the body touch the 10th or 11th lateral line scale. In the case of mature females, the pectoral fin is smooth on its dorsal side and reaches the 8 or 9th lateral line scale. Chakrabarty and Singh (1963) reported that the pectoral and pelvic fins of males are larger than those of females, and their dorsal fins measured higher than those of females. They also observed slight disparity in size between the fins of right and left sides in both sexes; at times the right fins being larger and sometimes vice versa. The relationship between the right pectoral fin and total length of the fish could be expressed by the equation:

$$P = -8.74 + .10877 \text{ Length (Males)}$$
$$P = -0.370 + .12890 \text{ Length (Females)}.$$

3.12 Maturity (age and size)

Mrigal is reported to have attained its first maturity when about one year old (Hora and Pillay, 1962), and about two years old (Khan, 1934; Alikunhi, 1957). According to Chacko and Ganapati (1951), the males mature at the end of the first year and females some time later. With regard to the average size at maturity of mrigal, according to Chakrabarty and Singh (1963), the length/weight relationship curves for the males and females intersect at at point lying between 600-700 mm. Hanumantharao (1974) reported the first maturity of mrigal at a length of 349 mm, when the fish is +2 years old. Sukumaran (1969) mentioned that induced-bred one year old mrigal of both sexes were found to be sexually mature in 2 ponds at Killa Fish Farm of Central Inland Fisheries Research Institute located at Cuttack, and they weighed 240 g and 278 g, respectively, in both ponds. The minimum age of mrigal at first maturity, in waters around Aligarh, has been reported to be 2 years for males and 3 years for females (Khan, 1972). The different maturity stages of gonads and seasonal changes in their condition in mrigal follow the same pattern as that of Labeo rohita (refer to Khan and Jhingran, 1975). Gonads began to increase in March, reached their peaks in June, and female spent individuals were observed during July and August. Khan (1972) stated that all males were mature at age 4 while all females were mature at age 5. The smallest mature individuals recorded were 502 mm (males) and 550 mm (females). Males were found to mature 11%, 32%, 70%, 97%, and 100% at the length group of 500 mm, 550 mm, 600 mm, 650 mm, and 700 mm respectively, while females were found to mature 0%, 10%, 30%, 75% and 96% at respective lengths, and 100% maturity was observed at 750 mm .

3.13 Mating

The female mrigal is often chased by two or three or several males (Khan, 1934; Alikunhi et al., 1964a) or vice versa is also observed (Khan, 1934). Disparity in the size of the mating pair is often observed, and females are generally begger than males.

3.14 Fertilization

Fertilization is external, being the same as in catla (Jhingran, 1968) and Labeo rohita (Khan and Jhingran, 1975).

3.15 Gonads

Khan (1934) observed the fecundity of mrigal to vary from 124,800 to 1,905,000 in specimens weighing 904 g and 4,503 g respectively. Chaudhuri (1963) recorded that maximum number of eggs released by a mrigal, weighing 4.76 Kg, were 11.64 lakhs. According to Alikunhi et al. (1964b), about 1-2 lakhs of eggs are produced per kg weight of female mrigal. In mrigal reared in ponds, the average number of eggs per kg body weight was found to range from 1.44 to 1.52 lakhs (Central Inland Fisheries Research Institute, Barrackpore, annual report 1964). Table VI shows fecundity of mrigal collected from ponds at Cuttack.

TABLE VI

Fecundity of mrigal from ponds at Cuttack (quoted by Sukumaran,1969)

Length range (mm)	Weight range (Kg)	Average weight of ovary (g)	N°. of eggs (average)	Average diameter of ova (mm)
400-450	0.5-1.0	90	100 900	1.035
450-500	1.0-1.5	130	130 000	1.08
500-550	1.5-2.0	160	192 000	1.08
550-600	2.0-2.5	320	320 000	-
600-650	2.5-3.0	325	389 000	-

The fecundity of mrigal from the riverine environment has also been studied. Sarkar and Kaushik (1959) estimated 58 649 eggs in a specimen weighing about 1 812 g caught from River Yamuna at Delhi in the month of December. Chakrabarty and Singh (1963) have recorded the total fecundity in mrigal to range from 463 671 to 1 809 536. Table VII shows fecundity of mrigal collected from River Yamuna at Allahabad. Khan (1972) reported that fecundity of mrigal varied between 16.302 to 263 510. Fecundity was found to be directly related to weight and to the 3.215 power of body length.

3.16 Spawning

- Number of spawnings per year

According to Qasim and Qayyum (1962), mrigal contains a single group of maturing eggs in the ovaries and spawns once a year in a single act. The process of egg deposition is repeated till the female is spent (Khan, 1943; Alikunhi et al., 1964b). Khan (1972) while confirming the findings of Qasim and Qayyum (1962) stated that the size of oocytes was not found to increase up to March, but in April the size started to increase. The maximum size of ova was recorded during June. Spawned fishes were found to contain either few or no mature ova in the ovary during post-spawning months. The size of

TABLE VII

Fecundity of mrigal collected from River Yamuna at Allahabad (Chakrabarty, Quoted by Sukumaran, 1969)

Wt. of fish (g)	Wt. of ovary (g)	Av. No. of eggs per gram of ovary	Individual fecundity	Relative fecundity	Average diameter of mature eggs (mm)
5897	745	1 481	1 103 025	187	1.196
5897	125	1 453	181 685	31	0.940
6971	373	1 873	685 201	99	1.106
7031	349	1 309	456 682	65	1.065
7144	1 506	1 194	1 798 164	252	1.342
7711	818	800	654 515	85	1.097
13013	2 144	844	1 809 536	139	1.406

Hanumantharao (1974) estimated fecundity of 40 mature mrigal from River Godavari and reported it to range from 75 900 to 1 123 200 in specimens measuring 349 mm to 810 mm in length. The relationship between fecundity (F) and total length (L) in mrigal was derived by him as:

$$\text{Log } F = -1.2225 + 2.4683 \text{ Log } L$$

Table VIII shows fecundity of mrigal estimated for different age groups. The fecundity was found to be maximum between 5-7 age group.

TABLE VIII

Average fecundity of mrigal from River Godavari for different year classes (Hanumantharao, 1974)

	Age (year)					
	II	III	IV	V	VI	VII
Fecundity (lakhs)	1.60	2.89	5.64	5.96	7.44	8.14

mature ova varied from 0.92 mm to 1.10 mm. At Cuttack Pond Culture Substation of the Central Inland Fisheries Research Institute, mrigal, like other major carps, has been induced to breed twice within the same spawning season after an interval of 2 months (Central Inland Fisheries Research Institute, Barrackpore, Annual report 1972).

- Spawning seasons

The spawning season of mrigal depends upon the onset and duration of the monsoon. It coincides with the south-west monsoon in India, Bangladesh and Pakistan. The duration of the spawning season varies in different regions of the sub-continent, shown as follows:

Authority	Spawning season	Locality
Khan (1934, 1942, 1945)	July and August	Punjab
Mookerjee (1945)	June-July	West Bengal
Rahman (1946)	April-June	Chittagong (Bangladesh)
Ahmad (1948)	April-July	Chittagong (Bangladesh) Rivers Halda and Karnafuli
Chacko and Ganapati (1951)	July-September	South India (The Godavari and Krishna)
Alikunhi (1957)	June-August	-
David (1959)	April-August and September	Ganga river system (depending upon floods in each region); Western Uttar Pradesh
Jhingran (1959)	June-August	Northern India (River Ganga)
Dubey and Tuli (1961)	During South-West monsoon from the end of June	Madhya Pradesh
Qasim and Qayyum (1962)	July-August	Western Uttar Pradesh (Rivers: the Ganga, Yamuna and Kali)
Chakraborty and Singh (1963)	June-August	Allahabad (River Yamuna)
Alikunhi *et al.* (1964)	Mid May to end of August	Different parts of the country
Gopalakrishnan *et al.* (1964)	July	Tilaiya and Panchet reservoir
Khan and Kamal (unpublished)	June	North Bihar (Kosi Khanua Dhar) a tributary of River Kosi

- Spawning time of day

The spawning of mrigal has been observed to begin during the night or in the early hours of the morning and it continues through the afternoon (Khan, 1943). Dubey and Tuli (1961) reported spawning of mrigal at noon, and differed from Ahmad (1955) in believing that celestial bodies, such as the moon, have any effect on spawning. Alikunhi et al. (1964b) mentioned that active spawning of mrigal took place in the morning and lasted until the evening. Gopalakrishnan et al. (1964) observed breeding of mrigal along with other carps at the head waters of Tilaiya reservoir during the night and continuing till next evening.

- Factors influencing time, temperature runoff, photoperiod, lunar or tidal cycles, size, age, latitude, altitude

No single critical factor can be assigned to be responsible for spawning. The act involves fulfilment of a chain of interrelated conditions as a prerequisite to spawning. 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. However, the availability of shallow spawning grounds, sufficient depth of water so as to enable the fish to swim to and from the spawning ground, still water or moderate to fast currents at the breeding site, the optimum temperature at the spawning ground ranging from 22 to 31°C, cloudy days accompanied by thunderstorm and rain, etc. are believed to be factors influencing spawning of mrigal. Other factors like high pH and high oxygen content of water are a necessary corollary to floods and are not essential in themselves for spawning. Flooding in the early phase of the south-west monsoon is necessary and the fish do not spawn if rains are delayed (Ganapati and Chacko, 1954). Spawn prospecting investigations carried out by the Allahabad Substation of the Central Inland Fisheries Research Institute, revealed that generally major carp spawning occurred intensively in the Indo-Gangetic plain in the middle and later parts of the monsoon, rather than its commencement or the terminal phase. For further details refer to Jhingran (1968).

Sinha et al. (1974) opined that spawning failure in confined waters is presumably due to reduced accumulation of gonadotropin in the pituitary. Thus the additional amount of exogenous pituitary material in induced spawning may enhance the rate of ion/water transport especially to the gonad resulting in its final maturation. In natural spawning, on the other hand, there may be a sudden drop in the electrolyte levels in the ambient water, which may induce hydration of the fish, as a whole, till a new equilibrium between fish and its outer medium is reached. It is this interval that is critical for spawning and those fish which are sexually mature may start spawning then. Also, the gonadotropic content of the pituitary of freespawners is considerably higher than that of the pituitary of nonspawners.

- Location and type of spawning grounds

Mrigal breeds in rivers, and in reservoirs and bundh type tanks where fluviatile conditions prevail during the monsoon. The nature of spawning grounds of mrigal have been described in Table IX.

TABLE IX

Characteristics of spawning grounds of mrigal

Spawning grounds	Locality	Authority
Hard and gritty beds with a gradually sloping bottom; shallow areas	Bundhs of Midnapore (West Bengal) and Singhabhum (Bihar)	Gosh and Gosh (1922)
Innundated fields adjoining flooded streams	Riverine habitat in Punjab	Khan (1924)
Shallow areas	Bundhs of Midnapore (West Bengal)	Mookerjee *et al.* (1944)
Shallow spawning grounds	Godavari and Krishna rivers (South India)	Chacko and Ganapati (1951)
Shallow areas adjacent to a nallah covered with grass (*Vitiveria indica*)	Garua nallah off River Betwa, Bhopal (Madhya Pradesh)	Khan (1959)
Interlacing channel systems of rivers Kosi and Burhi Gandak	Riverine habitat, Bihar	David (1959)
Hard and sandy soils and even rocky embankments in several tributaries of Chambal river, and in Bundh type tanks	Riverine habitat, reservoir and bundhs of Madhya Pradesh	Dubey and Tuli (1961)
Shallow margins of bundhs with muddy soil	Bundhs in Madhya Pradesh	Alikunhi *et al.* (1964b)
Shallow and sandy marginal areas	Tilaiya reservoir	Gopalakrishnan *et al.* (1964)

- Ratio and distribution of sexes on spawning grounds

Two or three males or even more to one female is the usual ratio in the breeding grounds, but the reverse has also been observed. Rarely is a single couple seen.

- Nature of mating act

The mating behaviour of mrigal is similar to that of other major carps including catla. 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. In this posture mating occurs with vigorous splashing of water. The sex play lasts for a short time. The coiling and interwining of the two sexes exerts pressure on the abdomen of the mating pair, resulting in the extrusion of the ova and release of the milt. All eggs are not laid at one place and at one time, but at intervals during which the pair keeps on moving.

- Induction of spawning

In India, the first unsuccessful attempt to induce spawning in mrigal, was made by Khan (1938) by injecting anterior mammalian pituitary hormone in 1937. Husain (1945)found it easy to strip female mrigal by administering 80-120 RU Prolan and Antuitrins but failed to fertilize their eggs. It was only in 1957 that, for the first time, success was achieved at the Central Inland Fisheries Research Institute in inducing a pair of mrigal to breed by injecting with carp pituitary (Chaudhuri and Alikunhi, 1957; Chaudhuri, 1960). From 1968 onwards, induced breeding of mrigal has been carried out on a large scale in different parts of the country. The breeding technique by hypophysation in the case of mrigal is the same as that adopted for catla and rohu. For further details reference may be made to Jhingran (1968) and Khan and Jhingran (1975).

In 1969, the FAO/UNDP regional seminar on "Induced breeding of cultivated fishes" was held during 15 July to 18 August, at Barrackpore, Cuttack and Bombay, and various aspects related to the subject were discussed. In 1971, a workshop on Induced breeding of carps was held at Bombay and the results reported by different workers are summarized in Table X. Anand (1973) successfully induced bred 36 mrigal during the period 1964 to 1968 at various centres in Uttar Pradesh. Out of these, 33 mrigal responded to the first injection and the rest spawned after receiving a second injection. The average number of ova per kg body weight laid by female mrigal was 1.93 lakhs as compared with that of rohu 2.59 lakhs. The average number of ova discharge per gram loss in body weight of mrigal was 917, while in rohu it was 1000. At Gujartal Fish Farm in Uttar Pradesh, Khan and Mishra (1975, unpublished) successfully bred several sets of small-sized (360-435 mm) pond reared two year old mrigal with only one injection to the females. Mrigal has also been successfully induced bred by pituitary injection in Pakistan (Khan and Bhatti, 1967) and Burma (FAO, 1971).

Alikunhi et al.(1964b) succeeded in inducing three pairs of mrigal in the laboratory under controlled temperature and other conditions by injecting females with a preliminary dose of 2 mg per kg body weight followed by second dose of 5 mg per kg body weight after $4\frac{1}{2}$ hours. The males received a dose of 3 mg per kg body weight at the time of the second injection to the female. Bhowmick and Kowtal (1973) described a simplified technique of hypophysation of Indian major carps in which fresh pituitary glands from donors of the comparable size to the recipients were macerated in distilled water in a homogenizer or in a morter/test tube/porcelain basin and the homogenated liquid was used in the fresh condition. By this technique they obtained more than 80% success.

An interesting case of spawning in confinement has been reported by Ranganathan et al. (1970). Two pairs of Labeo rohita were kept in hapa fixed in a cement cistern and injected on 9 July, 1966 with fish pituitary. Three pairs of untreated mrigal were also confined outside the hapa in the same cistern. The next day it was discovered that both rohu and mrigal had spawned.

For further details of induced breeding refer to Jhingran (1968), Bardach et al. (1972), Khan and Jhingran (1975) and Jhingran (1975).

TABLE X

Results reported by different workers on the induced breeding of *Cirrhinus mrigala* during 1971 in various Indian States

Name of centre/stats	Dose of injection given (mg/kg)		No. of trials made		Average weight of spawned fish (kg)	Number of eggs laid		Hatching hapa		No. of spawn obtained (lakhs)	Authority
	1st injection	2nd injection	Successful	Failure		Fertilised (lakhs)	Unfertilised (lakhs)	size (m)	No. of eggs per hapa (lakhs)		
1	2	3	4	5	6	7	8	9	10	11	12
Andhra Pradesh											
Regional Fish Seed	F 6	12	28	31	1.15	44.8	32.7	1.8x0.9x0.9	0.6	6.4	Frishna (1971)
Farm, Hyderabad	M 2	5									
Assam											
Cachar (Gandhibag)	F 1	2	4	-	0.5	1.3	0.7	3x1x1	0.35	0.4	Das (1971)
	M 2	5									
Cachar (Bihara)	F 1	2									
	M 2	5	2	1	0.8	1.5	0.5	3x1x1	0.5	1.1	-do-
Gauhati	F 2-3	6-8	28	7	1.5	78.34	22.05	1.5x1.4x1	1.0	56.39	-do-
	M 1-2	3-4									
Roha	F 2-4	6-8	9	3	2.0	22.3	10.87	1.5x1.4x1	0.1-1.0	14.90	-do-
	M 1-2	3-4									
Gujarat											
Dantiwada	F 3	5	5	1	4.0	14.40	13.90	1.5x0.75x0.45	0.25-0.5	11.50	Panicker (1971)
	M -	3									
Kerala											
Malampuzha	2	4	17	11	0.8	10.00	4.00	1.4x0.6x0.4	8.45	5.65	Meeran and Sebastian (1971)
Nayyar	2	4	1	-	1.0	0.12	0.60	-do-	0.45	0.08	
Pannivelichira	2	4	6	2	0.7	3.5	0.50	-do-	0.45	2.75	
Madhya Pradesh											
Patra	F 3	6	10	9	0.79	8.02	2.14	1.17x1.07x0.78	0.5	0.44	Bhatia (1971)
	M -	3									
Maharashtra											
Fish seed	F 3-4	6-8	41	22	0.8	15.27	3.81	1.65x0.75x0.4	1.0	1.8	Joshi (1971)
Farm, Aarey	M 3-4	-									

Table X continued

1	2	3	4	5	6	7	8	9	10	11	12
Mysore											
Vanivilasapura fish farm	4.3	4.5	36	54	1.15	26.32	20.17	2x1	0.4-0.6	19.95	Prasad (1971)
Tungabhadra Board Fish Farm (Bellary district)	2	3	46	86	3.5	70.8	52.39	1.5x0.75x0.75	0.6-0.8	41.6	Chandrasekhar (1971)
Orissa											
Sambalpur	2-3	5-8	11	4	1.4	9.0	2.0	1.25x0.75x0.3	0.4-0.7	4.0	Panda (1971)
Panjab											
Patiala	2-3	5-10	16	5	1.48	27.0	10.8	1.5x0.9x0.3	0.75-1.0	3.48	Malhotra (1971)
Rajasthan											
Kaithan Farm	3	6-8	3	2	2.5	9.21	1.03	1.5x0.75x0.75	0.5	6.0	Chaturvedi and Shukla (1971)
Tamil Nadu											
Bhavanisagar	2	6	31	106	2.0	3.0	0.5	-do-	0.75	62.0	Menon et.al.(1971)
Mettur Dam	3	6	36	68	1.75	3.0	0.75	-do-	0.75	62.0	
Vaigi	2	6	10	78	2.0	3.25	0.75	-do-	0.70	22.0	
Thanjavur	2	6	38	112	1.0	1.5	0.20	-do-	0.70	50.0	
Poondi	2	8	18	12	1.0	1.5	0.10	-do-	0.70	16.0	
Manimuthar	2	7	48	69	1.5	1.5	0.25	-do-	0.70	70.0	
Maravathy	3	6	2	23	1.5	2.75	0.25	-do-	0.5	2.5	
Sathanur Dam	2	5	39	11	2.0	4.0	0.5	-do-	0.5	203.4	
Tripura											
Udaipur	0.5-0.70	3.5-4.8	42	1	1.25	43.20	13.80	1.1x1.6x0.9	1.20	31.60	Ghosh (1971)
Agartala	2	3-4	6	7	1.5	17.95	5.4	-do-	-	11.35	
Uttar Pradesh											
Saroorpur	6-10	8-12	9	4	1.5	7.18	7.62	1.05x0.75x0.45	0.5-0.7	3.06	Chitravanshi and Verma (1971)
Chaubepur	2-5	5-10	19	14	1.2	9.12	9.08	-do-	-	6.48	
Tharaon	2-3	5-8	20	29	0.70	13.12	4.98	-	-	7.145	
Banki	3	6-8	21	78	0.60	15.18	7.36	1.05x0.75x0.45	0.20	7.79	
Gujarat	3-4	8-12	14	1	0.60	4.13	5.04	2.4x1.2x0.75	0.20	1.25	
West Bengal											
Jaunput	2	6-8	8	3	0.86	1.901	0.339	1.25x0.6x0.45	0.55	1.98	Sen Gupta (1971)
Krishnagar	3-8	6-20	31	12	1.36	32.08	18.35	1.2x0.76x0.45	0.25-1.12	6.1	Bhattacharya(1971)
Jaunput Fish Farm	F 1 M nil	9-15 3-8	2	-	0.45	1.85	0.15	1.5x.75x0.45	0.5-1.0	0.42	Singh and De(1971)

3.17 Spawn

Fertilized eggs of mrigal are spherical, transparent , non-adhesive, non-floating and are rather reddish in hue. Fully fertilized eggs, after they become water hardened, are 4.5-6.0 mm (Khan, 1943), 5.5 mm (Mookerjee, 1945 and Mazumdar, (1957), 5.0 mm (Chaudhuri, 1960) and 4.5-5.5 mm with an average of 5.0 mm (Chakrabarty and Murty, 1972) in diameter.

3.2 Pre-adult phase
(Defined as from fertilization of egg to sexual maturity)

3.21 Embryonic phase
(Defined as from fertilization to hatchling, i.e. during incubation period)

The developmental features of fertilized eggs of mrigal are given in Table XI.

3.22 Larval phase

The newly hatched larva varies in length from 3.4 to 4.8 mm (Khan, 1943). Chakrabarty and Murty (1972) reported its length ranging from 4.08-4.32 mm with an average of 4.20 mm. It is almost transparent and colourless and performs vertical movements initially, which later change to darting movements for the capture of good organisms. The mouth is not yet formed (Fig. 5.1). The pulsation of the heart gets visibly more pronounced. The tail is elongated further. The yolksac is produced posteriorly, its point of termination lying close to a slight depression on the ventral surface of the body, which is the future anal aperture. The narrow portion of the yolk is greater in length than the bulbous part. Yolk is more or less club-shaped. Twenty-eight pre-anal and 14 post-anal myotomes are seen in most of the hatchlings at this stage of development (Chakrabarty and Murty, 1972). The gills have not yet appeared. An embryonic fin-fold is present but the fins are not yet formed. Table XII gives some of the important characteristics of mrigal hatchlings at various ages.

The post-larva, after full absorption of the yolksac, measures 6.3-6.6 mm (Khan, 1943), and 7.38 mm according to Chakrabarty and Murty, 1972. Deep black chromatophores are present on the head. A few chromatophores are also present on the dorsal fin rudiment. The dorsal side of the body is distinctly yellowish. Black pigmentation below the tip of the notochord appears confined to a more or less semi-circular area. Caudal fin rays start forming (Chakrabarty and Murty, 1972). Khan (1943) reported that by the end of the fourth day 6-7 caudal fin rays appear. The pectoral fin is prominent. The dorsal fin starts separating from the embryonic fin fold. Lips are thin at this stage (Chakrabarty and Murty, 1972).

The different stages in the larval development of mrigal are shown in Table XIII and Figs. 5-6.

- Rates and periods of development and of survival and factors affecting these, including parental care, parasites and predators.

As in Catla catla (refer to Jhingran, 1968) and Labeo rohita (refer to Khan and Jhingran, 1975). Survival of hatchlings during the first 15 days of rearing in nursery ponds depends upon the special preparation of these waters, which includes removal of predatory and trash fishes and insects, drying, liming and manuring, aimed at sustained production of zooplankton to serve as food to achieve a rapid growth of the fry. Within 2-3 days after stocking, the natural fish food available in the nursery often becomes low, as the hatchlings subsist completely on natural food during the period. After this period, artificial feed along with the natural food enhances the growth and survival of fry considerably. Table XIV shows the survival and production of fry during the first 15 days of rearing.

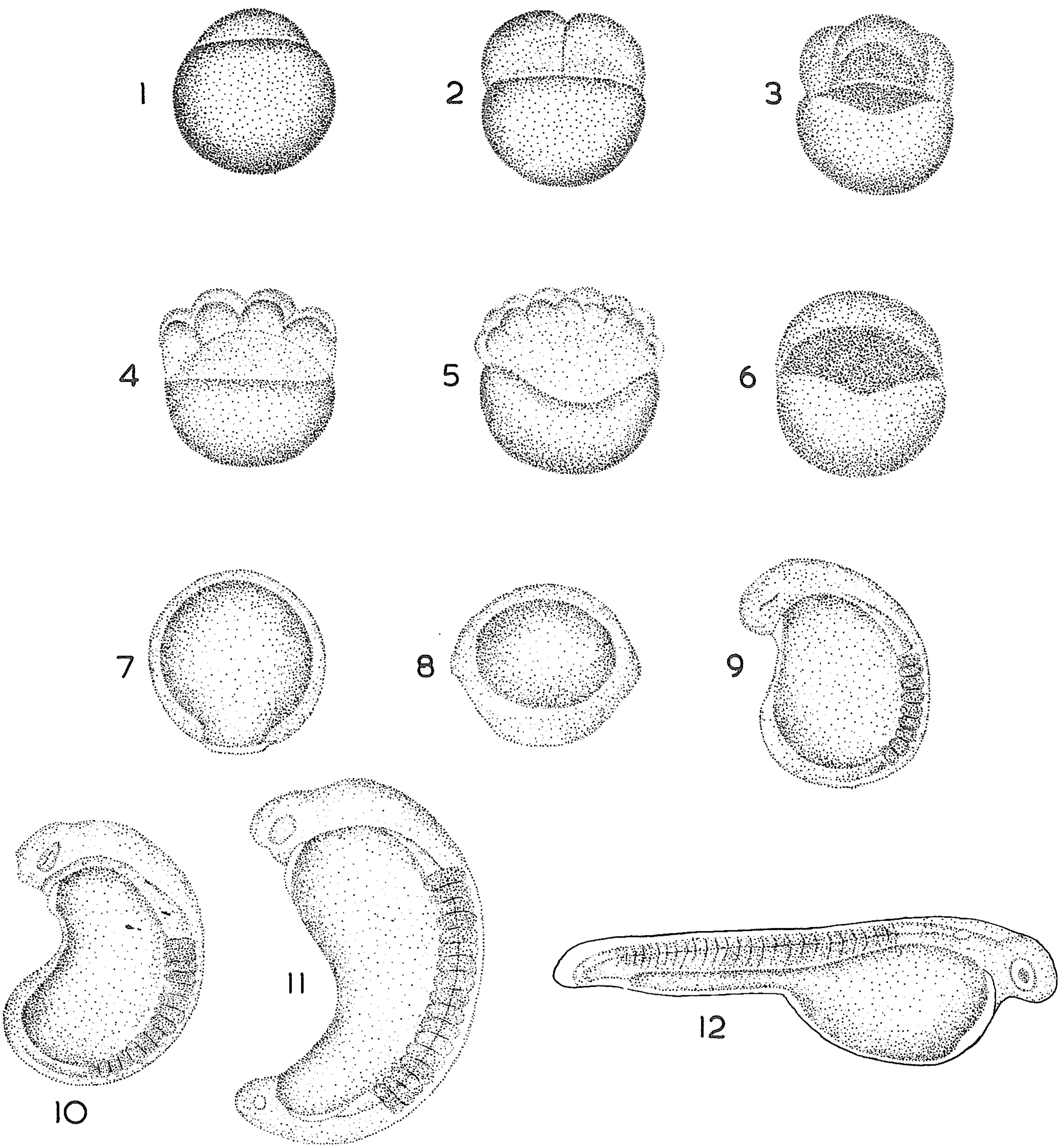

Figure 4 Embryonic development of Cirrhinus mrigala (Chakrabarty and Murty, 1972): Fertilized egg - (1) Blastodisc-just formed; (2) two-celled stage; (3) Four-celled stage; (4) Eight-celled stage; (5) Sixteen-celled stage; (6) Morula stage; (7) Yolk-plug stage. Embryo - (8) Elongation of yolk mass; (9) With six somites; (10) Appearance of optic cups; (11) Elongation of tail from yolk mass, formation of Küpffer's vesicle; (12) About two hours before hatching.

TABLE XI

Development of fertilized eggs of mrigal

Development features	Time after fertlization
Segmentation (Fig. 4.1, 4.2)	Regular, after 5 minutes (Khan, 1943); first cleavage in 45 minutes (Chakrabarty and Murty, 1972).
4 celled (Fig. 4.3)	10 minutes (Khan, 1943); 53-56 minutes (Chakrabarty and Murty, 1972).
8 celled (Fig. 4.4)	15 minutes (Khan, 1943); 63-70 minutes (Chakrabarty and Murty, 1972).
16 celled	During the early stages of cleavage the blastodem is a lens-shaped mass of cells, but becomes dome-shaped with further development
Gastrulation (Fig. 4.7)	Peripheral margins of the growing blastoderm get somewhat thickened to form the germ ring which with further growth of blastoderm increases in circumference tending to envelop the yolk. Yolk germ-ring in 3½ hours (Khan, 1943) or in 3-4 hours (Chakrabarty and Murty,1972); yolk invasion complete, only a small portion being exposed thereof called the blastopore, in 4½ hours (Khan, 1943), (4-5 hours Chakrabarty and Murty, 1972).
Appearance of embryonic ring (Fig. 4.8)	In 7 hours, the rudiment of the embryo becomes elliptical, with a well differentiated head and tail ends, and lies in the form of a belt over the yolksac. The blastopore now closes. According to Chakrabarty and Murty (1972), the earliest indication of embryo formation starts within 5½ hours, followed by elongation of the yolk mass. The embryo is clearly differentiated into head and tail regions in c. 7 hours.
Organogenesis (Fig. 4.9-4.12)	The embryo is well defined, with 7-8 somites, in 9 hours. Eyes appear as transparent objects at the head-end. In some embryos, 16-17 somites, a pair of eyes and a pair of otocysts with 2 otoliths in each appear in 10 hours. According to Chakrabarty and Murty (1972),19 somites, a pair of otocysts and Küpffers vessels, appear at the head-end of the fully elongated yolk mass in embryos after 10½ hours. In some eggs, embryos start movements after 10 hours. 27-30 somites develop in 11-12 hours. Embryonic fin fold distinct both on the dorsal and ventral sides in 12 hours (Chakrabarty and Murty, 1972). In 12-14 hours, 32 somites appear, an elongated tail projecting beyond the yolksac, and shows quick jerking movements. At this stage, eyes lack pigment, the notochord is cellular and fin fold visible. Heart, is a simple tubular structure in 15-16 hours, when auditory and optic vessels also develop.
Period of incubation	16-24 hours (Khan, 1943); 16-18 hours at a water temperature of 25-30°C (Chakrabarty and Murty, 1972).

TABLE XII

Larval stage of mrigal up to 48 hours after hatching (Chakrabarty and Murty, 1972)

	Time (hr.) after hatching					
	0	6	12	24	36	48
Total length (mm) :						
Average	4.20	4.50	5.00	6.21	6.70	6.84
Range	4.08-4.32	4.18-4.80	4.89-5.06	6.02-6.49	5.96-7.45	4.79-7.55
Length of yolksac (mm)	2.90	3.00	3.00	3.24	2.50	2.00
Maximum height of yolksac (mm)	0.90	0.90	0.80	0.54	0.30	0.25
Height of body at pectoral level (mm)	1.20	1.20	1.17	1.23	1.10	1.08
Number of pre-anal myotomes	28	28	28	28	28	28
Number of post-anal myotomes	14	14	14	14	14	14
Diameter of eye (mm)	0.18	0.20	0.27	0.27	0.40	0.40
Colour of eye	Colourless	Colourless	Black at the centre	Centre pigmented. Fully black in some	Deep black centre fully covered with chromatophores	Same as in 36 hours stage
Length up to hind tip of notochord (mm)	4.05	4.35	4.80	5.85	6.30	6.60
Directive movement	On their sides at the bottom of container	Occasional vertical with light jerks	Sluggish upward jerky movement occasionally coming to surface vertically upwards	Slight darting movement covering little distance at a time, upwards and horizontal zig-zag movement	Horizontal Jerky in some, feeble horizontal in others	Horizontal movement. Shooting and darting
Pectoral fin	Absent	Absent	Absent	Present	Present	Present

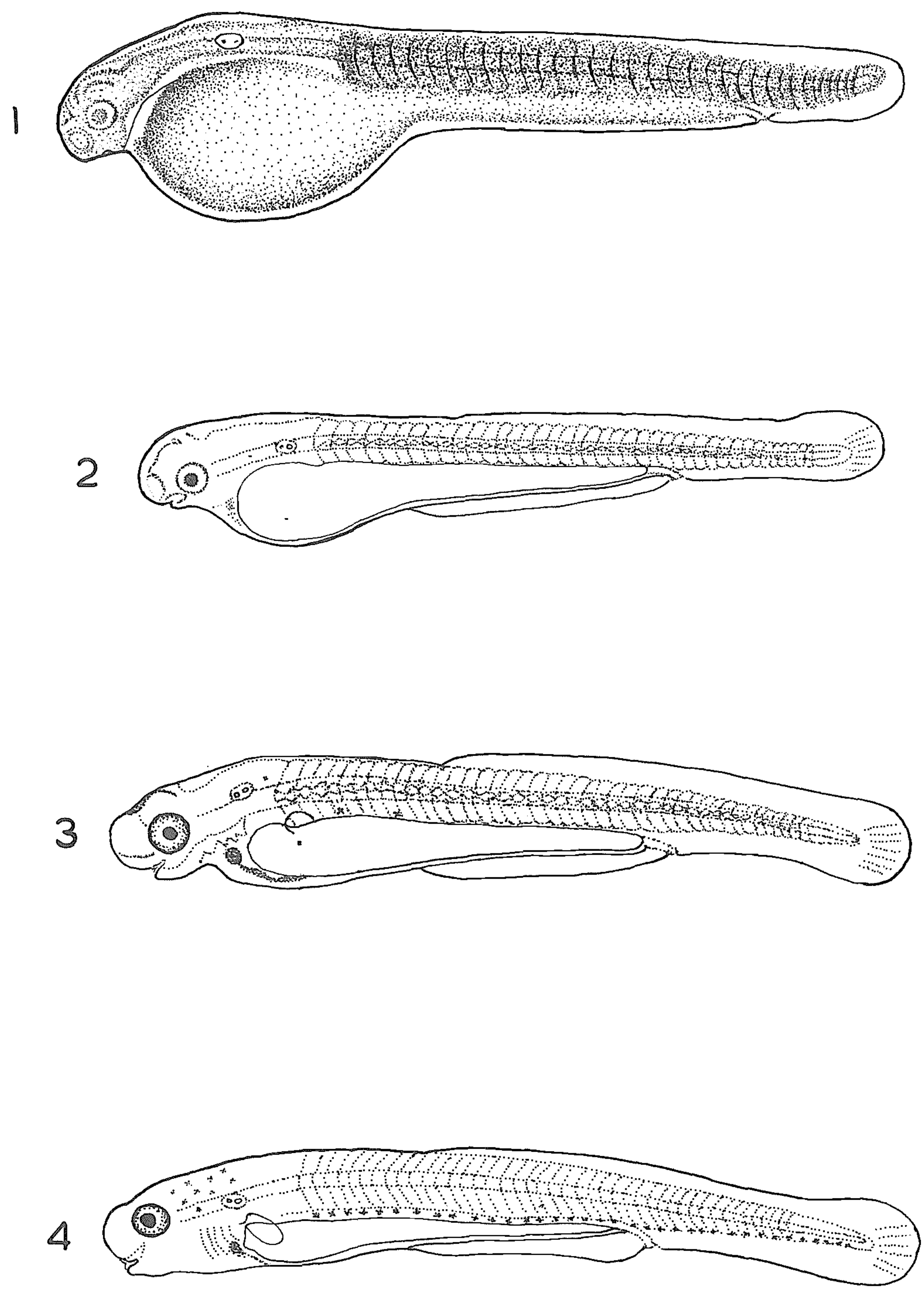

Figure 5 Larval Development of Mrigal. (1) Hatchlings; (2) 12 hours after hatching; (3) 24 hours after hatching; (4) 36 hours after hatching.

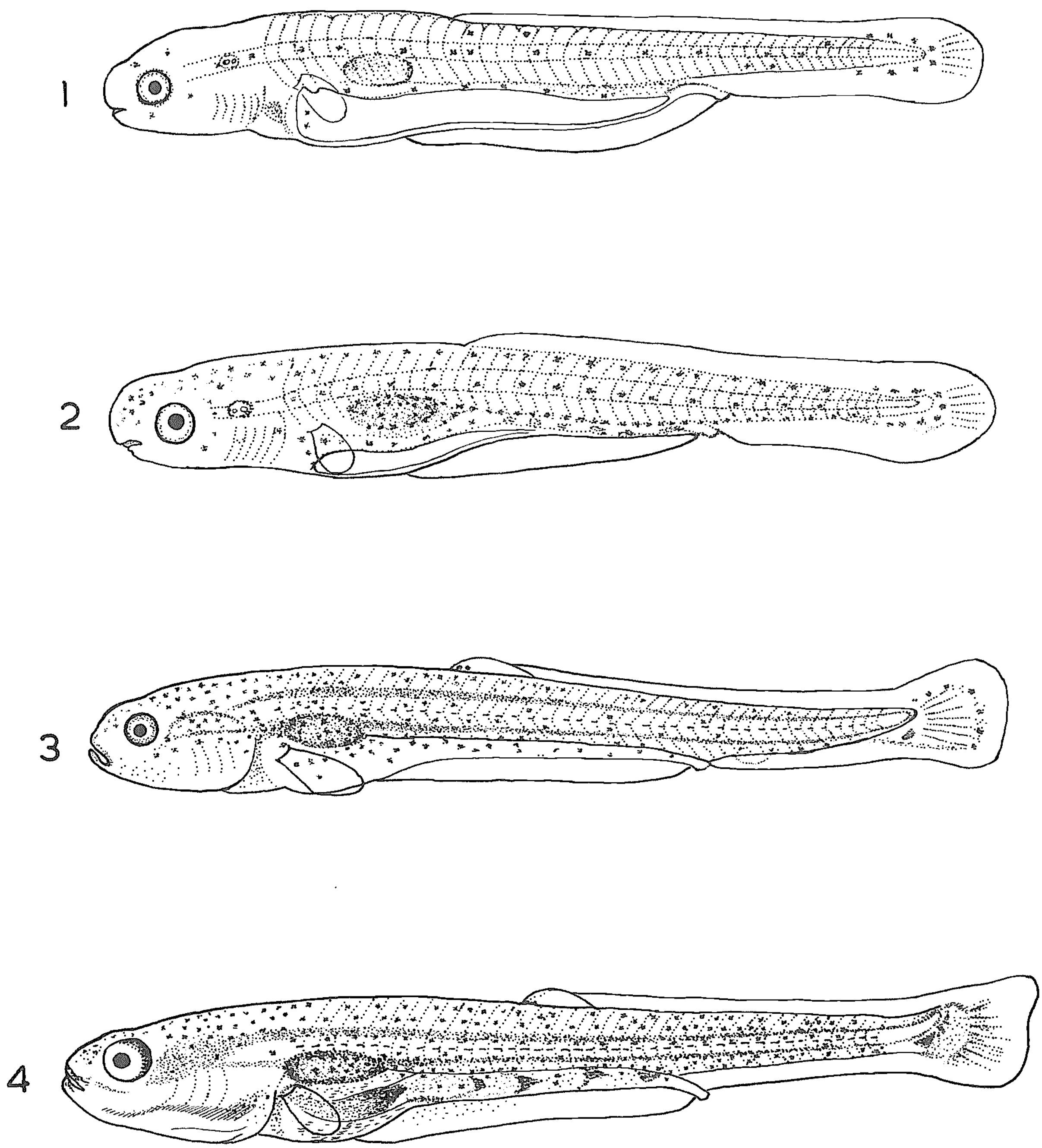

Figure 6 (1) 48 hours after hatching; (2) 72 hours after hatching; (3) 4th day after hatching; (4) 5th day after hatching.

TABLE XIII

Larval development of mrigal

Larval stage (hr. after hatching)	Development
1	2
6	Yolksac has a slight dorsal depression just behind the region of its maximum width. Notochord upturned at its lip. Posterior margin of caudal fin uniformly convex.
7	3 aortic arches develop (Khan, 1943)
9	4 aortic arches and a tubular pulsating heart seen (Khan, 1943).
12 (Fig. 5.2)	Faintly dark eyes with a central pigmented area, surrounded by a colourless rim. Ventral embryonic fin fold more prominent. Interior part of the yolk somewhat globular. Pectoral fin rudiment, faintly visible. (Chakrabarty and Murty, (1972). Pectoral fin bud appears at 11 hours (Khan, 1943).
24 (Fig. 5.3)	Length 5.6 mm. Pectoral fins well developed (Khan, 1943). Prominent fin folds, clearly visible mouth, more darkly pigmented eyes, a well marked anal depression, pectoral fin visible, and narrow end of yolk does not end sharply (Chakrabarty and Murty, 1972). Operculum appears but does not extend over gills. Air bladder visible as a space over the yolk area (Khan, 1943).
36 (Fig. 5.4)	Average size 6.70 mm. Black chromatophores seen, in a row in the region lying above the yolksac, up to the end of notochord, a few chromatophores appear on the head also (Chakrabarty and Murty, 1972).
48 (Fig. 6.1)	5.8 mm long. Open mouth, reduced yolksac, pigmented eyes with yellow border dorsally and head covered with yellow pigment rendering it opaque (Khan, 1943). Ovate region of yolksac has a dorsal depression above which the air bladder is located. Yolksac considerably reduced, its length being less than one-half of the total length of the embryo. Anterior margin of the yolksac more or less straight (Chakrabarty and Murty, 1972). Notochord, extending from the posterior end of the head to the caudal portion, is covered laterally and ventrally by black stellate cells. Airsac extends posteriorly. Stomach with a lumen, visible under the latter, extending posteriorly up to the location of the future anus. Intestine without a lumen. Gills covered with operculum. Airsac filled with gas. Yolksac further reduced by the end of second day; lumen appears in the intestine. Gullet not yet opened (Khan, 1943).
72 (Fig. 6.2)	6.3 mm long (Khan, 1943); 7.2 mm long (Chakrabarty and Murty, 1972). 6-7 caudal fin rays by the end of the fourth day. Dorsal side of hatchlings yellow. Prominent eyes. Lateral rows of black chromatophore seen along the body, a few located on the abdomen and in the caudal region posterior to the notochord. Embryonic fin rudiment on the ventral side originating halfway below the airsac, whereas dorsal fin rudiment commences behind it. Tip of notochord

continued

Table XIII continued

1	2
	gets slightly bent upwards. Striations seen in caudal fin. Yolksac fully absorbed at the end of third day, though in some cases still discernible (Chakrabarty and Murty, 1972).
96 (Fig. 6.3)	6.3-6.6 mm (Khan, 1943), and 7.38 mm (Chakrabarty and Murty, 1972) in size.
Postlarval stage (in days)	
5 (Fig. 6.4)	6.65 mm long (Khan, 1943) or 9.0 mm long (Chakrabarty and Murty, 1972). Black chromatophores in the form of a somewhat triangular patch in the caudal peduncle region. Chromatophores on the head deep black. Lips progressively thickening . Notochord slightly bent at its posterior extremity (Chakrabarty and Murty, 1972). Four distinct and 2 indistinct cartilages in the caudal region as a support to 6-7 caudal rays. By the end of 5th day, some show 12 distinct caudal rays and 6 basal cartilages.
6 (Fig. 7.1)	Average size 11.5 mm (Chakrabarty and Murty, 1972). Notochord with a distinct upward bend at the caudal end. 80 rays visible in the dorsal fin. Pelvic fin bud appears. First ray of dorsal fin with a cluster of black chromatophores. Dorsal fin rays start branching. Distinct star-shaped black chromatophores observed on the head and dorsal part of the body. From the region behind the eyes up to the caudal peduncle, the dorsal part of the body appears yellowish-green in colour. Liver visible as a reddish spot near the airsac (Khan, 1943). Air bladder divisible into 2 parts, the anterior being broader (Chakrabarty and Murty, 1972). This region densely packed with black chromatophores. 22 prominent fin rays seen in caudal fin. Black crescent-shaped markings observed on the caudal peduncle. Anal rays very faint.
7 (Fig. 7.2)	Average length 12 mm. Dorsal fin with 14 distinct and one indistinct ray, with yellowish pigmentation at its base. A few black chromatophores present at the base of the anterior part of dorsal fin. Anal fin with 6 branched rays. 22 caudal rays. Caudal fin shows 2 faint semicircular discs marking the termination of the vertebral column. Anterior to this, there is a cluster of black chromatophores forming a triangle. Caudal rays show dispersed yellow pigment cells ending half-way from the base of the fin. Chromatophores scattered over the entire body, which is yellowish in colour. Membranous part of caudal fin, anterior to the beginning of the caudal rays, is covered with yellowish pigmentation, more densely on the dorsal side (Chakrabarty and Murty, 1972).
10 (Fig. 7.3)	Average length 15.6 mm. Dorsal side of the body deeper yellowish and the rest pale yellow. Prominent black chromatophores scattered all over the body and those on the head region are darker. Out of 14 rays in the dorsal fin, the first 2 are unbranched and the rest branched. Anal and pectoral fins each with 7 rays. Caudal fin has 26 rays. Lateral line visible as a spotted line. A triangular area densely packed with black chromatophores seen just anterior to the region of the beginning of the caudal rays.
12	Average length 20.5 mm. 16 dorsal fin rays. Anterior margin of dorsal fin blackish, due to

continued

Table XIII continued

1	2
	densely packed chromatophores. Ventral fin with 9 rays. Anal fin, which shows the first 3 rays unbranched and other 5 rays branched, does not commence immediately behind the anus. Caudal rays 36 in number and covered with orangish pigment. Diamond-shaped area in caudal fin formed by the aggregation of black chromatophoresjust at the commencement of the rays. Barbels not seen (Chakrabarty and Murty, 1972).
15 (Fig.7.4)	Average size 27.0 mm. Side of the body above lateral line is more darkly pigmented. Scales visible first in the region posterior to the operculum, when fry 24 mm in length. According to Khan (1943), scales form on 24th day after hatching. Black diamond-shaped patch prominent in the caudal peduncle. Dorsal fin rays covered with yellowish pigment cells. Chromatophores distributed prominently as thick discontinuous bands along the fin rays, appearing as black dots to the naked eye. Caudal fin rays 38 in number. The basal half of caudal fin rays orangish, while fin margins are covered with dark pigment. Barbels not yet visible (Chakrabarty and Murty, 1972).
20	31.5 mm long. Barbels not yet seen. The diamond-shaped black spot in the caudal peduncle diffused and spread almost along the entire width but does not reach the margin. Scales above lateral line more prominent. Body whitish below the lateral line but yellowish above and covered with black chromatophores. Scale margins appear dark. Dorsal ventral and anal fins show 16, 9 and 8 rays respectively (Chakrabarty and Murty, 1972).
25	39 mm long. Body silvery with a greenish hue. Scales, with faint black margin, seen prominently all over the body. Lower lobe of the caudal fin faintly reddish. Dorsal fin rays (2/14 in number) show orange and yellow pigment on the branched portions. Caudal fin rays pigmented orange. Upper caudal lobe slightly longer (Chakrabarty and Murty, 1972).

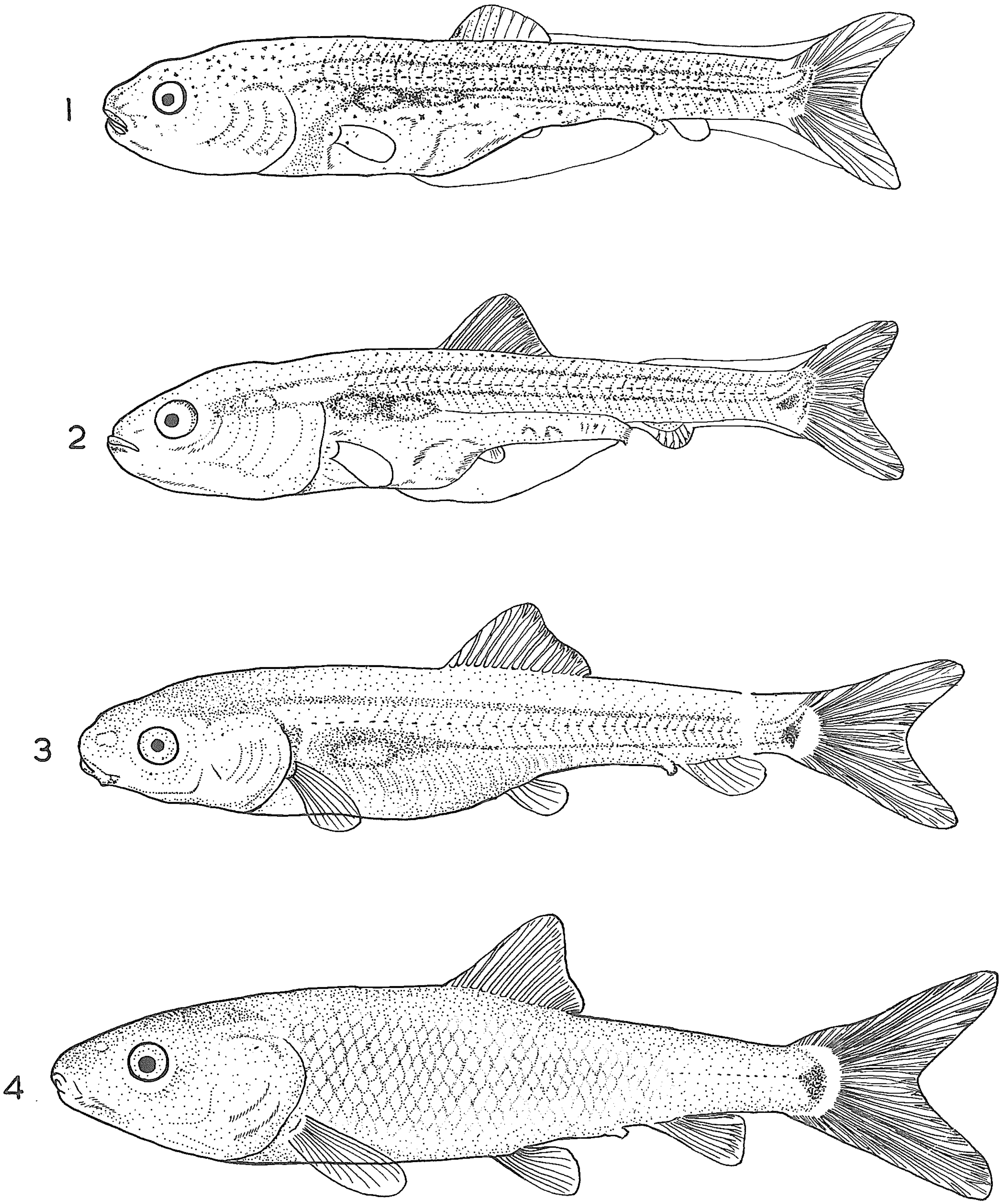

Figure 7 Post-larva of mrigal. (1) 6th day after hatching; (2) 7th day after hatching; (3) 10th day after hatching; (4) 15th day after hatching.

TABLE XIV

Survival and production of fry in the first 15 days
(Alikunhi, 1957)

Artificial feed provided	Survival (%)			
	No. of ponds used for rearing	Range	Average	Average production (number per ha)
Rice bran	4	47.0-99.0	77.2	953 633
Ground nut oilcake	5	13.2-71.8	36.6	477 076
Mustard oilcake	4	4.5-51.0	28.2	348 460
Coconut oilcake	2	47.8-61.0	54.4	672 409

Chakrabarty et al.(1973) observed, in experiments carried out during 1971, that the best survival rates in hatchlings were obtained with zooplankton as feed. With regard to artificial feeds, those 1970 experiments showed that silkworm pupae gave the best results, while in their 1971 experiments, soyabean or a mixture of groundnut oil cake and wheat bran gave better results. Mrigal hatchlings utilize artificial feeds better than rohu and catla. Table XV shows the performance of mrigal hatchlings with different feeds. Refer to section 7.6.

TABLE XV

Performance of mrigal hatchlings with different feeds
(Chakrabarty et al. 1973)

Feed	1970						1971		
	Increment						Increment		
	survival (%)	length (mm)	weight (mg)	survival (%)	length (mm)	weight (mg)	survival (%)	length (mm)	weight (mg)
Zooplankton	61.3	1.34	3.99	74.0	1.01	1.21	90.0	5.40	19.25
Mustard oilcake + rice bran	16.0	0.96	0.45	28.0	0.87	2.29	-	-	-
Silkworm pupae	68.0	2.39	5.20	96.0	2.73	4.45	65.0	1.65	2.28
Groundnut oilcake + wheat bran	71.3	2.08	3.43	96.0	2.45	4.72	96.7	6.08	16.00
Soyabean	-	-	-	-	-	-	96.7	3.51	7.90
Prawn	-	-	-	-	-	-	44.0	2.10	1.33

Any sudden change in temperature of an appreciable magnitude may prove fatal to mrigal. During 1962, a sudden fall in the temperature from 18.2°C to 6.5°C in River Gandak, proved fatal to mrigal and other major carps (Jhingran et al., 1964). Mrigal fingerlings (length: 65-70 mm) thrive well in temperatures ranging from 18.3 to 37.8° C but temperatures below 16.7°C and above 39.5°C have been observed to be lethal (Mookerjee et al., 1946). There is no parental carein mrigal. Refer to 3.34 and 3.35.

-Time of first feeding

Mrigal fry are reported to commence feeding on the third day after hatching (Kamal, 1967). The mouth is formed one day after hatching and gills are also then well developed. Table XVI shows development of gill arches, gill filaments, and alimentary canal in the larval and postlarval stages of mrigal. Gill rakers appear on the 6th day after hatching (Kamal, 1967) and they are ill adapted for filtering water and retaining particular organisms (Alikunhi, 1957). The alimentary canal becomes functionally complete on the third day after hatching, when it is a simple, nearly straight tube measuring 3.2 mm. Although the alimentary canal of mrigal fry initially looks like that of an adult carnivore (less than the body length), it soon assumes a herbivorous form and its length becomes more than that of the body length. The alimentary canal remains shorter than the body up to the 7th day and thereafter it increases at a much faster rate, becoming longer than the body (Table XVI). The ratio of the alimentary canal to body length in mrigal of lengths ranging from 35 mm to 687.0 mm is shown in Table XVII. According to Das and Moitra (1955 and 1956) the ratio of the gut length to the total body length is around 15-16 in the adult stage.

TABLE XVI

Development of alimentary canal, gill arches, gill filaments, gill rakers and the food consumed by larval and postlarval stages of Cirrhinus mrigala (Kamal, 1967)

Age (days)	No. of gill arches (pair)	No. of gill filaments per gill arch (range)	No. of gill rakers per gill arch (range)	Av. length (mm)		Ratio of gut length to body length	Coiling stages of the alimentary canal	Food (%)		Dominant item of food
				Body	Gut			Phytoplankton	Zooplankton	
1	4	8-10 pairs	Nil							
3	4	12-13 "	Nil	7.4	3.2	0.432	I	23.0	77.0	Cladocera
4	4	13 "	Nil	7.9	3.8	0.481	I	30.0	70.0	"
5	4	18 "	Nil	9.5	4.8	0.494	II	11.6	88.4	"
6	4	22-25 "	13 pairs	11.8	9.0	0.762	III	6.0	94.0	"
7	4	26-28 "	13-14 "	13.3	12.3	0.946	IV	3.3	96.7	Copepods
8	4	30-31 "	14-16 "	15.5	20.5	1.290	V & VI	Nil	100.0	"
9	4	32-34 "	16-19 "	17.3	25.3	1.462	VII	56.6	43.4	Trachelmonas Oscillatoria & Copepods
10	4	32-35 "	16-19 "	16.0	25.6	1.600	VIII	27.3	72.7	"
11	4	34-35 "	16-19 "	18.2	36.0	1.978	IX	7.0	93.0	"
13	4	35-37 "	17-19 "	18.6	48.6	2.604	X	100.0	Nil	Trachelmonas
15	4	35-37 "	17-19 "	18.6	45.3	2.462	XI	21.6	78.4	Copepods
17	4	44-50 "	24-25 "	25.0	105.0	4.400	XII	99.0	1.0	Trachelmonas

TABLE XVII

Ratio of length of alimentary canal to body length in mrigal (Kamal, 1967)

Body length (mm)	Gut length (mm)	Ratio of gut length to body length
35	175	5.00
50	347	6.94
80	721	9.01
113	1 250	11.62
150	1 800	12.00
255	3 626	14.22
394	5 989	15.20
590	10 350	17.54
687	18 700	24.31

- Type of feeding

After the yolksac is absorbed, mrigal fry start feeding predominantly on zooplankton, but later are able to feed on either zoo or phyto-plankton. According to Alikunhi (1952), (vide Table XVIII), they subsist almost exclusively on nauplii, rotifers (Brachionus, Keratella, Filinia, etc), cladocernans (Daphnia, Moina, etc) and copepods (Cyclops, Diaptomus, etc). Hora and Pillay (1962) state that fry up to a length of 25 mm feed preferably on zooplankton, especially on Crustacea and Rotifera, planktonic algae being taken only as emergency food. Kamal (1967) reports that both zoo and phytoplankton are fed on by fry soon after absorption of the yolksac (vide Table XVI)

3.23 Adolescent phase

The rate of development from the post-larval to adolescent stage of mrigal depends on several environmental factors. These are the same as for Labeo rohita (refer to Khan and Jhingran, 1975) and Catla catla (refer to Jhingran, 1968). Khan (1972) studied the food of mrigal juveniles from two environments, viz. rivers and moats. In both ecosystems, decayed organic matter formed the bulk of the food, followed by sand and mud. The other dietary items in the riverine environment were diatoms followed by rotifers, crustaceans and phyto-flagellates, while in the moat, crustaceans were found next to decayed organic matter in the order of preference. For details refer to

TABLE XVIII

Food consumed by mrigal during various stages of its life (Alikunhi, 1957)

Length (mm)	Average % of food item generally encountered in the stomach and gut					
	Unicellular algae	Filamentous algae	Vegetable debris	Animalcules & water fleas	Insects	Sand or mud
11-20	19.0	2.0	26.9	33.5	-	18.6
21-40	22.3	3.0	43.0	15.2	-	16.5
41-100	25.0	-	55.0	-	-	20.0
100 and longer	26.2	6.7	45.5	-	-	21.0

section 3.42.

3.3 Adult phase

3.31 Longevity

The oldest mrigal recorded is a 12 year old reaching a length of 1016 cm (Jhingran, 1959). Kamal (1969) and Khan (1972) reported 9 year old mrigal of lengths 96.0 cm and 92.2 cm, respectively. According to earlier literature, the species attained lengths of 45.7 - 61.0 cm (Hamilton, 1822) and 91.5 cm (Day, 1878).

3.32 Hardiness

According to Hamilton (1822), when mrigal is taken out of water, it is quite tenacious of life. Major carps, including mrigal, have been reported to grow up to a salinity level of 14‰.

3.33 Competitors

During the fry stage, in both the natural and artificial habitats, almost all the culturable species such as common carp, Indian and Chinese carps are planktophage and there occurs a high degree of inter-specific competition. Mrigal fingerlings and adults are bottom feeders. The competitors of mrigal are feeders on vegetable debris, microscopic plants and detritus, notably Labeo calbasu, L. fimbriatus, etc.

3.34 Predators

Among fishes, Wallago attu and Channa marulius are perhaps harmful to adult of more than 0.5 kg weight. Smaller mrigal encounter many predators, notably Lates calcarifer, Notopterus chitala, Silonia silondia, Channa striatus, Mystus spp. among fish; as well as crocodiles, cormorants, gulls, king fishers, kites, crows, herons, storks, etc. Otters are harmful to mrigal of all sizes.

3.35 Parasites diseases, injuries and abnormalities

Refer to 7.7.

The following parasites have been recorded from mrigal:

Bacteria	Aeromonas sp. (from body cavity, scales)
Fungi	Saprolegnia sp. (from any part of the body
Protozoa	Myxobolus calbasue (Chakrabarty) (from gills)
	M. catlae (Chakrabarty)(from gills)
	M. indicum (Tripathi) from muscles)
	M. mrigalae (Chakrabarty)(from scales)
	M. sphericum (Tripathi) (from scales)
	Thelohamellus mrigalae Tripathi (from head, eyes and snout)
	T. rohitae (Southwell and Prasad)
	Bodomonas rebae Tripathi (from gills)
	Trichodina indica Tripathi (from skin and gills)
	Scyphidia pyriformis Tripathi (from gills)
	Chloromyxum mrigalae Tripathi (from gall bladder)
Copepoda	Argulus siamensis Wilson (from body and fins)
	Ergasilus batai Karamchandani (from gills)
	Paraergasilus mrigalae Tripathi (from gills)
Trematoda	Gyrodactylus elegans indicus Tripathi (from skins and gills)
	Dactylogyrus brevifurcatus Kulkarni (from skin)
Hirudinea	Hemiclepsis marginata (from body)

- Injuries and abnormalities

Mrigal is quite a hardy fish. Three instances of abnormality have been reported in respect of mrigal (Sarkar and Kaushik, 1958; Kaushik, 1960). In the first example, the deformity commenced behind the dorsal fin and lay mainly in the region of the caudal peduncle. The deformed specimen showed a prominent dorsal hump on the right side and a short caudal peduncle. Internally, 25th to 37th vertebrae, except 27th, showed abnormalities. The prominent features of the deformity were: (i) 25th, 26th and 28th vertebrae showed both deformed centra and neural spines; 33rd to 37th vertebrae displayed coalesced centra as well as neural spines, (ii) the supporting skeleton of the caudal fin showed fusion and (iii) the anal fin showed a slight twist to the right.

The second deformity exhibited a prominent elevation followed posteriorly by a shallow depression in the region beginning from the middle of the dorsal fin and extending up to its end on either side of the body both above and below the lateral line. In this specimen also the fusion of vertebrae and abnormalities of spines were marked in 11th to 24th vertebrae.

In the third instance, the pelvic fin was entirely missing. The place of origin of the fin did not show any scar externally and the skin was covered with normal scales. There was no trace of a pelvic girdle.

Abnormal specimens of mrigal having more than two pairs of barbels (four or three) also occur (Günther, 1968 and Dutt and Murty, 1971). Dutt and Murty (1971) have recorded several such abnormal specimens of mrigal from the Lake Kolleru. They also examined the paratype of Cirrhinus chaudhryi Srivastava and reported that like some of the abnormal specimens of C. mrigal from Lake Kolleru it had three barbels - the normal two rostrals and a maxillary on the left side. There is no maxillary barbel on right side. Therefore, they concluded that C. chaudhryi Srivastava represented abnormal C. mrigal with one or two maxillary barbels.

3.4 Nutrition and growth

3.41 Feeding (time, place, manner, season)

Mrigal is an illiophage in its feeding habit and stenophage in food variety. According to Das and Moitra (1955), Alikunhi (1957) and Khan (1972), mrigal is a bottom feeder. Chacko and Ganapati (1951) described it a mid-water and bottom feeder, whereas Hora and Pillay (1962) termed the fish as an omnivore and bottom feeder. Chakrabarty and Singh (1965), who carried out detailed investigation on the food and feeding habits of mrigal from a riverine environment, described the fish as an illiophage, feeding at the bottom on decayed vegetation.

Mrigal shows some structural adaptations suited to its feeding behaviour. The thin terminal lips are adapted for picking up food material from the mud. Although mrigal is an illiophage in feeding habit, its mouth shows the characteristics of a planktophage i.e., it is large and immobile. The fish sucks its food along with the current of water, the senses of vision and smell helping in the search for food items in the aquatic environment (Mookerjee and Ganguli, 1948). Generally, however, the choice of food items for ingestion further into the alimentary canal, or their rejection, is instinctively done in the buccal cavity and pharynx, which are endowed with taste buds for the purpose. Unacceptable food is ejected out of the mouth after its sampling in the bucal cavity. The masticatory pharyngeal teeth working against and together with the callous pad on the underside of the posterior pharyngeal roof break up the large, hard and solid food masses to sizes suitable for passing into the narrow oesophagus, a process facilitated by the presence of mucous secretion. The rather closely set, small, soft and thin gill rakers arranged in two rows on each gill arch, form a sort of filtering apparatus, besides protecting the tender respiratory gill filaments from the abrasion which may be caused by coarse food material. The presence of taste buds in the oesophagus in conjunction with the striped muscles occurring there, give an indication of the probable importance of this region, besides the buccal cavity and pharynx, in the selection and rejection of food. The intestinal bulb serves the role of a store house for the accepted food materials. The intestinal coil, in adult mrigal is 10-17.6 times longer than the total body length of the fish and probably provides a large surface for absorption of food by virtue of its elongation, which function is also subserved by other anatomical features, such as the longitudinal folds in its lumen.

The feeding intensity of mrigal during various months of the year was examined by Chakrabarty and Singh (1963) and Khan (1972). According to Chakrabarty and Singh (1963), the feeding intensity varied with the size of the fish. Highest feeding intensity was observed in the size group up to 273 mm in total length. No significant difference in the composition of the diet of the two sexes was noticed. There was also a variation in the feeding intensity of the fish in the course of the year, feeding being good during the period November to January only. Khan (1972) reported that juveniles showed high feeding intensity throughout the year except during January and March. The maximum feeding was observed during October and April. In the case of adults, feeding was comparatively poor during most of the months except during the post-spawning period i.e. October-December.

The highest feeding in mrigal was recorded in the month of October by Khan (1972).

The relative condition factor, which depends upon the stage, maturity of gonads and length of the fish, was studied by Chakrabarty and Singh (1963) in respect of juveniles and two sexes collected from Yamuna at Allahabad. They reported that relative condition was best in the smallest size group (273 mm), due to fact that the intensity of feeding is the highest in this size group. Fluctuations noticeable in the relative condition of males were much less than in females. Both males and females attained their peak condition in June. Khan (1972) also reported K_n values of juveniles being high throughout the year and those of adults being influenced by maturation and spawning.

3.42 Food (type, volume)

Table XIX shows food items, in their order of preponderance, encountered in the gut of mrigal in different localities, as observed by different workers. Detailed analyses of gut contents have been made by Chakrabarty and Singh (1963) and Khan (1972). Chakrabarty and Singh reported that the percentage of semi-decayed organic matter was considerable in the case of large-sized fish (group IV) which probably browsed on aquatic vegetation and algae more actively than smaller-sized ones. The average annual percentage of the food items of mrigal is given in Table XX.

TABLE XIX

Food preponderance in the gut contents of mrigal according to locality

Food items	Locality	Feeding type	Authority
Semi-rotten higher aquatic plants, mud and sand	Bengal	Bottom feeder	
Blue-green algae, green algae and diatoms in mid-waters; mud and dark mucilaginous matter	Godavari and Krishna districts, Madhya Pradesh (Ponds and tanks)	Mid-water and bottom feeder	Chacko and Ganapati (1951)
Higher aquatic plants (72.5%), unicellular algae (10%), sand and mud (10%), Multicellular algae (7.5%)	Lucknow, Uttar Pradesh (Local tanks and ponds)	Bottom feeder	Das and Moitra (1955)
Fingerlings: Vegetable debris (55%), unicellular algae (25%), sand and mud (20%)			
Adults: Decayed organic and vegetable debris, phytoplanktonic organisms, sand and mud; proportion of animal matter poor		Bottom feeder	Alikunhi (1957)
Blue-green algae, filamentous green algae, diatoms and pieces of higher plants (50%); rest consisting of decayed vegetable matter, mud and detritus, flagellates, rotifers and small crustaceans taken incidentally		Bottom feeder and omnivore	Hora and Pillay (1962)
Decayed organic matter (72.5%), semi-decayed organic matter (20%), plankton (1.9%), sand (13.1%) and mud (10.5%)	Allahabad (Rivers : Ganga and Yamuna)		Chakrabarty and Singh (1963)

TABLE XX

Average annual percentage of gut contents of mrigal (Chakrabarty and Singh (1963)

Size group class (mm)	Decayed organic matter	Semi-digested organic matter	Plankton food	Sand	Mud	No. of guts examined	Diatoms	Chlorophyceae	Myxophyceae	Euglenae	Zooplankton	Fungi
1	2	3	4	5	6	7	8	9	10	11	12	13
I Up to 318	68.7	0.8	2.8	15.9	11.8	131	51.6	20.5	8.7	11.8	6.9	0.5
II 391—560	71.9	1.4	1.0	12.6	13.1	90	40.6	40.7	7.2	2.3	5.0	4.2
III 561—765	71.7	1.4	3.2	13.4	10.3	83	54.8	27.7	5.1	2.9	7.6	1.9
IV 766 and above	77.6	4.5	0.5	20.6	6.8	58	33.0	49.4	8.4	-	9.2	-

Table XXI shows the food of mrigal fingerlings (less than 100 mm long), juveniles (101-300 mm long), and adults (above 300 mm) obtained from pond moats and rivers around Aligarh. Khan (1972) remarks that in the case of fingerlings, zooplankton formed the bulk of the diet, consisting of about 39% and 54% of the total food in moats and rivers, respectively. In juveniles the percentage of zooplankton decreased considerably, as compared with fingerlings, while that of phytoplankton increased substantially. The percentage of decayed organic matter, sand and mud also increased. In the adult mrigal, the food consisted mainly of decayed organic matter, sand and mud.

TABLE XXI

Food composition of fingerlings, juveniles and adults of mrigal from two environments (Khan, 1972)

Food items	Percentage composition of food of					
	Fingerlings		Juveniles		Adults	
	Moat	River	Moat	River	Moat	River
1	2	3	4	5	6	7
Green algae	3.0	5.1	6.2	5.9	10.0	14.2
Diatoms	6.5	4.3	12.0	8.2	13.0	10.8
Blue-green algae	2.0	1.0	7.0	4.0	9.5	6.3
Desmids	6.0	4.1	5.1	4.0	4.1	2.0
Phytoflagellates	8.5	3.0	8.1	6.1	7.0	3.9
Algal spores and zygotes	3.7	1.5	3.0	3.6	3.8	5.9
Macrovegetation	1.2	-	1.0	2.1	-	1.0
Decayed organic matter	15.5	12.3	19.5	22.3	31.1	30.0
Protozoons	6.0	6.3	5.0	4.3	2.5	1.3
Rotifers	15.2	19.1	10.1	8.3	3.0	2.0
Crustaceans	16.4	27.3	10.0	15.1	2.0	2.5
Sand and mud	16.0	1.6	13.0	16.0	14.0	20.1

3.43 Growth rate

Mrigal is reported to grow 200-250 mm in the first year and 350 mm in the 2nd year (Khan, 1934). Basu (1950) reported that the fish attained 180 mm in $3\frac{1}{2}$ months, thus averaging 50 mm per month. Chacko and Ganapati (1951) observed a growth of 450-600 mm and a weight of 1 135 to 1 815 g in one year in some tanks and swamps of the Godavari and Krishna districts. In Chetpur Fish Farm the same authors reported that mrigal attained 550 to 650 mm and a weight of 1 362 to 2 270 g in one year. In Ichapur Fish Farm in North Vizagapatam, 75-125 mm long fingerlings stocked in December 1949 grew to 300-375 mm by June, 1950. The growth rates are reported to be 37.5 — 50 cm in fertilized waters. In unfertilized waters having poor algal flora, such as the Dhobi tank, Chodavaram tank and Abbi tank in the Ramchandrapuram area, the fish attained 25-37.5 cm in length 340-453 g in the first year. Alikunhi (1957) mentioned that in ponds stocked at the rate of 15 000 fingerlings/ha, an average length of 20 cm could be obtained. According to Hora and Pillay (1962), mrigal grew to 650-1 800 g, 2 600 g and 4 000 g, respectively, during the first, second and third years respectively. Menon et al. (1959) reported that mrigal attained a growth of 500 mm in the first year and 640 mm in the second year in fluviatile environments, while in tanks it attained a growth of 580 mm, 720 mm and 780 mm respectively in the first, second and third years. They also stated that a Chetput Fish Farm mrigal grew to 830 mm in 4 years. Khan (1972) observed that mrigal, from different waters around Aligarh, attained lengths of 275 mm, 480 mm, 630 mm, 750 mm, 840 mm, 873 mm, 900 mm, 913 mm and 920 mm at the age of I, II, III, IV, V, VI, VII, VIII and IX, respectively. He observed that the growth rate of mrigal increased during first and second year of life and decreased gradually up to age group 7, after which growth rate became very slow. The maximum length and age recorded by Khan (1972) were 922 mm and 9 years respectively.

Jhingran (1957 and 1959) and Kamal (1969) studied the age and growth of mrigal from its scales. According to them, the scales show growth checks which are in the form of broad grooves or depressions lying between adjacent circuli running all round (except at the posterior end). The broad grooves are preceded by closely packed circuli and followed by relatively more widely spaced ones (Fig. 8). These growth checks are annular in nature and hence suitable for age determination. In mrigal, apart from true annuli, 2 types of false rings are encountered: (i) those which are not continuous in the embedded portions of the scales and (ii) those appearing like compactly deposited circuli seen among stunted specimens occurring in isolated river pools. The cause of formation of an annulus in mrigal appears to be starvation on the part of the fish during the months March to June, when its feeding intensity goes down. The maximum number of scales with marginal rings under formation have been found during the early summer months of March and April.

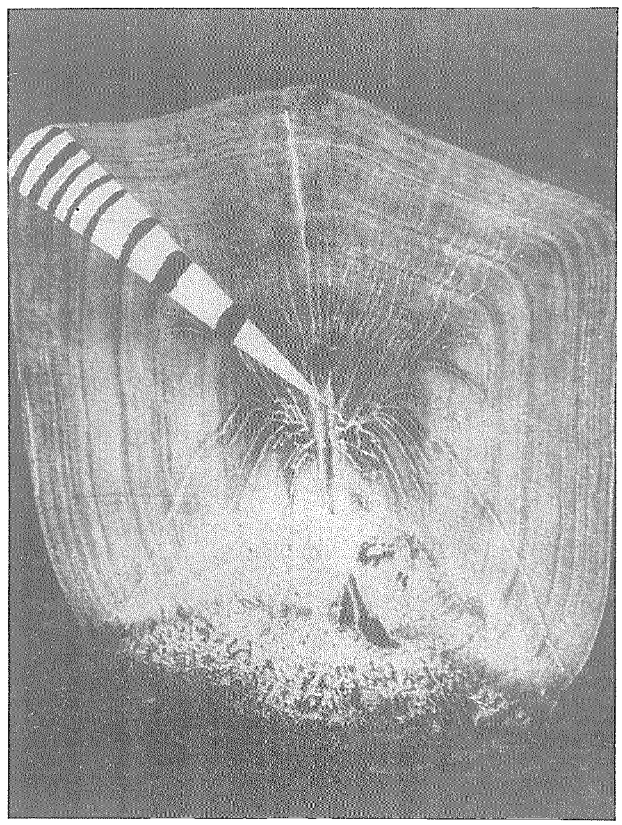

Figure 8 Scale of mrigal showing age 5+ years (Jhingran, 1959)

There is no absolutely rectilinear relationship between scale and body lengths, the coefficient of correlation between them being +0.96 (Jhingran, 1959) and +0.99 (Kamal, 1969) in mrigal from Ganga and Yamuna rivers, respectively. The absolute growth and the relative growth, as interpreted from locations of annuli on mrigal scales, are given in Table XXII and XXIII and graphically represented in Fig. 9.

TABLE XXII

Average size and Weight of mrigal from River Ganga at the time of various annuli formation (Jhingran, 1959)

Number of completed annuli	Total length (mm)	Weight (g)
1	2	3
I	290.9	245.7
II	511.4	1 512.0
III	670.5	3 618.0
IV	797.4	6 324.0
V	858.0	8 030.0
VI	888.5	8 960.0
VII	911.0	9 712.0
VIII	921.8	10 090.0
IX	947.0	11 000.0
X	958.25	11 430.0
XI	958.25	11 430.0
XII	992.0	12 770.0

TABLE XXIII

Annual growth increment and growth rate of mrigal from River Ganga (Jhingran, 1959)

Duration between checks	Growth in length			Growth in weight		
	Growth increment (mm)	Growth rate per month (mm)	Relative growth	Growth increment (g)	Growth rate per month (g)	Relative growth
1	2	3	4	5	6	7
0-I	290.0	32.3	31.9	245.7	27.3	2.5
I-II	220.5	18.4	24.2	1 266.3	105.5	13.0
II-III	159.1	13.3	17.5	2 106.0	175.5	21.7
III-IV	126.9	10.6	13.9	2 706.0	225.5	27.9
IV-V	61.4	5.1	6.7	1 706.0	142.2	17.6
V-VI	29.7	2.5	3.3	930.0	77.5	9.6
VI-VII	22.5	1.9	2.5	752.0	62.7	7.7

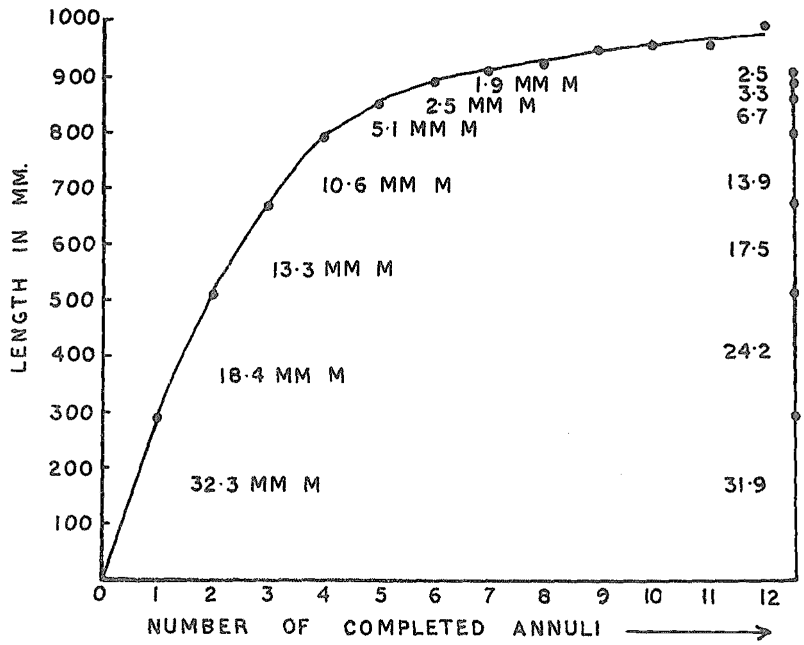

Figure 9 Absolute and relative growth of mrigal as interpreted from annuli on scales (Jhingran, 1959)

Observations made on the age and growth of mrigal from the River Yamuna (Kamal, 1969) confirm Jhingran's findings. Table XXIV and XXV show the salient features of the growth of the fish from the River Yamuna. Mrigal displays a very rapid growth rate in the first four years of its life, followed by a period of slow growth in the next three. The growth rate thereafter becomes much slower. Each species of fish has its own pattern of growth. The pattern of growth in mrigal is adequately described by von Bertlanfy's growth fit, as shown in Table XXIV, and the theoretical formula applicable to mrigal has been worked out as:

$$Lt = 1060 \,[1 - e^{-0.29065}(t - 0.03964]$$

Where Lt = length at age t; 1 = asymptotic length; e = base at the naperian logarithm.

TABLE XXIV

Mean lengths at different ages of mrigal from River Yamuna derived by various methods of study (Kamal, 1969)

	Length at age			
Age (Year)	Scale method (mm)	Peterson's method (mm)	Probability method (mm)	von Bertlanfy's fit (mm)
1	2	3	4	5
I	268.0	260.0	240.0	276.4
II	458.4	470.0	471.0	473.9
III	644.2	600.0	620.0	622.8
IV	736.1	740.0	775.0	732.4
V	816.7	840.0	842.0	815.0
VI	867.1	890.0	898.0	876.8
VII	924.0	920.0	-	923.0
VIII	958.6	940.0	948.0	957.5
IX	-	960.0	-	-

TABLE XXV

Rate of growth in mrigal from River Yamuna (Kamal, 1969)

Duration between checks	Growth increment (mm)	Growth per year (mm)	Relative growth (%)
1	2	3	4
0-1	268	29.8	27.95
1-2	190	15.8	19.82
2-3	186	15.5	19.40
3-4	92	7.7	9.60
4-5	81	6.8	8.45
5-6	50	4.2	5.22
6-7	57	4.8	5.95
7-8	35	2.9	3.65

As stated above, mrigal scales also showed two types of false rings. The second type of false rings were commonly encountered in specimens, measuring up to 240 mm, collected from isolated river pools. These specimens were either the stunted progeny of the previous year's brood or probably the late brood of the year class concerned. These false rings are encountered only during the spring and early summer months. The fish containing these false rings attained sizes of 156.3 mm, 376.28 mm and 559.6 mm which represented one, two and three-year-old specimens (Kamal, 1969).

Hanumantharao (1973) studied age and growth of mrigal collected from the River Godavari. Table XXVI shows the mean lengths of fish at various ages, as estimated by different methods. Hanumantharao (1973) concluded that mrigal from River Godavari showed fast growth during the first 4 years and thereafter declined.

TABLE XXVI

Mean lengths at different ages of mrigal from River Godavari derived by different methods (Hanumantharao, 1973)

Age (years)	Scale method (mm)	Probability method	Peterson's method	von Bertalanfy's fit
1	2	3	4	5
I	230	235	255	223
II	358	345	340	363
III	470	452	455	482
IV	580	580	560	587
V	676	652	636	681
VI	760	740	730	763
VII	828	820	800	856
VIII	885	-	900	900

Ghosh (1974), while comparing the von Bertalanfy and the Gompertz equations for describing the growth of Indian major carps, concluded that the latter provided a better fit than other exponential expressions prevalent in population studies, and being free from some restrictive conditions necessary for the validity of von Bertalanfy's curve. The values of various parameters of Gompertz equition :

$$W_t = W_r \exp [G - G \exp -g (t - t_r)]$$

in respect of mrigal are : W_α 11.497 kg, G 6.8866, g 0.5788, t_r .0 and W_r 12 g.

3.44 Metabolism*

3.5 Behaviour

3.51 Migrations and local movements

Same as in catla (refer to Jhingran, 1968) and rohu (refer to Khan and Jhingran, 1975). Mrigal is said to be a local migrant undertaking short journeys in search of suitable spawning grounds in the breeding season.

3.52 Schooling

In ponds and other enclosed water bodies, mrigal could be seen schooling in shallows, even during the fry and fingerling stages, mainly for feeding purposes. In adults, this habit may not be so pronounced.

3.53 Response to stimuli*

4 POPULATION (STOCK)

4.1 Structure

4.11 Sex-ratio

According to Chakrabarty and Singh (1963), the number of individuals of the two sexes of mrigal is approximately equal, the sex ratio being 48.6% males and 51.4% females. Males were more numerous than females within the 260-319 mm and 680-739 mm class ranges, but the reverse was the case amongst larger specimens of the class range 740-799 mm. Khan (1972) reported that the sex ratio was very close to 1 : 1 and no significant difference was noted from this ratio. He also confirmed the findings of Chakrabarty and Singh (1963) that the percentage of females was little higher at older age.

4.12 Age composition

Age at maturity has already been discussed under 3.12 and maximum age under 3.3.

4.13 Size composition

Size at maturity and maximum size attained have been dealt with under 3.12 and 3.31, respectively.

The size composition of mrigal, as revealed from random samples from the catches of River Yamuna and Allahabad, both year-wise and pooled length-frequency distribution for the years 1961-62 to 1966-67 is given in Tables XXVII and XXVIII. Table XXIX shows the size composition of mrigal from catches of D.V.C. reservoirs (Jhingran and Natarajan, 1974).

- Length and weight relationship

Length-weight relationship in mrigal was first studied by Khan and Hussain (1945b). Using the total length of fish, they observed that weight (in chhatak i.e., 1 chhatak=58 g), which could be determined for a particular length (in cm) by multiplying the cube of the length with the weight-length factor 0.000 180, tends to increase approximatively to the cube of length. The length-weight relationship of mrigal derived by various workers is presented in Table XXX and in Fig. 10.

Jhingran (1952) studied the general length-girth relationship of mrigal. He based his observations on 1 102 fish ranging in total length from 200-1 010 mm and in girth from 82.6-736 mm. The length-girth relationship is described by the following formula:

$$\text{Log girth} = -0.758\ 780 + 1.1\ 846 \text{ log length.}$$

4.2 Abundance and density (of population)*

4.3 Natality and recruitment

4.31 Reproduction rates

Refer to Jhingran (1968) and Khan and Jhingran (1974). Alikunhi et al. (1964b) suggested that in order to produce about 50 lakhs of spawn in one breeding in a small bundh of 0.12-0.20 ha area, breeders of mrigal should be introduced in it as follows:

Average weight of females (kg)=2.0,3.0,4.0
Number of females to be introduced = 50-90, 30-60, 25-50
Number of males to be introduced = 80-120, 50-90, 40-70.

4.32 Factors affecting reproduction*

4.33 Recruitment

There are indications of breeding and recruitment of mrigal in the Konar reservoir, as revealed from the examination of species composition of catches. In 1963-64 mrigal formed just 1.30% of the fishery. But in 1967-68 it formed the dominant catch, contributing 38.78% of the total. Since there was no stocking from 1960, and the average wieght in 1967-68 was less than 1 kg, there is little doubt about their breeding and recruitment (Jhingran and Natarajan, 1974).

TABLE XXVII

Year-wise length frequency of Cirrhinus mrigala

Length group (mm)	1961-62 f	%	1962-63 f	%	1963-64 f	%	1964-65 f	%	1965-66 f	%	1966-67 f	%
1	2	3	4	5	6	7	8	9	10	11	12	13
51-70												
71-90	1				12							
91-110	29		18		23		1				5	
111-130	66		69		50		38				27	
131-150	35		26		113		32				7	
151-170	29		8		67		14				6	
171-190	11		15		56		13		1		15	
191-210	20		52		23		31		7		9	
211-230	21		129		46		44		12		5	
231-250	57		272		49		59		26		5	
251-270	121		366		75		75		48		1	
271-290	219		316		128		121		45		1	
291-310	317		368		211		195		81		26	
311-330	263		287		174		144		86		45	
331-350	227		286		141		181		110		69	
351-370	137		289		171		166		115		75	
371-390	158		260		149		151		116		120	
391-410	143		315		130		154		191		177	
411-430	117		390		120		154		198		244	
431-450	127		433		161		171		241		306	
451-470	131		389		175		168		258		357	
471-490	143		515		237		170		303		410	
491-510	188		488		250		242		379		459	
511-530	197		404		297		244		402		454	
531-550	224		402		260		291		380		377	
551-570	171		398		298		288		329		375	
571-590	120		223		212		242		272		240	
591-610	116		160		153		197		148		136	
611-630	89		113		119		123		94		93	
631-650	64		118		109		54		75		45	
651-670	40		89		51		56		46		40	
671-690	34		59		45		31		36		13	
691-710	27		51		36		32		24		18	
711-730	14		24		30		20		19		24	
731-750	15		29		19		28		23		26	
751-770	16		22		24		21		13		19	
771-790	11		25		28		26		26		15	
791-810	12		12		22		28		15		11	
811-830	3		9		29		20		22		15	
831-850	4		18		22		19		26		14	
851-870	6		13		20		16		22		18	
871-890	5		26		21		20		29		19	
891-910	11		10		16		12		14		4	
911-930	12		13		12		6		22		5	
931-950	8		11		9		9		13		8	
951-970	6		12		22		10		1		4	
971-990	3		1		5		6		7		3	
991-1 010	2		3		4				5			
1 011-1 030			1				1					
Total :	3 770		7 537		4 424		4 124		4 280		4 345	

f = frequency

TABLE XXVIII

Pooled length frequency distribution of mrigal of the Yamuna river for the year 1961-62 to 1966-67

Class range	January	February	March	April	May	June	July	August	September	October	November	December
1	2	3	4	5	6	7	8	9	10	11	12	13
51-70												
71-90									1	12		
91-110									33	35	7	1
111-130				2		3		1	76	100	59	9
131-150	2		1	2		7	2		29	88	27	35
151-170	2	5	1		1	14	1		7	45	23	25
171-190		2	1	4		25	2	2	11	35	20	9
191-210	5			12	1	14	24	5	17	30	31	3
211-230	7	3	4	17	4	37	37	24	27	46	34	17
231-250	5	9	6	41	10	45	131	28	62	76	45	10
251-270	5	18	1	28	10	50	149	69	95	171	62	28
271-290	16	9	4	5	15	44	120	96	95	282	118	26
291-310	34	13	12	8	34	75	186	128	168	306	188	46
311-330	41	36	13	9	29	82	160	100	129	205	150	45
331-350	49	37	11	14	26	89	189	123	133	179	116	48
351-370	64	44	12	20	23	63	164	149	111	132	97	74
371-390	50	30	17	26	32	54	151	141	128	139	110	76
391-410	56	52	19	38	28	58	168	174	146	163	117	91
411-430	74	57	48	43	73	74	136	195	140	121	141	121
431-450	97	45	47	65	103	81	142	201	188	165	154	151
451-470	136	68	40	81	74	108	182	174	184	146	134	151
471-490	170	108	77	72	108	164	222	175	164	156	172	190
491-510	213	151	94	119	101	190	215	199	190	157	173	204
511-530	273	168	109	125	86	149	156	160	156	205	183	228
531-550	270	174	111	133	118	104	149	144	186	155	208	182
551-570	283	163	93	117	109	92	109	122	180	190	208	193
571-590	157	151	83	83	79	50	81	88	128	127	132	150
591-610	113	87	51	52	46	33	55	64	106	99	99	115
611-630	67	49	40	36	38	24	24	47	78	83	76	69
631-650	45	33	17	37	44	12	23	31	61	65	49	48
651-670	29	19	23	12	21	10	13	27	37	53	40	38
671-690	18	11	13	10	17	6	11	17	22	37	34	22
691-710	9	7	13	15	11	6	6	14	23	38	33	13
711-730	4	7	13	15	8	4	7	10	13	17	19	14
731-750	11	6	14	15	11	5	5	7	13	13	26	14
751-770	6	9	17	8	8	7	7	3	11	7	19	13
771-790	6	13	11	5	15	5	10	8	15	18	9	16
791-810	12	13	15	16	9	3	2	3	7	5	7	8
811-830	6	11	23	14	9	3	6	3	6	6	9	2
831-850	6	16	22	13	6	5	9	4	5	1	10	6
851-870	8	19	22	7	5	2	7	3	6	2	8	6
871-890	9	31	23	10	4	3	3	3	4	7	11	12
891-910	2	16	11	4	5		1	1	5	4	5	13
911-930	3	19	13	2	8		3	4	4	3	6	5
931-950	7	12	11	2	4	3	2	2	3	4	5	3
951-970		14	10	6	9	3	1	4	2	2	4	
971-990	3	7	4	1	4	1		1	2	1		1
991-1 010		3	2		3		1		1	2	1	1
1 011-1 030	1				1							
Total :	2 374	1 745	1 172	1 344	1 350	1 807	3 072	2 754	3 208	3 933	3 179	2 532

TABLE XXIX

Pooled length frequency of mrigal from three D.V.C. reservoirs
(Jhingran and Natarajan, 1974)

Class intervals (mm)	D.V.C. reservoir									
	Konar				Tilaiya		Maithon			
	1963	1964	1965	1966	1961	1962	1962	1963	1964	1965
1	2	3	4	5	6	7	8	9	10	11
154.0										
297.4										
305.0										
330.2										
355.6	1				1	1	1			
381.0						6				
406.4	3	1	2			8	3			2
431.8	1	4	3		4	44	3			1
457.2	12	1	21	2	6	26	5	1	1	10
482.6	28	6	26	7	30	116	11	1	1	6
508.0	3	16	30	10	92	142	23	11	10	15
533.4	28	13	12	3	108	152	52	21	18	16
558.8	11	6	6	1	127	93	94	43	40	14
584.2	5	2	3		68	53	81	58	46	8
609.6	10	1	8		31	19	67	43	37	18
635.0	5		2		27		51	29	26	6
660.4	3		3		11		30	19	35	2
685.8	1				3		11	9	22	1
711.2	1		1		4		2	6	10	3
736.6					1		3	2	9	
762.0									1	1
787.4								2	3	
812.8								2	2	
838.2									1	
863.6										
889.0										
914.4										
939.8										
965.2										
990.6										
1 016.0										
Total :	112	50	117	23	513	660	437	247	262	103

TABLE XXX

Length-weight relationship in mrigal collected from different localities

Authority	Equation	Locality from where fish studied
1	2	3
Jhingran (1952)	$\text{Log } W = -4.922212022 + 3.0248352 \text{ Log } L$	Tanks and Fort moat at Cuttack
Jhingran (1959)	$\text{Log } W = -5.54534 + 3.221 \text{ Log } L$	River Ganga at Buxar
Chakrabarty and Singh (1963)	For males : $\text{Log } W = -5.85919 + 3.33668 \text{ Log } L$ For females : $\text{Log } W = -5.94481 + 3.36690 \text{ Log } L$ For Juveniles : $\text{Log } W = -5.3370 + 3.1270 \text{ Log } L$	
Srivastava and Singh (1964)	$\text{Log } W = -0.45276 + 2.0357 \text{ Log } L$	Ranchi Lake
Kamal (1971)	$W = 1.009 \times 10^{-5} \times L^{2.99552}$ or $\text{Log } W = -4.99627 + 2.99552 \text{ Log } L$	River Ganga and Yamuna at Allahabad
Khan (1972)	$W = 0.7328 \times 10^{-5} L^{3.0520}$ or $\text{Log } W = -5.1350 + 3.0520 \text{ Log } L$	From Fishery waters around Aligarh
Hanumantharao (1973)	$W = 10^{-9} \times 6853 \; L^{3.0830}$	River Godavari
Pantulu *et al.* (1967)	$W = 0.0011771 \; L^{3.2931}$ $W = 0.0063183 \; L^{2.7573}$ $W = 0.0012362 \; L^{2.6877}$ $W = 0.0287010 \; L^{2.2841}$	Maithon reservoir Tilaiya reservoir Panchet reservoir Konar reservoir
Devaraj and Natarajan (1973)	$\text{Log } W = -2.9003 + 2.0976 \text{ Log } L$	Aruputhiodai Paddy fields of Thaunjore District

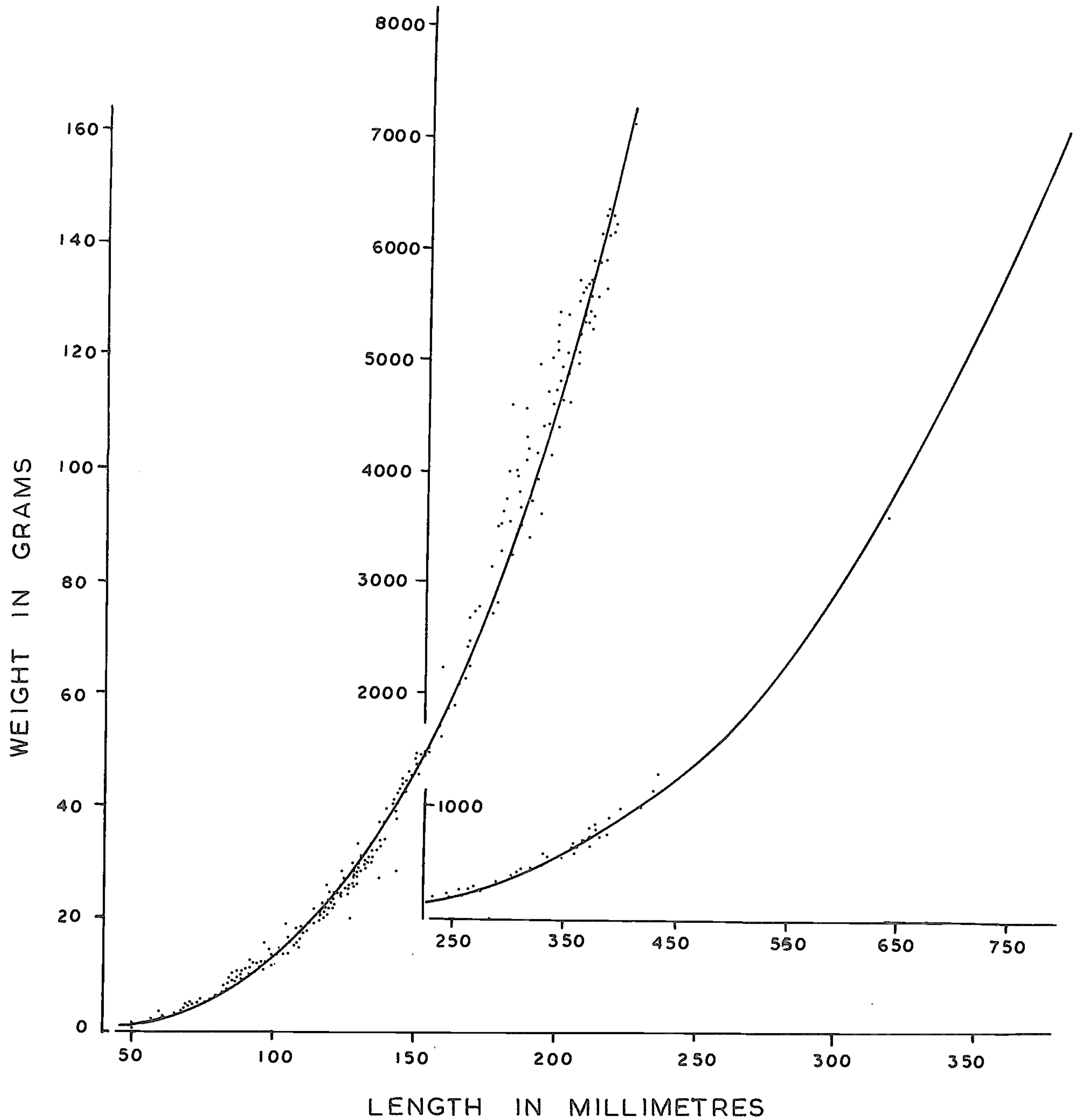

Figure 10 Curve depicting length-weight relationship of mrigal (Jhingran, 1952)

4.4 Mortality and morbidity

4.41 Mortality rates

Jhingran and Chakrabarty (1958) determined the mortality rates of Cirrhinus mrigala, Catla catla and Labeo rohita, between the fingerling and yearling stages, as a result of being commercially fished in a 208 km-stretch of River Ganga, between Patna and Moghalsarai. A total of 305 512 specimens of all the 3 species, weighing 12.7 t, was estimated to have been captured in 13 days. Species-wise, the catch consisted of 159 783 specimens of mrigal; 110 595 of catla and 35 134 of rohu, making 52.3% , 36.2% and 11.5% of the total catch of carp juveniles respectively. By weight, catla, being the heaviest of the three, constituted 8.9 t (70.5%), mrigal 2.8 t (22.1%) and rohu 1 t (7.4%) of the total weight of the catch, respectively.

Similarly, in 1953 a total of 328 408 specimens of these three species, weighing 14.99 t, were estimated to have been captured in 12 days (19 - 30 September) in the same stretch of River Ganga. By number, the catch consisted of 166 503 (50.7%) specimens of mrigal, 87 028 (28.5%) specimens of catla and 74 877 (22.8%) specimens of rohu. By weight, the percentage contributions of mrigal, catla and rohu amounted to 4.41 t (29.4%), 8.32 t (55.5%) and 2.26 t (25.1%), respectively.

4.42 Factors causing or affecting mortality

Large-scale mortalities of fish caused by oxygen depletion have been observed in lakes, ponds and tanks, usually in summer, when continuous sultry weather is followed by sudden showers. Other conditions which have been reported to cause severe mortalities are highly alkaline conditions of the water (570 ppm), drastic fall in the water temperature, etc. For predaton refer to 3.34. For diseases see 3.55 and 7.7. At times fish die as a result of injuries caused by nets, angling gear, screens, turbines, etc.

4.43 Factors causing or affecting morbidity

Fish mortalities due to pollution usually result from the sudden discharge of one or more toxic substances into normally clean water. When rivers receive a continuous but moderate pollutional load, fish will either be absent or be replaced by more resistant species. There are generally two categories of pollutants, viz. those altering the natural environmental variables beyond the range tolerated by fish and those poisons which exert a direct toxic effect on them (Palting, 1971). Organic pollutants containing nontoxic materials of high oxygen demand may deplete the oxygen resources of the water leading to asphyxiation and death of fish. Some effluents may contain chemicals such as sulphites which have a direct oxygen demand. Mookerjee and Bhattacharya (1949) reported on asphyxiation of mrigal 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.

The second category of pollutants include industrial wastes containing inorganic substances and various toxic agents e.g. acids, alkalies, dyes, oil, detergents, compounds of arsenic, chromium, sulphur, zinc, lead, vanadium, hydrocarbons, chlorinated hydrocarbons, cyanides, phenols, free chlorine, free ammonia, hydrogen sulphide, bio-cides and even some radioactive material which have deleterious effects on fish and fish food organisms. Surveys and characterization of waste waters discharged into various river systems of India and fish mortality caused by them have been carried out by numerous investigators (Bhimachar and David, 1946; Ganapati and Alikunhi, 1950; Menon et al., 1959; Seth and Bhaskaran, 1950; Motwani et al., 1956; Banerjea et al., 1956; Banerjea and Motwani, 1960; David and Roy, 1960; Qasim and Siddiqui, 1960; George et al., 1965, 1966; Ghosh et al., 1973). Saha et al. (1958) reported on the inimical effects of raw sewage (if in high concentration) on fish life due to presence of CO_2, H_2S , NH_3 and suspended solids. 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 pulp factories clog the gills of fish and bring about synergetic action after the suspended matter enters the gastrointestinal tract. The suspended colloids of pulp affluents accelerate the toxic effect of chlorine.

It is probable that the poisons enter the fish through the gills and, in cases of acute toxicity, as with heavy metal poisoning, the gills themselves may be affected, and result in death by asphyxiation. George et al. (1965) reported that the DDT and chloral hydrate present in wastes from the DDT factory in Delhi affected fish in River Yamuna mainly by coagulation of mucus in the gills and opercular chamber, under moderately acidic pH conditions. With other poisons, such as phenolic substances, the site of action may be the nervous system, the syptoms being similar to drunkenness, followed by muscular tumors.

4.44 Relation of morbidity to mortality rates*

4.5 Dynamics of population (as a whole)

The average annual mrigal landings based on 11 years' data for the period 1958-59 to 1968-69 along with average percentages contributed by the fish at different sampling centres along the Ganga river system is shown in Table XXXI. Mrigal was the most dominant species in the upper stretches of the Ganga from Kanpur down the Allahabad and in the Yamuna. Its average annual landing was found to be 31.2% and 22.4% at Agra and Allahabad and 21.8% at Kanpur. At Varanasi, Buxar and Ballia, its annual landings dwindled to 1.4%, 0.9%, 83.7%, respectively. Further down stream, mrigal became a little more abundant showing average annual landings of 9.7% and 6.3% at Patna and Bhagalpur, respectively. Table XXXII shows mrigal landings from zone I, II and III of the 189-km stretch of River Godavari, between Dowlaiswaram and Dummagudem anicuts, during the years 1963 to 1969 (Rajlakshmi et al., unpublished and Jhingran, 1975). Mrigal, which is a transplanted species in the Godavari system, forms an important fishery. During the period 1963 to 1966, the yield of mrigal was relatively stable, being 19.3 t in 1963, 18.6 t in 1964 and 18.5 t in 1963 as well as 1966. Thereafter, catches of the species fluctuated between 11.8 t in 1969 and 16.4 t in 1968. Mrigal catches from zone I and II were higher than those from zone III.

Pantulu et al. (1967) examined various aspects of fish populations over a period of about 4 years. Table XXXIII shows fingerlings stocked in the D.V.C. reservoir up to 1960. In Maithon reservoir, mrigal accounted for 52.1% and 24.7% of the total catches for a constant effort during 1961 and 1962. Only one size group of mrigal, with a modal length of 575 mm, contributed to the catches. In Tilaiya, mrigal contributed 52.2% and 28.8% of the total catches during 1960 and 1961, respectively. Length-frequency analysis showed that the modal size group that contributed to the catches was 500 mm for mrigal. In Panchet, mrigal showed a single modal at 500 mm and during 1960 contributed 40.4% of the total catch. However, in Konar, mrigal contributed about 2.3% during 1959, and showed a single mode at 575 mm. Taking the catch per unit effort as an index of abundance, mrigal was comparatively most abundant in Panchet and least in Maithon. The species composition for 1966-67 and 1967-68 indicated that mrigal formed 33% to 39% by weight in Konar, 43% in Tilaiya during 1967-68, 20% to 22% in Maithon and 22% to 36% in Panchet (Jhingran and Natarajan, 1974).

4.6 The population in the community and the ecosystem

Same as in Labeo rohita (refer to Khan and Jhingran, 1975). In a community where common carp is abundant, mrigal does not show satisfactory growth because of the competition for food between the two species.

TABLE XXXI

Annual market arrivals of mrigal and their total percentages in total arrivals at different markets

Year		Landings at							
		Agra	Allahabad	Kanpur	Varanasi	Buxar	Ballia	Patna	Bhagalpur
1		2	3	4	5	6	7	8	9
1958-59	Wt(t)	75.56	32.28	28.83	1.96	3.01	3.87	10.68	5.47
	%	24.6	22.2	30.9	4.2	2.8	8.5	19.6	13.2
1959-60	Wt(t)	89.98	43.85	42.0	1.8	2.26	3.14	7.94	2.69
	%	33.2	22.6	39.8	3.8	3.1	6.3	19.8	4.5
1960-61	Wt(t)	14.3	49.63	24.03	0.5	0.24	1.03	8.1	3.41
	%	24.6	24.8	29.4	0.7	0.4	1.2	8.4	4.0
1961-62	Wt(t)	27.95	51.74	5.16	0.73	Incomplete	3.06	12.01	4.42
	%	37.1	25.5	17.4	1.0	data	6.0	11.3	3.7
1962-63	Wt(t)	25.0	60.39	11.68	0.43	"	0.98	11.18	6.01
	%	39.9	22.9	22.3	0.4	"	1.4	8.6	6.1
1963-64	Wt(t)	20.37	45.79	9.89	0.62	0.13	1.83	9.03	4.18
	%	31.9	22.8	23.0	0.8	0.4	1.6	7.8	3.4
1964-65	Wt(t)	15.89	66.41	4.31	0.59	0.24	Incomplete	8.78	8.25
	%	37.4	25.9	12.8	0.8	0.8	data	11.4	10.8
1965-66	Wt(t)	19.0	46.28	6.61	2.08	0.18	"	9.12	6.2
	%	31.6	21.8	20.3	1.9	0.3	"	7.9	6.5
1966-67	Wt(t)	18.15	55.72	9.06	0.91	0.2	0.66	4.93	5.0
	%	33.1	29.9	18.6	0.9	0.3	1.3	4.2	6.0
1967-68	Wt(t)	12.21	41.78	4.05	0.56	0.06	0.76	4.35	6.6
	%	33.0	24.7	16.0	0.4	0.1	1.9	4.4	5.4
1968-69	Wt(t)	22.87	55.7	3.66	0.42	0.09	2.24	3.43	5.94
	%	27.2	24.4	9.2	0.3	0.1	5.4	3.1	4.3
Average	Wt(t)	31.02	49.53	13.57	0.96	0.71	1.95	8.14	5.29
	%	31.2	22.4	21.8	1.4	0.9	3.7	9.7	6.3

N.B. Year March to February

TABLE XXXII

Annual mrigal and total fish landings from a 189-km stretch of River Godavari during the year 1963 to 1969

Zone	Fish landings in t													
	1963		1964		1965		1966		1967		1968		1969	
	Mrigal	Total	Mrigal	Total	Mrigal	Total	Mrigal	Total	Mrigal	Total	Mrigal	Total	Mrigal	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
I	10.2	224.8	10.1	224.8	7.0	173.2	8.7	162.9	6.8	191.5	8.8	175.2	3.3	163.6
II	7.5	32.3	6.8	35.5	10.9	42.2	8.8	31.2	5.3	28.6	7.0	30.2	8.2	27.8
III	1.6	73.0	1.7	41.5	0.6	30.2	1.0	37.0	0.5	41.7	0.6	28.1	0.3	26.6
Total:	19.3	330.1	18.6	301.8	18.5	245.6	18.5	231.1	12.6	261.8	16.4	233.5	11.8	218.0

TABLE XXXIII

Fingerlings stocked in the D.V.C. reservoirs up to 1961 (Pantulu et al., 1967)

Reservoirs	Fingerlings (lakhs)
1	2
Maithon	1.8
Tilaiya	36.6
Panchet	1.0
Konar	5.6
Total:	45.0

5 EXPLOITATION

5.1 Fishing equipment

5.11 Gear

Fishing gear used to capture mrigal e.g. drag, gill, drift, purse, cast and scoop nets, traps, hooks and lines, are the same as those employed for catla (Jhingran, 1968).

Mrigal, like catla and rohu, is also caught by hand, when tanks are being fished with dragnets; some of the fishermen follow the net and collect the fish escaping from it.

MacDonald (1948) stated that mrigal is a good game fish and is caught in tanks and rivers in the same manner as rohu, although they do not come up to the surface like rohu to suck in vegetation.

5.12 Boats

In the mid-alluvial zone of the Ganga River system, fishing is done from small, light boats, known as "dongi" which are usually 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. In River Narmada, fishing is done from flat-bottomed boats 6-9 m long operated by 3 or 4 men. In River Godavari, open plank-built, undecked boats of c. 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. These pointed and elongated boats, measuring from 3 to 9 m in length and 0.9 to 1.8 m in width, are variously called locally as "dinghi", "jale dinghi" "jalia dinghi" or "pansi nauka" and used for operation of clap and dip nets.

5.2 Fishing areas

5.21 General geographic distribution

See Table Va under 2.1

5.22 Geographical range (latitudes, distances from coast, etc.)

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

5.23 Depth range

In rivers, fishing nets are operated both in deep and shallow waters depending upon the type of gear used. Drag nets are used in depths ranging from only a few cm to 11 m. Bottom-set gill nets, kamel, 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

5.31 General pattern of fishing season

Fishing in tanks and ponds is done throughout the year. In main rivers fishing is generally accentuated during the winter (November to February) and spring (March-June), but suspended during the south-west monsoon (May-October) because off excessively strong currents and greatly increased depths. During the monsoon, fishing is concentrated in small tributaries, creeks, nullahs, drains, etc., where adult mrigal migrate for spawning and the juveniles enter for shelter. From shallow inundated areas juveniles are fished out alive by fine-meshed drag nets from September to December for culture.

5.32 Dates of beginning, peak and end of season(s)

See 5.31

5.33 Variation in dates or duration of fishing season

In summer, when the water level runs extremely low, fishing nets can be easily operated in rivers and reservoirs, and on the whole there is therefore more intensive fishing. During the south-west monsoon, when rivers are in spate and often overflow their banks and inundate vast areas, fishing activity is greatly reduced.

In India, Bangladesh 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 the extremely high demand for freshwater fish in the eastern states of India, especially Bengal, influence the time and duration of fishing operations. Fishing activity in different parts of India, Bangladesh and Pakistan is suspended on certain religious festivals and ceremonial occasions.

5.4 Fishing operations and results

5.41 Effort and intensity*

5.42 Selectivity*

5.43 Catches

Annual landings of mrigal and their percentage composition in total fish arrivals at 6 urban assembly centres located on River Ganga and at 2 on River Yamuna, are presented in Table XXXIV. Table XXXV shows the average percentage distribution of annual landings in summer, monsoon and winter seasons at various fish landing centres for the period 1958-59 to 1965-66. The percentage composition of mrigal in the total fish arrivals at various marketing centres during the three seasons for the same period is given in Table XXXV. Table XXXVI gives the pooled averages of percentage contributions of different months to annual mrigal landings at various centres. The pattern that emerges from these tables is that mrigal catches are maximum in summer in the upper zones of Agra and Kanpur, during the monsoon at Allahabad and Buxar, and during winter in the lower zones of Ballia, Patna and Bhagalpur. The only centre that did not fit into the pattern was Varanasi, where the maximum availability was in summer, although monsoon landings were also quite high (Jhingran et al., 1972).

With a view to apportioning the contribution by various types of fishing gear to the landings of different species, a program was commenced in 1962 by the Riverine Division of the Central Inland Fisheries Research Institute to collect data on gear-wise catches. Preliminary data was collected for 15 days per month at different centres on the Ganga river system. Table XXXVII shows the percentage composition of gear-wise mrigal catches throughout the period of the investigation.

TABLE XXXIV

Average percentage landings of mrigal during different seasons at various centres of the Ganga River System

Season	Average percentage landings at							
	Agra	Allahabad	Kanpur	Varanasi	Buxar	Ballia	Patna	Bhagalpur
1	2	3	4	5	6	7	8	9
Summer	60.5	20.7	54.3	40.0	24.3	18.2	33.2	27.4
Monsoon	17.5	47.5	17.2	34.1	58.3	28.0	21.4	10.1
Winter	22.0	31.8	28.5	25.9	17.4	53.8	45.4	62.5

TABLE XXXV

Percentage composition of mrigal in the total market arrivals of fish, according to the seasons

Season	Places							
	Agra	Allahabad	Kanpur	Varanasi	Buxar	Ballia	Patna	Bhagalpur
1	2	3	4	5	6	7	8	9
Summer	33.5	17.4	29.0	1.8	1.1	1.5	10.3	6.5
Monsoon	37.8	25.3	26.6	1.5	3.1	2.3	8.7	2.8
Winter	21.1	17.3	25.8	1.1	1.0	8.3	11.5	8.3

TABLE XXXVI

Percentage distribution of average monthly landings of mrigal in different zones (Jhingran et al., 1972)

Zones	Months											
	March	April	May	June	July	August	September	October	November	December	January	February
1	2	3	4	5	6	7	8	9	10	11	12	13
Agra	16.5	16.9	9.3	17.8	15.0	0.4	0.7	1.4	6.3	7.9	3.4	4.4
Allahabad	7.2	4.6	4.5	4.4	7.4	8.8	13.4	17.9	9.8	7.0	7.3	7.7
Kanpur	11.8	16.2	16.4	9.9	7.0	2.1	2.7	5.4	5.4	6.4	6.9	9.8
Varanasi	10.2	8.9	8.6	12.3	10.7	10.8	10.0	2.6	6.8	5.6	6.4	7.1
Buxar	3.5	6.8	5.9	8.1	29.5	5.9	12.7	10.2	5.1	9.1	3.0	0.2
Ballia	3.7	3.9	4.4	6.2	6.2	5.3	2.7	13.8	14.2	20.8	15.6	3.2
Patna	8.4	14.2	4.1	6.5	8.6	3.4	4.0	5.4	12.2	11.3	11.7	10.2
Bhagalpur	8.4	9.2	4.5	5.3	2.9	0.5	3.4	6.3	6.6	12.9	20.7	19.3

TABLE XXXVII

Percentage of mrigal caught by different gear at different assembly centres of the Ganga River system (Jhingran et al., 1972)

Type of net	Local name of gear	Centre	Season	% composition of mrigal in the total landing
1	2	3	4	5
Drag (major)	Mahajal	Sadiapur (Allahabad)	Year round	2.8
	Mahajal	Bhagalpur	Late winter early summer	28.0
	Paunrhi	Buxar	Winter-Summer	0.3
	Darwari	Sadiapur (Allahabad)	Year round	4.3
	Joha	Ballia	Winter	40.1
	Chhanta	Sadiapur (Allahabad)	Monsoon	8.1
	Chhanta	Mahendorighat	Year round	12.3
	Chhanta	Ballia	Year round	6.8
	Poorai	Mahendorighat	Year round	0.4
	Ghanaili	Buxar	Summer-Winter	0.2
	Ghanaili	Ballia	Year round	2.9
	Kaprajal	Bhagalpur	Late winter early summer	9.1
	Chaundhi	Sadiapur (Allahabad)	Winter-Summer	18.1
Drag (minor)	Dodandi	Sadiapur (Allahabad)	Summer-Winter	0.1
	Sangel	Bhagalpur	Year round	0.9
	Kamel	Sadiapur (Allahabad)	Year round	6.2
	Songaila	Buxar	Winter-Summer	55.5
Scoop	Jali	Sadiapur (Allahabad)	Monsoon	2.6
	Bishal jal	Bhagalpur	Winter	5.3
Traps	Saira	Buxar	Winter	2.9
	Kuriar	Mahendorighat	Summer-Winter	58.3
	Kuraila	Ballia	Monsoon	100.0
	Sirki	Bhaglapur	Late winter early summer	14.5
	Chilwan	Ballia	Winter	2.3
	Arsi	Ballia	Monsoon	2.1
	Anta	Bhagalpur	Year round	5.9
Long line	Jor	Sadiapur (Allahabad)	Year round	12.6

6 PROTECTION AND MANAGEMENT

6.1 Regulatory (legislative) measures

6.11 Limitation or reduction of total catch*

6.12 Protection of portions of population

Closed areas: Certain areas have been declared as "protected waters" or sanctuaries and closed for fishing. Sanctuaries have been declared in Assam, Bihar (River Son above and below the anicut at Dehri and Barun, and Shahabad and Gaya districts) and Punjab (specified waters of Gurdaspur, Hoshiarpur and Ambala districts and near the specified bridges). In Tamil Nadu, fishing is prohibited in Cauvery River from Cauvery Bridge to its confluence with Ellis surplus Channel, Ullar River in Tanjore district, etc. Uttar Pradesh, Andhra Pradesh and Madhya Pradesh also observe restrictions on fishing in prohibited waters. Closed seasons: are followed in Bihar, Tamil Nadu, Madhya Pradesh, Karnataka, etc. In all large reservoirs fishing is closed from June-July to end of September so that fish are not hampered during their breeding migration.

Limitations on size or efficiency of gear: In Delhi, every year since 1948 restrictions have been imposed on fishing except with rod and line, hand lines, long lines, from 1 July to 31 August, and any net with a mesh size below 37 mm square mesh is prohibited. Generally, the minimum mesh size of the nets permitted is 25 mm in Indian reservoirs. However, nets of smaller meshes are permitted in marginal areas as in Tilaiya (D.V.C.) and some reservoirs of Andhra Pradesh and Tamil Nadu.

In 1956, the Punjab State Government prohibited the catching of mrigal, rohu, mahaseer and catla of a size smaller than 25.4 cm in length. In Delhi, the capture and sale of these species below 20.4 cm in length have 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 15 July to 30 September, and of breeders from 13 June to 31 July in certain prohibited areas, except with a licence issued by the proper authority. In Madhya Pradesh, the minimum limit of 22.9 cm has been imposed since 1953 for the capture of mrigal, rohu, mahaseer and catla.

6.2 Control or alteration of physical features of the environment

6.21 Regulation of flow*

6.22 Control of water levels*

6.23 Control of erosion and silting*

6.24 Fishways at artificial and natural obstructions*

6.25 Fish screens*

6.26 Improvement of spawning grounds

Alikunhi et al. (1964) recommended that the spawning grounds, located on muddy soil in the bundhs of Madhya Pradesh, may be prepared by leveling them at different elevations so that they could get flooded at different water levels.

6.27 Habitat improvement*

6.3 Control or alteration of chemical features of the environment*

6.4 Control or alteration of biological features of the environment*

6.41 Control of aquatic vegetation

Adult mrigal subsists mainly on blue-green and filamentous green algae, diatoms and pieces of higher aquatic plants, decayed vegetable matter, mud, detritus, etc. Hence, some weed growth in the pond will provide food for the fish. But excessive growth of aquatic weeds should be checked as they create a big problem to the fish culturists and are detrimental to fish health. For details on the control of aquatic vegetation refer to section 7.5

6.42 Introduction of fish foods (plants invertebrates, forage fishes)*

6.43 Control of parasites and diseases*

TABLE XXXXIII

Effectiveness of different drugs in sedating *Cirrhinus mrigala* (Kewalramani and Gogate, 1968)

Experiment No.	Sl. No.	Species	Total length (cm)	Weight (kg)	Anaesthetic concentration				Stage of anaesthesia
					(Mg)	(Ml)	(Mg)	(kg)	
1	2	3	4	5	6	7	8	9	10
Novocaine									
I	1	Mrigal	52	1.5	-	-	-	-	
II	1	-do-	52	1.5	20	0.5	13	I-(I)	
III	1	-do-	53	1.6	50	0.5	30	I-(2)	
IV	2	-do-	38.5	0.67	50	0.5	83	I-(1)	
V	1	-do-	39.5	0.6	60	0.6	100	II-(2)	
Amobarbital Sodium									
I	1	-do-	44	1.0	20	0.5	20	I-(1)	
	3	-do-	26	0.2	18	0.10	40.6	I-(1)	
II	2	-do-	24	0.2	10	0.12	50	1-2	
Barbital Sodium									
I	3	-do-	44	1.0	80	1.0	80	I-(1)	
II	2	-do-	27	0.325	48	0.6	148	II-2	

Experiment No.	Fish behaviour			
	State maintained	Complete recovery	Opercular rate	
			When undisturbed	When disturbed
1	11	12	13	14
Novocaine				
I	No anaesthesia given		130	170
II	3/4	3/4	130	
III	1/2	$2\frac{1}{2}$	120	
IV	3/4	$3\frac{1}{2}$	90	
V	1/2	5	90	
Amobarbital Sodium				
I	$3\frac{1}{2}$ to 4	$3\frac{1}{2}$ to 4	120	130
	-do-	-do-	105	120
II	$5-5\frac{1}{2}$	$5-5\frac{1}{2}$	120	130
Barbital sodium				
I	12-18	12-18		
II	36	36		

as low as 2.5 to 5 ppm, when O_2 concentration was maintained between 0.5 and 1 ppm. According to Saha et al. (1956), any concentration of dissolved O_2 above 0.5 ppm should be sufficient for maintaining the life of fry up to 5.08 cm in length, and the fry can stand a concentration 20 ppm of dissolved CO_2. They also observed that 0.4 mg of O_2 can diffuse through 1 cm^2 of still water surface at a temperature of 31°C in an hour, under 1 280 mm O_2 pressure. They furnished data(Table XXXXIV)indicating the maximum number of carp fry, catla, rohu and mrigal of different size groups that can be kept in a closed system under 1 sq cm of free surface at the above-stated pressure, without disturbing the oxygen balance. They further remarked that in estimating the actual requirement of O_2 for a medium of transport, a positive allowance of 25% is considered adequate.

Tank water, having a pH of 7.8 to 8.5 and a minimum dissolved O_2 content of 4 ppm, was found to be suitable for survival of catla during transport. Instantaneous mortality occurred in distilled water, even at a pH slightly below 7, possibly due to the absence of mineral ingredients, and at pH 8.8 or above, survival period was considerably decreased.

TABLE XXXXIV

Number of fry under 1 cm^2 of free surface area at 1 280 mm pressure

Length of fry (cm)	Average weight (g)	Maximum weight (g) of fry per sq cm	Maximum number of fry per sq cm
1	2	3	4
4.93 to 6.0	1.91	2.2	1.1
3.12 to 4.74	0.92	1.9	2.1
2.60 to 3.60	0.35	1.2	3.3
2.03 to 3.43	0.25	1.1	4.3
1.77 to 1.91	0.076	0.9	11.4

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of stagnant water are stocked from 12 to 20 lakhs per ha. However, much higher stocking densities, up to 7 812 500 larvae per ha are known to be adopted by fish farmers. With artificial feeding on rice bran and mustard oilcake, mrigal larvae attain an average length of 25 mm in 15 days. More recently, survival rate has been raised from 50% to as high as 70-75%. Stocking of larvae has been increased at the Pond Culture Division of the Central Inland Fisheries Research Institute from 1 million to 3.75 million/ha. Two to three crops each of c. 2.5 million fry, can be produced from one ha of water in a season. The Department of Fisheries, Government of Maharashtra, Bombay has suggested that the stocking density of fish larvae be 6 million per ha. In the case of rohu, during recent years, nursery ponds stocked at a very high rate of 6.25 million larvae per ha, yielded about 3.9 million of healthy fry in two week's time (Khan and Jhingran, 1975). At present the stocking rate of larvae of Indian major carps has been raised to 10 million/ha.

In rearing ponds, which are bigger than nursery ponds and are c. 183 cm in depth, a stocking rate of 50 000-75 000/ha fry (25-30 mm long) without feeding and 1.25-1.50 lakhs/ha with feeding is usually followed. Fry attain the fingerling stage in 3 months. In experiments conducted during 1965-1967 on the rearing of carp fry to fingerling stage, Indian major carp and common carp fry (size range 23.6-314 mm and average weight of 0.15-0.3 g) were stocked in properly prepared and manured ponds at the rate of 62 500, 93 750 and 125 000 per ha, and with a species ratio of catla 3 : rohu 4 : mrigal 1 : common carp 2. With proper feeding in the course of 3 months, an average survival rate of 72-80% was obtained. During 1972, two ponds (each of 0.08 ha in area) were stocked at the rate of 2.07 lakhs/ha, and with species ratio of catla 3.6 : rohu 3.6 : mrigal 1.6 : grass carp 10.2 respectively. The aggregate percentages of survival obtained were 75 and 39.2, respectively. Mrigal showed 77-95.5% survival (refer to Khan and Jhingran, 1974).

In production or stocking ponds of different sizes and c. 1.83 m or more in depth, fingerlings are stocked at various densities and ratios, depending on the fertility of the pond and the management techniques. Table XXXVIII shows rates of stocking in production ponds.

7.5 Pond management (fertilization, aquatic plant control, etc.)

Mrigal larvae and fry, being easily susceptible to diseases and predation, require specially prepared ponds for their rearing. Nurseries, which may be both seasonal and perennial ponds, are used for rearing of mrigal larvae. Perennial ponds have the disadvantage of harboring a host of predators, parasites and competitors, which are difficult to eradicate. Seasonal ponds are preferable because their bottom gets automatically exposed to the sun and soon mineralized, preventing the production of toxic gases and spread of diseases. The problem of eradicating predatory and weed fishes also does not exist in such ponds. The preparation of nursery ponds includes drying the pond bottom, removal of aquatic weeds, eradication of predatory and weed fishes, their fertilization for production of fish food and, finally, control of predatory aquatic insects just prior to stocking with fry.

Manual labour is cheap for the removal of aquatic weeds in nursery ponds. Algal blooms are harmful and should be immediately controlled by covering the water surface with Lemna, by the application of superphosphate or urea at 50 ppm or more, or by repeated application of raw cowdung. Recently, use of anhydrous ammonia at 15 ppm N has been suggested for the control of submerged aquatic weeds in perennial nursery ponds, which has the triple advantage of killing predatory and weed fishes, fertilizing the pond with nitrogen and controlling weeds.

The most efficient method of eradicating predatory and unwanted fish from ponds is by draining them. However, in many cases, nurseries may not have draining and re-filling facilities and the only method of predator removal in such cases is by poisoning to kill all fish. While the use of derris-root powder at 4-6 ppm was found to be an effective method, the non-availability of derris-root powder during the last few years compelled the use of other chemical and indigenous plant fish poisons. Endrin (Tafdrin-20) at 0.1 ppm and powdered bark of Barringtonia acutangula at 20 ppm have been found to be effective and suitable substitutes for derris-root powder.

Silkworm pupae feed is very well accepted by mrigal and rohu fry, whereas a groundnut oilcake and wheat bran mixture is well utilized by Catla fry.

The results obtained on the use of antibiotics, vitamins and micronutrients for enhancing the growth and survival of major carp larvae are very encouraging. In experiments conducted at the Biometry Research Institute of the Indian Statistical Institute the addition of yeast, vitamin B complex, and ruminant stomach extract with cobalt nitrate to ponds containing 3-6 day old hatchlings of catla and rohu, being fed on Daphnia showed higher survival. Yeast also resulted in better growth, and its addition to fry diet decreased the total protein per gram dry weight of fry. The addition of cobalt chloride at the rate of 0.01 mg/day/fish to the diet enhanced the survival and growth of rohu hatchlings and fry.

7.7 Diseases and parasite control

Large-scale mortality of mrigal often occurs in ponds and tanks due to parasitic afflictions, fungal and bacterial infestations, etc. Infestations are more liable to occur in ponds which are overcrowded with fish and such situations provide favourable conditions for the rapid spread of diseases. Adverse hydrological conditions, lack of food and mechanical injuries sustained by fish facilitate parasitic infections and spread of diseases causing en masse mortality. Weak or emaciated fish may die due to starvation or may be attacked by disease organisms. Certain algae may cause mortality among fishes by choking their gills or by producing toxic substances in the water. When intensive farming of cultivable species with heavy feeding is practised, parasites and diseases are more likely to occur. These can be controlled or minimized by maintaining satisfactory pond conditions, regular inspection of fish stocks for timely detection of parasites or diseases, removal and/or destruction of infected or diseased fish, prophylactic treatments and careful handling at all stages. (Reference should also be made to FAO Fisheries Synopsis FIRS/S111) Khan and Jhingran and to FR/S32 (Rev 1) on Catla V.G. Jhingran 1968.

7.8 Harvest

Harvesting of mrigal depends on the type of culture carried out and also on the local market preferences. In the case of nursery ponds, fry should be harvested at the end of 2-3 weeks in order to achieve maximum survival. In rearing ponds, where fry are grown to fingerling stage, periodical harvesting should be done at an appropriate time to avoid overcrowding. In production ponds, where the aim is to grow marketable-sized fish, it becomes essential to carry out partial harvests of the crop before the carrying capacity of that ecosystem is reached, because their carrying capacities cannot be further increased after a certain stage, no matter how much better management is practised. Thus, in order to get a sustained production throughout the year, a gap should be maintained between the carrying capacity and standing crop of fish at any time by periodical removal of fish. This "skimming" brings the biomass down again well below the carrying capacity, and the remaining fish grow fast until the latter is approached. Under intensive fish culture, multiple cropping is feasible in ponds when mrigal reaches marketable-size during a short rearing period. This becomes economical in the sense that the investment can be obtained very quickly. However, multiple cropping will depend upon the availability of fingerlings for replenishment of the harvested stock. If complete harvesting is desired, it may be done, as far as possible after draining the ponds, and by repeated seining. Where complete draining is not possible, any remaining fish can be poisoned with mahua (Bassia latifolia) oilcake @ 250 ppm, and fishes coming to the water surface may be caught by nets. Fish killed by the application of mahua oilcake in ponds can be eaten by human beings. Table XXXXII shows some data on total fish productions for composite culture of Indian Major carps, and the contribution of mrigal (by weight) therein.

7.9 Transport

Before their transportation to distant destinations, fish larvae, fry and fingerlings are conditioned in order to eliminate all food and excreta in their guts and also to accustom them to the crowded conditions prevailing during transport. Conditioning of fish seed can be achieved by confining them within cloth "hapas" pits, boxes made of wire mesh , bamboo or cane wicker baskets barrels or boats with perforated bottoms, temporary enclosures made of netting or bamboo matting, ect.

TABLE XXXXII

Total fish yield in composite culture of Indian major carps and percentage contribution by mrigal therein

Experiment	Total yield (kg/ha) & duration (months)	Contribution of mrigal (by weight) in total production (%)	Percentage of stocking of mrigal in total fish population	Authority
1	2	3	4	5
Indian major carps alone (3 species combination)	2 535 (12 months)	28.52	30.00	Anon. (1969)
	1 821 (12 months)	11.80	10.00	
	2 193 (12 months)	21.00	10.00	
	2 974 (12 months)	32.00	10.00	
	2 274 (11 months)	38.20	30.00	Sinha and Gupta (1974), and Gupta et al. (1976)
	3 174 (12 months)	30.20	30.00	
	1 761 (7½ months)	16.50	30.00	Khan et al. (1976)
	1 420 (7½ months)	24.50	30.00	
	1 806 (12 months)	32.30	30.00	Krishnamurty et al. (1976)
Indian major carps and common carp (4 species combination)	2 570 (12 months)	19.60	15.00	Khan et al. (1976)
	2 466 (12 months)	17.70	15.00	
	5 456 (18 months)	29.70	20.00	Sukumaran et al. (1976)
	1 676 (12 months)	26.60	30.00	Krishnamurty et al. (1976)
	2 244 (8 months)	19.08	20.00	Nambier et al. (1976)
	2 534 (8 months)	21.70	5.00	
	1 680 (12 months)	38.80	20.00	Sinha and Gupta (1974), and Gupta et al. (1976)
	2 322 (12 months)	34.30	20.00	
Indian and exotic carps (5 or 6 species combination)	3 236 (6 months)	10.10	11.50	Sinha et al. (1973)
	2 963 (6 months)	3.93	12.50	Khan et al. (1976)
	3 210 (6 months)	4.07	12.50	
	4 794 (12 months)	5.30	10.00	
	4 298 (12 months)	7.80	10.00	

TABLE XXXXIII

Effectiveness of different drugs in sedating *Cirrhinus mrigala* (Kewalramani and Gogate, 1968)

Experiment No.	Sl. No.	Species	Total length (cm)	Weight (kg)	Anaesthetic concentration				Stage of anaesthesia
					(Mg)	(Ml)	(Mg)	(kg)	
1	2	3	4	5	6	7	8	9	10
Novocaine									
I	1	Mrigal	52	1.5	-	-	-	-	
II	1	-do-	52	1.5	20	0.5	13	I-(I)	
III	1	-do-	53	1.6	50	0.5	30	I-(2)	
IV	2	-do-	38.5	0.67	50	0.5	83	I-(1)	
V	1	-do-	39.5	0.6	60	0.6	100	II-(2)	
Amobarbital Sodium									
I	1	-do-	44	1.0	20	0.5	20	I-(1)	
	3	-do-	26	0.2	18	0.10	40.6	I-(1)	
II	2	-do-	24	0.2	10	0.12	50	1-2	
Barbital Sodium									
I	3	-do-	44	1.0	80	1.0	80	I-(1)	
II	2	-do-	27	0.325	48	0.6	148	II-2	

Experiment No.	Fish behaviour			
	State maintained	Complete recovery	Opercular rate	
			When undisturbed	When disturbed
1	11	12	13	14
Novocaine				
I	No anaesthesia given		130	170
II	3/4	3/4	130	
III	1/2	2½	120	
IV	3/4	3½	90	
V	1/2	5	90	
Amobarbital Sodium				
I	3½ to 4	3½ to 4	120	130
	-do-	-do-	105	120
II	5-5½	5-5½	120	130
Barbital sodium				
I	12-18	12-18		
II	36	36		

as low as 2.5 to 5 ppm, when O_2 concentration was maintained between 0.5 and 1 ppm. According to Saha et al. (1956), any concentration of dissolved O_2 above 0.5 ppm should be sufficient for maintaining the life of fry up to 5.08 cm in length, and the fry can stand a concentration 20 ppm of dissolved CO_2. They also observed that 0.4 mg of O_2 can diffuse through 1 cm^2 of still water surface at a temperature of 31°C in an hour, under 1 280 mm O_2 pressure. They furnished data(Table XXXXIV)indicating the maximum number of carp fry, catla, rohu and mrigal of different size groups that can be kept in a closed system under 1 sq cm of free surface at the above-stated pressure, without disturbing the oxygen balance. They further remarked that in estimating the actual requirement of O_2 for a medium of transport, a positive allowance of 25% is considered adequate.

Tank water, having a pH of 7.8 to 8.5 and a minimum dissolved O_2 content of 4 ppm, was found to be suitable for survival of catla during transport. Instantaneous mortality occurred in distilled water, even at a pH slightly below 7, possibly due to the absence of mineral ingredients, and at pH 8.8 or above, survival period was considerably decreased.

TABLE XXXXIV

Number of fry under 1 cm^2 of free surface area at 1 280 mm pressure

Length of fry (cm)	Average weight (g)	Maximum weight (g) of fry per sq cm	Maximum number of fry per sq cm
1	2	3	4
4.93 to 6.0	1.91	2.2	1.1
3.12 to 4.74	0.92	1.9	2.1
2.60 to 3.60	0.35	1.2	3.3
2.03 to 3.43	0.25	1.1	4.3
1.77 to 1.91	0.076	0.9	11.4

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