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SYNOPSIS OF BIOLOGICAL DATA ON ROHU

Labeo rohita (Hamilton, 1822)

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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- MAST Sinopsis sobre métodos y materias
- OT Sinopsis sobre oceanografía
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- CB Lists of periodicals, special sections of "Aquatic Sciences and Fisheries Abstracts (ASFA)," special bibliographies and papers concerning documentation problems
- MFS Provisional editions of "FAO Manuals in Fisheries Science"
- WAFR Provisional reviews of fisheries resources and their level of exploitation, by regions or by species groups, within the World Appraisal of Fishery Resources system

Some documents also have another identification, if, for example, they have been contributed to a meeting for which papers have been numbered according to another system.

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- RE Listes indexées d'experts et institutions tirées des registres tenus à jour par la Division des ressources halieutiques
- IN Editions provisoires des listes et inventaires concernant les données sur les pêches accumulées et mises à jour par le Centre de données halieutiques de la FAO
- CB Listes de périodiques, des sections spéciales de la «Aquatic Sciences and Fisheries Abstracts (ASFA)», des bibliographies particulières et des articles sur les problèmes de documentation
- MFS Editions provisoires des «Manuels FAO de science halieutique»
- WAFR Synthèses provisoires des ressources halieutiques et leur niveau d'exploitation, préparées, par régions ou groupes d'espèces, dans le cadre du Programme mondial pour l'évaluation des ressources halieutiques

Certains documents portent parfois d'autres numéros d'identification, par exemple s'ils ont été préparés pour une réunion dont les documents ont été marqués à l'aide d'un autre système.

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- RE Listas índices de expertos y de instituciones tomadas de los registros que se llevan en la Dirección de Recursos Pesqueros
- IN Ediciones provisionales de los inventarios y listas de datos de pesca acumulados y guardados por el Centro de Datos Pesqueros de la FAO
- CB Listas de periódicos, secciones especiales de la «Aquatic Sciences and Fisheries Abstracts (ASFA)», bibliografías especiales y trabajos relativos a los problemas de documentación
- MFS Ediciones provisionales de los «Manuales de la FAO de Ciencias Pesqueras»
- WAFR Reseñas provisionales de los recursos pesqueros y de su estado actual de explotación, por regiones o por grupos de especies, en el marco del sistema mundial para la evaluación de los recursos pesqueros

Algunos documentos tienen también otra identificación si, por ejemplo, son contribuciones a una reunión cuyos documentos han sido marcados con arreglo a otros sistemas.

SYNOPSIS OF BIOLOGICAL DATA ON ROHU

Labeo rohita (Hamilton, 1822)

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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 Labeo rohita 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

Bibliographic entry:

Khan, H.A. & V.G. Jhingran (1975)
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Nomenclature. Taxonomy. Morphology (organisms). Geographical distribution. Ecology. Life history. Growth. Behaviour. Population dynamics. Fishing gear. Fishing grounds. Fishery management. Rearing. Fish culture. Artificial feeding. Bangladesh. Burma. India. Nepal. Pakistan.

CONTENTS

* As no information was available to the authors, these items have been omitted from the text

1 IDENTITY

1.1 Nomenclature

1.11 Valid name

Labeo rohita (Hamilton, 1822), Fig. 1
Günther, Cat.Fish.Brit.Mus., 7, p. 55, 1868

1.12 Objective synonymy

Cyprinus rohita Hamilton, Fish.Ganges, pp. 301, 388, pl. 36, fig. 85, 1822; type locality freshwater rivers of the Gangetic provinces; McClelland, Asiat. Res., 19, pp. 266, 391, pl. 41, fig. 2, 1839; Bengal and Assam.
Rohita buchanani Valenciennes, Hist.Nat. Poiss., 16, p. 251, 1842; Bleeker, Verh. Bat.Gen., 25, p. 133, 1853
Rohita duvaucelli Valenciennes, Hist.Nat. Poiss., 16, p. 353, 1842
Labeo rohita Günther, Cat.Fish.Brit.Mus., 7, p. 55, 1868; Day, Fish.India, p. 538, pl. 127, fig. 4, 1877; Day, Faun.Brit.Ind. Fish., 1, p. 262, 1889; Shaw and Shebbeare, J.Asiat.Soc.Beng., 3, p. 57, text-fig. 54, 1937; deep pools in clear streams, N. Bengal; Misra, Rec.Indian Mus., 57, pp. 162, 163, text-fig. 83, 1959; Srivastava, Fishes of Eastern Uttar Pradesh, p. 44, fig. 27, 1968; Ramgarh Tal, Gorakhpur; Menon, A check-list of fishes of the Himalayan and the Indo-Gangetic plains, p. 35, 1974
Labeo horai Fowler, Proc.Acad.Nat.Sci. Philad., 76, p. 97, 1924; type locality, R. Sutlej near Ludhiana

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 (Eventognathi)
Family Cyprinidae
Subfamily Cyprinini
Genus Labeo Cuvier 1817

- Generic

Labeo Cuvier, Regne Animal, 2, ed. 1, p. 194, 1817; type, Cyprinus niloticus (Forskål) Geoffroy. Not Labeo Bowdich 1825 (a sparoid fish) (Jordan, 1923). Marulius Hamilton, Fish.Ganges, p. 391, 1822; type Cyprinus morala Hamilton = Cyprinus angra Hamilton. Body oblong or elongate. Mouth inferior, wide, transverse and protractile, lips thick, covering the jaws, continuous at the angle of the mouth, papillate or smooth. Lower lip with an inner transverse fold. A soft and movable horny covering with a sharp margin on the inner side of one or both lips. Snout broadly rounded or obtusely pointed, projecting beyond the mouth and sometimes having a lateral lobe and often covered with tubercles. Barbels when present, four or two, if only one pair, they are on the maxilla, the second being the rostral, or they may be absent. Pharyngeal teeth 5.4.2. Eyes with a free circular rim. Dorsal fin with more than nine branched rays, begins before pelvic fins, ends above or before anal which has five rays. Scales moderate or small. Lateral line running along the middle of the tail. Gill-membranes broadly united with isthmus. Gill-rakers short.

- Specific

Labeo rohita (Hamilton, 1822). (Type locality: Gangetic provinces).

Fins: D.15-16(3/12-13); P.17, V.9, A.7(2/5), C.19.

Scales: Moderate, 40-42 scales along lateral line, scales in transverse series from origin of dorsal fin to base of ventral 6.5-9, 14-17 predorsal scales, about 20 scales round caudal fin.

Barbel: A pair of short thin maxillary barbels concealed in lateral groove.

Measurements: Head 4.5-5, depth 4.2-4.7 in total length. Eye located in the anterior half of head, 4.0-6.0 in total length, 1.6-2.0 in length of snout and 2.6-3.5 in inter-orbital width which is flat. Snout obtuse, without labial folds. Mouth inferior, with a distinct inner fold to each lip, width of the gape 4.2-5.0 in head length.

Colouration: Bluish along back, becoming silvery on the sides and beneath, usually with a red mark on each scale during breeding season, fins greyish or black, eyes reddish (Skene Dhu, 1923). According to environment, the body colour tends to vary in fishes living among weeds, exhibiting greenish black along back.

1.22 Taxonomic status

Labeo rohita is a morpho species

1.24 Standard common names, vernacular names

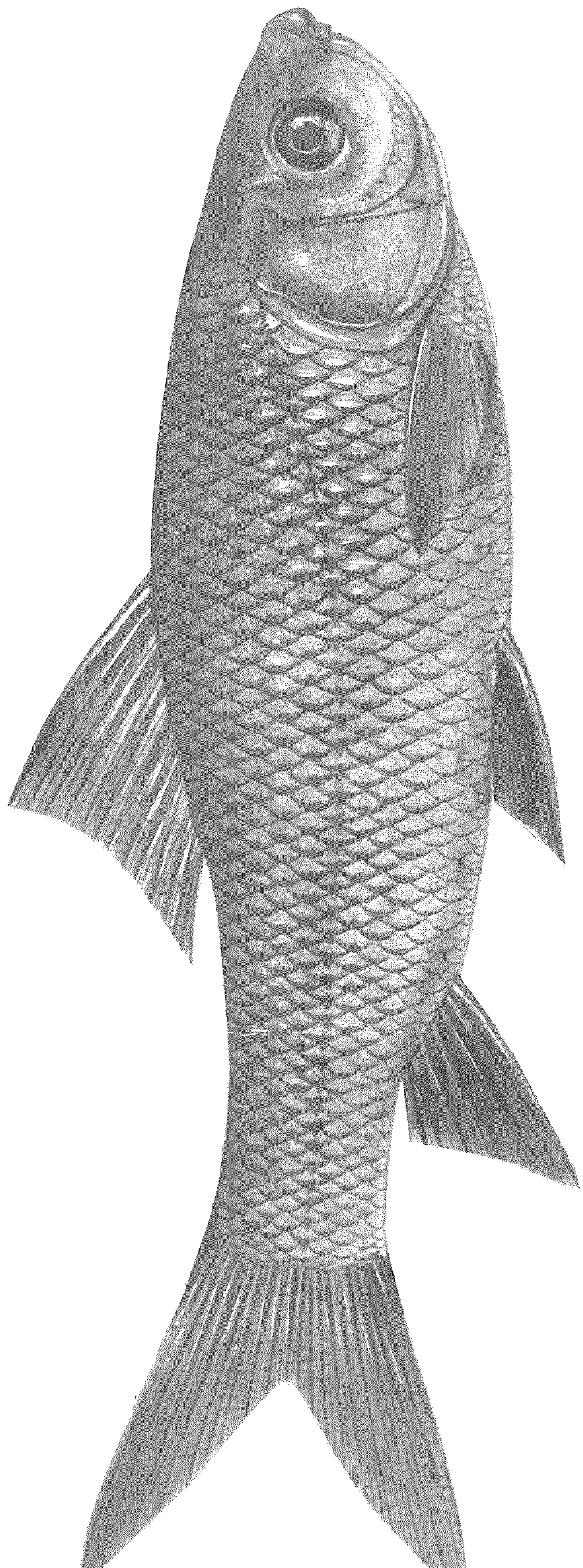

Figure 1 Labeo rohita (Hamilton, 1822)

TABLE I

Standard common names, vernacular names

Country	Standard common name	Vernacular name
Burma		Nga-myit-chin and Nga-myit-tsan-nee
Bangladesh	Rohu	1/ Ruee (Gengali)
India	Rohu	2/ Rohiti, or rui (Assamese) Ruee (Bengali) Rohu (Hindi) Tambada-massa (Marathi) Rohi, Ruhu (Oriya) Rohu, Tapra, Dhambra (Panjabi) Bocha-gandumeenu (Telegu)
Pakistan		3/ Rohu (Panjabi) Dum-bra (Sindhi)

1/, 2/ and 3/ These languages are spoken in Bangladesh, India and Pakistan.

TABLE II

Meristic counts of *Labeo rohita*

B	D	P	V	A	C	L.l.	L.tr.	Vert.	Authors
III	15	18	10	7	19+				Hamilton (1822)
	15-16			7		40-41	6/9		Günther (1868)
III	3/12-13	17	9	2/5	19	41	6½/9		Day (1869)
	3/12-13			2/5		41	6½/9		Day (1873)
III	15-16($\frac{3}{12-13}$)	17	9	7(2/5)	19	40-42	6½/9		Day (1878)
	16					41			Beaven (1877)
III	15-16(13/12-13)	17	9	7(2/5)	19	40-42	6½/9		Day (1889)
	3/12-13	17	9	2/5	19	40-42			Shaw and Shebbeare (1937)
	15-16($\frac{3}{12-13}$)	17	9	7(2/5)	19	40-42			MacDonald (1948)
III	3/12-13	17	9	2/5	19	40-42	6½/9		Misra (1959)
	16(3/13)	17	9	7(2/5)	19	40-41	6½-7½/9		Srivastava (1868)

1.3 Morphology

1.31 External morphology

Meristic counts of Labeo rohita, as described by various authors, are presented in Table II.

Khan (1972) carried out meristic studies of rohu obtained from two different environments around Aligarh, i.e., from moats which represented the lentic environment and from rivers Ganga and Yamuna which represented the lotic environment. The characters selected for study were total length, standard length, head length, body length, depth at pectoral fin base, depth at dorsal fin base, and depth of caudal peduncle. The regression of different body measurements on total length were carried out and it was found that within a certain range of independent variable, the regression of all the characters on total length were linear in fishes of both the environments. Table III shows equations of the regression of different body measurements on total length of rohu. The various body proportions expressed as percent of total length revealed that depth of caudal peduncle, depth at dorsal fin base and head length were more significantly different between the fishes of moat and rivers than other character (Table IV). Analysis of covariance revealed no significant differences between the two sexes or ages in both the environments. However, when the fishes of moats and rivers were compared, a significant difference (Table IV) was noted in each of the characters which suggested that the fishes of moats and rivers belonged to different independent stocks.

1.32 Cytomorphology

The diploid number of chromosomes, as determined by counting them at the spermatogonial metaphase plates, is 52 in rohu (Srivastava and Das, 1967).

1.33 Protein specificity

Haematological studies of rohu, conducted by Das (1958a) have shown average count of r.b.c to be 471 000 and that of w.b.c 7 100. The haemoglobin content of the blood was found to be 9.7 g. When compared to human beings, the average r.b.c count is only 1/10 but other figures are comparable.

Seasonal variations were observed in inorganic phosphorus, calcium, total protein, cholesterol and iron contents in the blood serum of L. rohita, with significantly higher values of all the constituents in the males in all the seasons, except calcium which is much higher in females especially during the spawning months (Table V). Naseem and Siddiqui (1970) observed that almost all biochemical constituents of the blood were low in the post-spawning period. These authors also reported that fish soon retain the normal values after intensive feeding in the first transitory period.

A comparative study of the albumin value of rohu with those of the other Indian carps was studied by Chandrasekhar (1959). Details are given by Jhingran (1968). Means and standard deviations of biochemical and electrophoretic measurements of rohu are presented in Table VI. Figure 2 presents the densitometric curve of the electrophoretic patterns of the plasma protein fractions of rohu (Das, 1961). For details refer to Jhingran (1968).

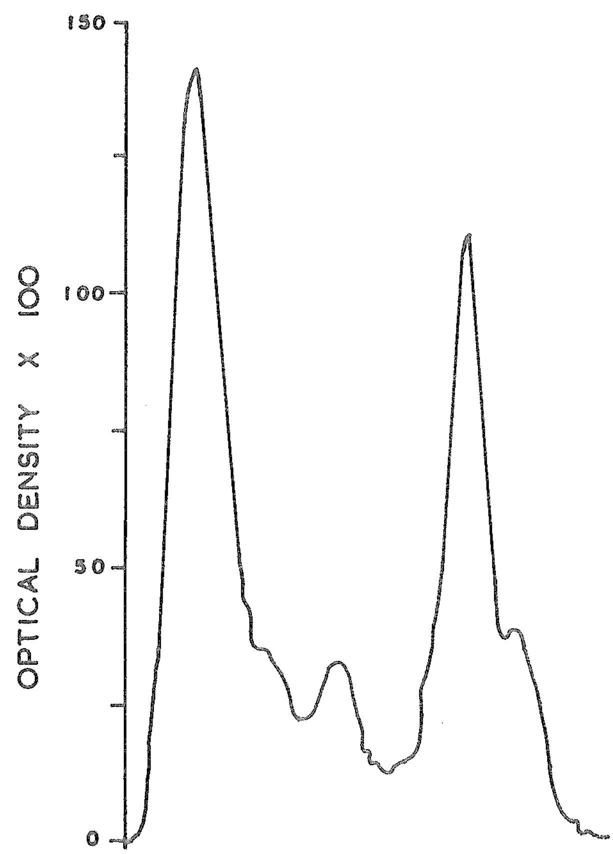

Figure 2 Densitometric curve for plasma protein fraction of L. rohita. The albumin fraction and globulin fraction a_1, a_2, β and γ appear when the graph is read from left to right (Das, 1961).

TABLE III

Equations of the regression of different body measurements on total length of *L. rohita* (Khan, 1972)

Character	Mean total length (cm) ($\bar{x}$)	Mean length of body measurement ($\frac{cm}{y}$)	Regression equation $y = a + bx$	Percent of total length
Moat fishes				
Standard length	29.81	25.17	$y = 0.730 + 0.820x$	84.4
Head length	29.81	6.68	$y = -1.330 + 0.269x$	22.4
Body length	29.81	18.49	$y = 2.560 + 0.551x$	62.0
Depth through pectoral fin base	29.81	8.18	$y = 1.080 + 0.238x$	27.4
Depth through dorsal fin base	29.81	8.83	$y = 0.900 + 0.266x$	29.6
Depth of the caudal peduncle	29.81	3.49	$y = 0.700 + 0.123x$	11.7
Riverine fishes				
Standard length	42.13	35.14	$y = 1.400 + 0.801x$	83.4
Head length	42.13	8.86	$y = -1.250 + 0.240x$	21.0
Body length	42.13	26.28	$y = 2.650 + 0.561x$	62.4
Depth through pectoral fin base	42.13	11.38	$y = 0.340 + 0.261x$	26.9
Depth through dorsal fin base	42.13	13.48	$y = 0.410 + 0.309x$	31.9
Depth of the caudal peduncle	42.13	0.141	$y = 0.130 + 0.141x$	13.8

TABLE IV

Comparison of different body measurements of *L. rohita* between moat and rivers by covariance analysis (Khan, 1972)

Characters	Deviation from total regression		Deviation from individual regression		Difference				Observed	5%	Significance
	D.F.	S.S.	D.F.	S.S.	M.S.	D.F.	S.S.	M.S.	F	F	
Standard length	831	18216.8	830	17995.8	21.68	1	221.00	221.00	10.20	3.84	S
Head length	831	965.0	830	916.6	1.10	1	48.05	48.05	45.40	3.84	S
Body length	831	4353.4	830	4298.5	5.23	1	54.90	54.90	11.00	3.84	S
Depth through pectoral fin base	831	1257.4	830	1225.3	1.47	1	32.06	32.06	21.80	3.84	S
Depth through dorsal fin base	831	1319.2	830	1205.9	1.45	1	113.27	113.27	78.11	3.84	S
Depth of the caudal peduncle	831	376.5	830	330.6	0.40	1	18.35	18.35	45.87	3.84	S

TABLE V

Seasonal changes in the biochemical constituents in blood serum of Labeo rohita (Naseem and Siddiqui, 1970)

Seasons	Sex	Length range (cm)	Weight range (g)	Alkaline Phosphatase (B.U) Range	Alkaline Phosphatase (B.U) Mean	Phosphorus (mg/100 ml) Range	Phosphorus (mg/100 ml) Mean	Calcium (mg/100 ml) Range	Calcium (mg/100 ml) Mean
1	2	3	4	5	6	7	8	9	10
Summer	M & F combined	31.0-56.5	215.0-1208	0.86-4.87	2.52	6.00-7.25	6.65	9.00-14.77	10.90
	Male	31.0-45.0	215.0-905.0	2.45-4.87	3.42	6.00-7.25	6.50	9.00-9.85	9.40
	Female	42.0-56.5	460.0-1208	0.86-2.05	1.62	6.45-7.25	6.80	10.50-14.77	12.40
Monsoon	M & F combined	41.0-46.0	448.5-936.5	0.22-4.21	1.13	8.20-10.12	9.10	7.60-10.00	9.05
	Male	42.5-45.5	475.0-544.0	0.22-1.20	0.36	8.20-10.12	9.40	9.15-10.00	9.60
	Female	41.0-46.0	488.5-936.5	0.86-4.21	2.00	8.20-9.40	8.80	7.60-9.40	8.50
First transitory period	M & F combined	40.0-59.0	340.0-3538	1.05-3.25	1.92	8.40-13.66	11.12	6.40-9.40	8.25
	Male	40.0-56.0	340.0-1422	1.85-3.25	2.03	8.40-13.66	11.03	7.80-9.40	9.05
	Female	43.0-59.0	356.0-3538	1.05-2.00	1.80	9.60-12.85	11.20	6.40-8.50	7.45
Winter	M & F combined	28.0-51.0	180.0-1365	2.86-7.26	5.28	9.60-14.50	12.02	7.80-11.50	9.33
	Male	41.5-51.0	723.0-1365	3.56-5.76	4.69	9.60-14.50	11.80	9.50-11.50	10.00
	Female	28.0-50.0	180.0-1180	2.86-7.26	5.87	9.60-13.50	12.23	7.80-11.00	8.65

Seasons	Sex	Protein (g/100 ml) Range	Protein (g/100 ml) Mean	Cholesterol (mg/100 ml) Range	Cholesterol (mg/100 ml) Mean	Iron (mg/100 ml) Range	Iron (mg/100 ml) Mean
1	2	11	12	13	14	15	16
Summer	M & F combined	1.05-2.08	1.540	150.0-308.0	219.8	30.28-34.06	33.28
	Male	1.05-1.32	1.200	150.0-205.5	175.0	30.28-34.06	33.39
	Female	1.25-2.08	1.880	218.0-308.0	264.5	31.18-34.76	32.14
Monsoon	M & F combined	2.00-3.60	2.890	210.0-337.0	260.3	26.54-32.33	29.17
	Male	2.15-3.05	2.740	210.0-309.0	245.5	28.53-32.33	31.18
	Female	3.00-3.60	3.050	221.3-337.0	275.0	26.54-30.37	28.36
First transitory period	M & F combined	2.15-3.60	2.765	191.2-375.0	301.5	27.71-33.64	31.68
	Male	2.22-3.54	2.985	262.5-375.0	328.0	27.71-33.64	32.67
	Female	2.15-3.60	2.535	191.2-309.0	275.0	28.18-31.66	29.74
Winter	M & F combined	1.20-3.11	1.905	175.0-361.0	240.9	26.05-30.37	28.54
	Male	1.20-3.11	2.265	221.5-361.0	258.1	26.05-29.94	27.30
	Female	1.20-2.37	1.540	175.0-264.5	223.8	27.15-30.37	29.81

M & F = Male and Female

TABLE VI

Biochemical and electrophoretic characters of rohu (Das, 1961)

Measurement	Mean	Standard deviation
Weight (g)	665.08	88.03
Blood sugar (mg per 100 ml)	95.34	14.29
Total plasma protein in g per 100 ml (micro-Kjeldahl)	2.87	0.46
Plasma albumin (%)	46.17	7.94
α_1 plasma globulin (%)	20.42	8.58
α_2 plasma globulin (%)	13.83	6.08
β plasma globulin (%)	6.83	2.82
γ plasma globulin (%)	12.75	7.93
α_F lipoprotein (%)	–	–
α lipoprotein (%)	77.80	7.88
β lipoprotein (%)	22.20	7.88
Plasma albumin (g/100 ml)	1.29	0.61
α_1 plasma globulin (g/100 ml)	0.62	0.39
α_2 plasma globulin (g/100 ml)	0.37	0.16
β plasma globulin (g/100 ml)	0.18	0.08
γ plasma globulin (g/100 ml)	0.34	0.18
Total plasma protein (electrophoresis)	2.80	1.16
α_F lipoprotein (g/100 ml)	–	–
α lipoprotein (g/100 ml)	1.26	0.75
β lipoprotein (g/100 ml)	0.34	1.12
Total lipoprotein (electrophoresis)	1.60	0.85

TABLE VII

Results of significance tests

Measure	Age (days)	F-ratios: Days (d) (5)	Rows (12)	Source of variation Columns (12)	Treatment (t) (2)	t x d (10)
Dry weight	3-8	27.92++	0.84	2.04	1.80	0.58
	9-14	4.59++	0.57	0.63	7.98++	0.71
	15-20	1.32	0.33	1.30	38.55++	0.75
	21-26	2.25	0.83	2.06	44.61++	0.65
Total protein per fish	9-14	0.73	0.90	0.81	1.00	0.81
	15-20	1.62	0.99	0.71	2.93	1.08
	21-26	0.38	0.85	0.35	10.47++	1.28
Total protein per g dry weight	9-14	3.08*	1.58	1.28	9.16++	0.62
	15-20	2.99*	1.29	1.36	7.45++	6.10++
	21-26	6.61++	2.59*	2.62	26.06++	2.76*
Non-protein nitrogen per fish	15-20	6.13++	1.38	1.55	6.27++	0.79
	21-26	2.23	1.15	0.73	2.72	1.30
Non-protein nitrogen per g dry weight	15-20	6.41++	1.20	1.59	0.42	1.55
	21-26	1.98	0.98	0.70	4.21*	0.95
Acid phosphate per fish	15-20	0.72	1.13	0.86	6.23++	0.31
	21-26	5.38++	1.32	1.33	5.76++	4.06*
Acid phosphatase per g dry weight	15-20	1.21	1.13	0.51	0.49	0.35
	21-26	4.65++	1.20	1.15	1.33	1.73
Alkaline phosphatase per fish	15-20	1.84	2.22	2.10	8.96++	0.72
	21-26	3.45*	1.08	0.63	10.35++	1.10
Alkaline phosphatase per g dry weight	15-20	2.28	1.92	1.41	0.94	0.91
	21-26	5.27*	1.93	0.90	0.18	0.47

*P $<$ 0.5 ++P $<$ .01

( ) = Degrees of freedom

Das (1968) conducted an experiment to quantitatively compare amylase in the rohu from the 3rd day to 16th day of post-embryonic life in the presence and absence of exogenous yeast Saccharomyces cerevisics. The yeast dosages used were 0 g, 0.5 g and 2 g daily per experimental unit containing 9 l of water. Amylase was evaluated by agar electrophoresis of the supernatant fluid obtained after centrifugation of a homogenate of whole carp. Only one electrophoretic band was observed for the tissue amylase so measured, in both treated and untreated fish. Exogenous yeast significantly enhanced amylase synthesis (Das, 1968).

Table VII shows total protein, non-protein nitrogen, acid phosphatase and alkaline phosphatase of post-embryonic rohu in relation to age and yeast treatment. A 6 x 3 x 3 latin-square design was employed to experimentally administer yeast for 6 days at 3 levels of treatment and was repeated 4 times, enabling study of fish from 3 to 26 days of age. This design required 5 experimental units, which initially contained 20 378 one-day-old rohu. The dosage levels were 0,0.5 g and 2 g yeast daily per experimental unit containing 9 l of water. Changes in total protein occurred with age and yeast treatment induced change in total protein, acid phosphatase and alkaline phosphatase (Das, 1970).

Qayyum and Naseem (1968) studied alkaline phosphatase in the blood serum of catla, rohu and mrigal. They remarked that the differences in the alkaline phosphatase were most probably due to diet difference among the three species. In catla, which is a surface plankton feeder, the values of phosphatase ranged from 0.50 to 6.72 B.U. with a mean of 3.04, while in rohu, which is a herbivore mid-column feeder, the range of phosphatase level was 0.26-7.80 B.U. with a mean of 3.23. In mrigal, which is a bottom feeder, the maximum range was 0.86-10.52 B.U. with a mean value of 4.27. There was no significant variation in the phosphate levels of males and females.

2 DISTRIBUTION

2.1 Total area

Day (1877 and 1889) mentioned the distribution of the fish as "Freshwaters of Sind and from the Punjab through India, Assam and Burma". According to Day, rohu is not found in Madras and the western coast of India. Setna and Kulkarni (1949) reported its occurrence in the Sabarmati drainage. It is also reported to occur in the Narmada and the Tapti. Alikunhi and Chaudhuri (1951) mentioned its occurrence in the Godavari. It is also found in the Mahanadi. The fish is, however, more common in the plains of northern India. Misra (1959) mentioned the distribution of rohu in India to be freshwaters of East Punjab, Uttar Pradesh, Bihar, Darjeeling district, West Bengal, Assam, Orissa, Madhya Pradesh and Ahmadabad; Pakistan, freshwaters of West Punjab; Bangladesh and Burma. The fish has also been recorded from Nepal (De Witt, 1960).

The earliest attempt to transplant rohu was made some time before 1925 when its fingerlings were taken from Calcutta to Andamans (Jones and Sarojini, 1952). The Madras Fisheries Department imported this carp from Bengal in the years 1943-1947 consecutively and subsequently in 1949 from Orissa (Thyagarajan and Chacko, 1950). The other interstate transplantation of rohu took place between Bihar and Bombay in which rohu fry along with that of kalbasu were introduced in Powai Lake, Bombay, where both species are reported to be established (Kulkarni, 1947). Rohu has also been transplanted in the lower reaches of the Godavari and the Krishna, where the fish has established itself (David, 1963). The fish has also been introduced in the Mettur reservoir. However, because of successful transplantations carried out since the beginning of the 20th century and the wanderings of the fish, aided by the occurrence of extensive canal systems, rohu has now spread over the whole of Peninsular India.

Rohu has been transplanted to Ceylon, where it is believed not to have thrived. It has also been introduced in Mauritius in 1961. Messrs. Fish Seed Syndicate, Calcutta, have exported Indian major carp seed to several countries, the details of which are given in Table VIII.

Figure 3 shows the geographical distribution of rohu including areas where it has successfully established itself as a result of transplantation. Table IX gives the rivers and lakes where rohu has been recorded to occur in literature.

2.2 Differential distribution

2.21 Spawn, larvae and juveniles

Rohu breeds naturally during the southwest monsoon in shallow inundated marginal areas, in fields adjoining rivers and in "bundh"-type tanks which simulate riverine conditions. The depth of water at the spawning ground in bundhs may vary from 0.5 to 1 m or even more. Spawning occurs over hard or sandy soil and even on rocky embankment. In bundhs, when breeding is over, a thick blanket of eggs remains over the spawning ground. The fertilized eggs, abandoned by the parents, either drift to the marginal areas of the bundh or get washed down the nullah depending on the location of the spawning ground. Larvae generally remain in surface or sub-surface waters while adult rohu inhabit deep waters.

2.22 Adults

Rohu can thrive well in all fresh waters below an altitude of approximately 549 m (Motwani, unpublished). Faruqui and Sahai (1943) reported that in the upper reaches of the rivers

TABLE VIII

Export of Indian major carp seed by Messrs. Fish Seed Syndicate, Calcutta (Personal communication)

Country where exported	Year of export	Total quantity of seed sent (Size up to 30 mm)	Sale/Gift
Africa (Blantyre)	1968	2 000	Sale
Japan (Tokyo)	1961	6 000	Gift
Malaysia:			
Penang	1957	4 700	Sale
	1959	6 000	Sale
Malacca	1957	2 620	Sale
	1961	300	Sale
Sarawak	1970	10 000	Sale
Nepal	1957	60 000	Sale
	1958	35 000	Sale
Philippines (Manila)	1965	15 000	Sale
U.S.S.R. (Moscow)	1966	3 000	Sale
South Rhodesia (Norton)	1965	6 600	Sale

Ganga, Yamuna and Sarda in Uttar Pradesh, catla and other major carps occur for a part of the year in certain sections of the rivers. Temperature and not altitude or latitude was attributed by them to limit distribution of catla in these rivers. A temperature of 57°F appears to be the minimum temperature tolerated by rohu. However, larger fish generally frequent deeper water but they also come up into shallow water for feeding. During monsoon months, rohu migrates to breed in shallow pockets in the marginal areas, in fields adjacent to the rivers which are inundated after heavy showers.

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 the developing eggs, hatchlings, spawn, etc. When heavy rains occur, causing appreciable quantities of silt-laden water to be washed down over the spawning ground, the fine silt-settling on the developing eggs would soon smother them. For the effects of other ecological determinants, see sections 3.16, 3.22, 3.33, 3.34 and 3.35.

2.4 Hybridization

2.41 Hybrids

In India, Chaudhuri (1959) produced a number of interspecific hybrids of the genus *Labeo*, *viz.*, (i) male *L. rohita* x female *L. calbasu*; (ii) male *L. calbasu* x female *L. rohita* and (iii) male *L. bata* x female *L. rohita*. Growth of both rohu-kalbasu and kalbasu-rohu were far satisfactory and superior to the slow growing *L. calbasu* (Chaudhuri, 1971). Hybrids of male *L. calbasu* and female *L. rohita* were successfully bred by induced spawning and backcrossed with parent species. The F_2 generation of rohu-kalbasu was obtained in 1966, the hybrids possessing varying characters intermediate between rohu and kalbasu (Chaudhuri, 1971).

A large number of intergeneric hybrids between *L. rohita* and other members of Cyprinidae have been produced. These are: (i) male *Catla catla* x female *L. rohita*; (ii) male *L. rohita* x female *Cirrhina mrigala*; (iii) male *C. mrigala* x female *L. rohita* and male *C. reba* x female *L. rohita* (Chaudhuri, 1959) and male *L. rohita* x female *C. catla* (Chaudhuri, 1973). The first generation of hybrid male *L. rohita* and female

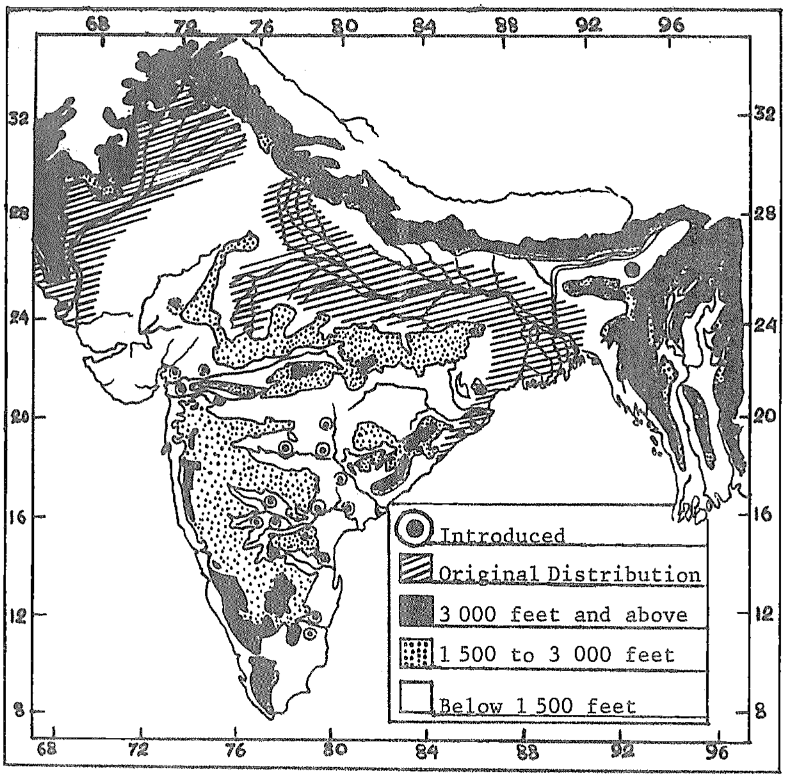

Figure 3 Geographical distribution of Labeo rohita.

TABLE IX

Distribution in rivers and lakes*

Habitat	Burma	India					Bangladesh	Pakistan
		Ganga River System	East Coast River System	West Coast River System	Brahmaputra River System	Indus River System		
Rivers and important tributaries	Irrawady	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		Powai				
		Lower-Bhopal		Bokh				

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

C. catla were induced bred in 1962 to produce F_2 generation (Chaudhuri, 1973). The first generation hybrids of male C. mrigala and female L. rohita were produced in 1958 (Chaudhuri, 1973). Of all the hybrids produced of greatest promise is the one between male catla and female rohu which seems to combine the quick growth of catla and small head of rohu.

The hybrids produced between L. rohita and Chinese carps such as male Aristichthys nobilis x female L. rohita; male Ctenopharyngodon idella x female L. rohita; male L. rohita x female C. idella and male L. rohita x female Hypophthalmichthys molitrix (Alikunhi et al., 1963) did not survive long. In most of the cases, either the embryos died before hatching or on the first day after hatching. The hybrid between grass carp and rohu survived for 2 weeks. Intergeneric hybrids produced by crossing male Cyprinus carpio with female L. rohita were sterile (Alikunhi and Chaudhuri, 1959).

2.42 Influence of natural hybridization in ecology and morphology

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

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.11 Sexuality

Rohu is heterosexual. Sex recognition is possible only when ripe females show a fully bulged and soft abdomen with a slightly swollen reddish vent. On being slightly pressed at their abdomen, the mature males and females exude milt freely and release eggs respectively. According to Mookerjee (1938), the pectoral fin, during the breeding seasons, is greater than or equal to anal fin in the males while in females, the former is less than the latter. Khan and Hussain (1945) observed that in identical-sized rohu, during the breeding season, the males have their pectoral fin better developed and greater than the anal fin during the breeding season, but in females, the pectoral fin is less than or equal to the anal. In a few females, pectoral was found greater than the anal, but the former being always less developed. Chaudhuri (1959) studied 55 male and 80 female specimens of rohu and inferred that pectoral fin in mature males of the majority of the species is slightly stouter and, when extended backward and toward the dorsal side of the body, meets the lateral line scales at a place more posterior to that in the mature females. While in male rohu, the pectoral fin reached 8th or 9th lateral line scale, in females, it touched 6th or 7th lateral line scale. The pectoral fin in mature males, during the breeding season, has a very rough dorsal surface which, in the case of females, is very smooth.

3.12 Maturity (age and size)

Rohu attains maturity towards the end of the second year of life in ponds (Alikunhi, 1957). It has been observed at Cuttack that a certain percentage of both males and females reached sexual maturity in one year only. The average size of maturity was 292 mm/282 g in one pond and 348 mm/500 g in the other pond. One of the smallest ripe female rohu has been reported to measure 26 cm in length and 250 g in weight in ponds at Cuttack (Sukumaran, 1969). Ali (1957) reported that rohu matures in Bangladesh at the age of 3-4 years. Khan (1972) estimated the maturity age of rohu by examining the gonadial condition of fish collected from the Aligarh market over a period of 18 months from July 1968 to December 1969. Seasonal cycle in gonad condition exhibited that gonads started development during the month of February; and ripe stage during June and July and finally spent individuals were found in late July and early August. The gonado-somatic index also gave exactly similar information. During the spawning season, males were found to mature earlier than females. The larger-sized individuals were also found to mature earlier than the smaller ones. The minimum age at first maturity for both the sexes was age II while complete maturity was reached by males at age IV and by femalesat age V. Fifty percent maturity point was 2.702 years for males and 2.937 years for females. The minimum size at first maturity of males was 46.2 cm and 100 percent maturity was found in 650 mm length group. The smallest mature female observed was 515 mm and all the females were mature in 700 mm length group. The 50 percent maturity points were 548.97 mm and 579.59 mm for males and females respectively. Table X shows number and percentage of males and females at various age groups and test of heterogeneity for sex ratio.

3.13 Mating

Rohu is polygamous and also seems to be promiscuous. A spawning female is often chased by several males. The spawning activity is characterized by splashing and frequent jumping. The fish first indulge in a courtship. The males chase the female, darting about in the water. The female is then held by the male, the latter bending its body round the female, rubbing, knocking and nudging her. At the climax of this activity, the pairs are seen to be locked in embrace, their bodies twisted round each other with the fins erect and caudal fin quivering. Sometimes, the coiling of the male may be behind the dorsal fin of the female. In this posture, mating occurs with vigorous splashing of water, wherein many fish lose a number of scales and also sustain other minor injuries. The sex-play lasts about 5-10 seconds and several such matings take place before the female is fully spent. The coiling and intertwining of the two sexes exert a pressure on the abdomen of the mating pair, resulting in the extrusion of the ova and ejection of the milt. All the eggs are not laid at one

TABLE X

Number and percentage of male and female rohu at various age groups and test of heterogeneity for sex ratio (Khan, 1972)

Age groups	No. of		Percentage of		Sex ratio
	Males	Females	Males	Females	
I	52	38	56.6	44.4	1:0.78
II	110	104	51.4	49.6	1:0.96
III	54	64	45.8	54.2	1:1.18
IV	32	33	49.2	51.8	1:1.05
V	28	33	45.9	54.1	1:1.18
VI	16	12	55.1	44.9	1:0.86
VII	2	4	33.4	66.6	1:1.93
VIII	1	1	50.0	50.0	1:1.00

Chi square (x^2) test of Heterogeneity (combined)

Degree of freedom	Observed x^2	5% n^2	Significance
7	10.80	14.07	Not significant

TABLE XI

Rohu fecundity (Alikunhi, cited by Sukumaran, 1967)

Length of fish (cm)	Weight of fish (kg)	Weight of ovary (g)	No. of eggs per g ovary weight	Total No. of eggs	No. of eggs per g body weight	Percentage of ovary weight in body weight
51	1.75	300	1 230	369 000	211	17
54.5	1.50	300	965	289 500	193	20
57.3	2.00	250	906	226 500	113	12.5
57.5	2.50	500	1 516	758 000	303	20
61	2.25	262	1 025	268 500	109	11.6
62.0	2.7	500	1 528	764 250	283	18.5
69.0	2.5	450	747	335 925	134	18
73.0	6.75	2 000	1 397	2 794 000	413	29.6

TABLE XII

Age, length, weight, ovary weight and estimated fecundities of 39 specimens of L. rohita (Khan, 1972)

No. of fish	Age (yr)	Lt (mm)	Wt (g)	Ovary wt (g)	Gona-doso-matic index	Total no. of ova	No. of ova/ g of body wt	No. of ova/ g of ovary wt	No. of ova/mm of body lt
1	II	540	1 801	390.0	21.6	621 345	535	1 335	1 116
2	II	550	2 140	540.0	25.2	787 520	368	1 450	1 458
3	II	558	2 010	456.0	22.6	747 720	372	1 600	1 366
4	III	558	2 216	561.8	25.3	901 912	407	1 608	1 616
5	III	560	2 250	596.0	26.4	950 250	425	1 603	1 707
6	III	573	2 393	525.0	21.9	851 908	356	1 620	1 486
7	III	575	2 355	608.0	25.8	965 550	419	1 582	1 675
8	III	578	2 416	572.0	23.6	1 024 334	424	1 790	1 722
9	III	583	2 500	624.0	24.9	910 200	364	1 459	1 561
10	III	595	2 652	685.0	25.8	1 092 624	412	1 595	1 836
11	III	602	2 703	627.0	22.1	993 575	367	1 610	1 659
12	III	608	2 750	706.0	25.7	1 185 580	431	1 680	1 950
13	III	613	2 920	629.0	24.9	1 188 440	407	1 630	1 938
14	III	625	3 010	637.0	22.1	1 090 250	362	1 710	1 744
15	IV	638	3 212	811.0	25.3	1 380 536	412	1 702	2 163
16	IV	640	3 510	889.0	25.3	1 611 250	459	1 812	2 317
17	IV	650	3 750	948.0	25.2	1 526 250	407	1 609	2 349
18	IV	661	3 800	894.0	23.5	1 420 636	373	1 589	2 149
19	IV	678	4 115	1 105.0	26.8	1 724 185	319	1 560	2 543
20	IV	689	4 450	1 020.0	23.1	1 710 840	384	1 661	2 483
21	IV	700	4 500	1 150.0	25.5	1 880 520	417	1 635	2 686
22	IV	702	4 760	1 164.0	24.4	1 984 920	417	1 705	2 827
23	IV	718	5 025	1 348.0	26.8	2 262 830	450	1 618	3 151
24	V	725	5 250	1 412.0	26.8	2 210 860	421	1 565	3 049
25	V	750	5 805	1 407.0	24.2	2 467 125	425	1 753	3 289
26	V	750	5 500	1 502.0	27.3	2 216 200	402	1 475	2 959
27	V	755	6 000	1 305.0	21.7	2 241 500	373	1 713	2 968
28	V	758	6 015	1 410.0	23.4	2 412 150	401	1 710	3 216
29	V	780	6 225	1 530.0	24.7	2 602 058	418	1 690	3 335
30	V	790	7 500	1 390.0	18.5	3 110 200	414	2 238	3 936
31	VI	790	6 510	1 765.0	27.3	3 005 100	461	1 702	3 803
32	VI	795	6 750	1 702.0	25.2	2 832 648	419	1 664	3 563
33	VI	800	6 750	1 748.0	25.8	3 106 000	460	1 776	3 832
34	VI	810	7 000	1 800.0	25.7	3 012 856	430	1 673	3 719
35	VII	820	7 907	2 077.0	26.2	3 400 010	430	1 636	4 146
36	VI	825	7 400	2 010.0	27.1	3 268 300	441	1 626	3 961
37	VI	855	8 507	1 950.0	22.9	3 449 845	405	1 769	4 034
38	VII	862	7 800	2 083.0	28.7	3 454 000	442	1 658	4 006
39	VII	871	9 210	2 060.0	22.3	3 521 025	382	1 709	4 042
				Mean :		1 926 233	488	1 654	

TABLE XIII

Summary of the regression analyses of the regressions of fecundity on body weight, gonad weight, length and age (Khan, 1972)

No.	Source	Regression coefficient (b)	Intercept (a)	Regression equation	Significance of 'b'				Correlation Coefficient (r)	Coefficient of variation of 'b' (CV)
					D.F.	Observed 't'	5% 't'	Significance		
39	Weight and fecundity	0.4698	-267.900	F = -267.900 + 0.4698W	37	302.9	2.614	S	0.99	0.00515
39	Gonad weight and fecundity	1.7180	59.497	F = 59.497 + 1.7180W	37	121.5	2.614	S	0.99	0.00820
39	Log weight and log fecundity	1.1569	2.034	Log F = 2.834 + 1.1569 Log W	37	59.6	2.614	S	0.98	0.01670
39	Log length and log fecundity	3.7590	-4.435	Log F = -4.435 + 3.7590 Log L	37	73.7	2.614	S	0.99	0.01340
6	Log age and log fecundity	1.3590	5.399	Log F = 5.399 + 1.3590 Log A	4	31.3	2.614	S	0.98	0.03170

D.F. = Degrees of freedom   S = Significant

TABLE XIV

Summary of the multiple regression analysis of the regression of fecundity on length, weight, gonad weight and age and their test of significance (Khan, 1972)

Source	Regression coefficients b_1	Regression coefficients b_2	Intercept (a)	Regression equation	S.E. regression coefficients b_1	S.E. regression coefficients b_2	Observed 't' b_1	Observed 't' b_2	Probability b_1	Probability b_2
Log length (x_1) Log weight (x_2) Log fecundity (y)	3.9295	0.5641	-2.8608	Log F = -2.8608+ 3.9295 Log L + 0.5641 Log W $(F=0.001378_L 3.9295_W\ 0.5641)$	2.7010	0.0845	1.450	6.60	0.10	0.001
Log length (x_1) Log age (x_2)	2.1385	0.5793	0.5395	Log F=0.5395+ 2.1385 Log L + 0.5793 Log A $(F=1.3463_L 2.1385_A 0.5993)$	0.4030	0.1290	4.490	4.49	0.05	0.05
Log weight (x_1) Log age (x_2)	0.6281	1.3236	6.0295	Log F=6.0295+ 0.0817 Log W + 1.3236 Log A $(F=107x_1 04_W 0.0281_A 1.3236)$	0.1130	0.2073	0.248	6.39	0.70	0.01
Weight (x_1) Gonad weight (x_2) Fecundity X 1000(y)	0.6240	-0.5700	7.9600	$F=7.9600+ 0.6290_W+0.5700_W{}^{o}$	0.0053	0.0195	116.8	29.2	0.001	0.001

place and at one time, but at intervals, during which the pairs keep on moving.

3.15 Gonads

Khan (1934) found a ripe rohu female of 4.54 kg containing a total number of 1 905 000 eggs, which worked out to be 419 eggs per g body weight. Fecundity of rohu is also reported to be about 2 million eggs at a time (India Council of Scientific and Industrial Research, the Wealth of India, New Delhi, 1962). Alikunhi (quoted by Sukumaran, 1969) reported the fecundity of rohu to vary from 226 500 to 2 794 000 depending upon the length and weight of the fish and weight of the ovary, as shown in Table XI. According to Khan (1972), the fecundity of rohu varied from 621 345 to 3 521 025 with a mean of 1 926 233 and the number of ova per g of body weight and ovary weight averaged 488 and 1 654 respectively (Table XII). The number of ova per mm of body length increased with length irregularly and did not show any definite pattern. Fecundity increased with increasing length, weight, ovaryweight and age. Table XIII shows summary of the regression analyses of the regressions of fecundity on body weight, gonad weight, length and age. Fecundity was related non-linearly to length and linearly to weight and ovary weight. However, fecundity was found to increase with age up to VI and later decreased in the subsequent age group. The multiple regression analysis (Table XIV) between fecundity and combination of length, weight, ovary weight and age revealed that fecundity was most significantly related to weight and ovary weight together.

3.16 Spawning

- Number of spawnings per year

Rohu spawns only once a year (Khan, 1972). Studies on maturation of intraovarian eggs showed that a single batch of ova started development in February, increased gradually in size and was finally discharged in July. The absence of multiple modal curves and presence of only 2 widely separated groups of ova in ripe ovary indicated that every individual spawns only once during a season and the spawning duration is short. The size of mature ova and the number of mature ova per g of body weight were not found to differ significantly in various regions and lobes of the ovary. The size of mature ova was almost constant and was not affected by size, body weight or age (Table XV).

At the Cuttack Pond Culture Substation of the Central Inland Fisheries Research Institute, rohu has been induced to breed twice within the same spawning season after an interval of about 2 months. Almost equal quantities of eggs were obtained at each of the two spawnings, thereby doubling the production of spawn. In 1972, 5.95 lakhs of spawn were produced from 2 numbers of rohu for the second time, which was about the same obtained when the fish bred for the first time (Central Inland Fisheries Research Institute, Barrackpore, Annual report 1972).

- Spawning seasons

The spawning season of rohu generally coincides with the southwest monsoon, but it appears to be somewhat variable in different parts of India, as shown below:

Authority	Spawning season	Locality
Khan (1924 & 1942)	July-August	Western Uttar Pradesh and Punjab
Das and Das Gupta (1945)	June-August	Orissa and West Bengal
Ahmad (1948)	April-June	River Halda, Chittagong
David (1959)	April-August	Ganga system of north Bihar
Qasim and Qayyum (1962)	July-August	Ganga system (Aligarh, Uttar Pradesh)
Parameswaran _et al._ (1970)	April/May-June	Assam
Khan (1972)	June-September	Aligarh

TABLE XV

Comparison of size of ova in the fishes of different length and groups (Khan, 1972)

Length group (mm)	No. of fishes	Mean size (mm)	Age group	No. of fishes	Mean size (mm)
550	1	1.07	II	2	1.05
600	5	1.05	III	6	1.10
650	4	1.10	IV	5	1.06
700	4	1.14	V	3	1.13
750	2	1.12	VI	2	1.12
800	2	1.10			

- Spawning time of day

Alikunhi et al. (1964) observed active spawning of rohu and mrigal commencing in the morning and continuing up to evening in the bundhs of Madhya Pradesh. Gopalakrishnan et al. (1966) observed breeding of major carps at the head waters of Tilaiya reservoir during night which continued till the next evening.

- Factors influencing spawning time, temperature run-off, photoperiod, lunar or tidal cycles, size, age, latitude and altitude

No single factor can be said to be responsible for spawning. The act involves fulfilment of a chain of interrelated conditions as a prerequisite to spawning. 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, 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; optimum temperature (22-31°C) at the spawning ground; cloudy days accompanied by thunderstorms, etc., are believed to be factors influencing the spawning of catla. Other factors like high pH and high oxygen content of water are incidental to floods and are not essential in themselves for spawning. Flooding in the early phase of the southwest monsoon is necessary and the fish do not spawn if rains are delayed. Spawn-prospecting investigations carried out by the Allahabad Substation of the Central Inland Fisheries Research Institute revealed that intensive spawning of major carps in the Indo-Gangetic plain generally occurred during the middle and later parts of the monsoon rather than at its commencement or the terminal phase. Celestial bodies like the moon have no effect on spawning. Low alkalinity, minerals either in solution or in suspension and low salinity do not seem to play any significant part in the spawning of fish.

- Location and type of spawning ground

Rohu does not breed naturally in small confined waters. It spawns in rivers, reservoirs and bundh-type tanks where fluviatile conditions are simulated during the spawning season. Breeding grounds are found in the middle reaches of most of the rivers, where flood water spreads in more or less limpid shallows over fertile flats, well above tidal reaches. Spawning of major carps has been observed on soft, clayey, hard, sandy and even rocky soil in the bundhs of Madhya Pradesh.

- Ratio and distribution of sexes on spawning ground

Rarely a single couple is seen. Two to three males or even more are often seen chasing the female, but the reverse has also been observed.

- Nature of mating act

(Refer to section 3.13).

- Induction of spawning

Since the initial success in induced breeding of Indian carps by hypophysation (Chaudhuri and Alikunhi, 1957), several investigators have successfully adopted the techniques to breed carps in different parts of India (Alikunhi et al., 1960, 1964; Chaudhuri, 1960; Chaudhuri et al., 1962; Vijayalakshmanan et al., 1962; Roy and Das, 1962; Rajan and Rao, 1965; Kulkarni, 1968 and many others).

The technique of induced breeding of Indian carps by means of pituitary injection, termed as hypophysation, has been reviewed by Alikunhi et al. (1960); Chaudhuri (1963, 1967 and 1969); Das and Khan (1962); Bhimachar and Tripathi (1967 and 1972); Jhingran (1968, 1969 and 1973); Chondar (1970); Shehadeh (1970); Bardach et al.

(1972), etc. In 1969, the FAO/UNDP regional seminar on "Induced breeding of cultivated fishes" was held from 15 July to 18 August, 1969 at Barrackpore, Cuttack and Bombay. Various aspects of induced breeding of Indian major carps including rohu and other important culturable species were discussed. In 1971, a workshop on hypophysation of carps was held at Bombay and the results reported by various workers on induced breeding of rohu are presented in Table XVI. Rohu has also been successfully induced-bred by hypophysation in Pakistan (Khan and Bhatti, 1967) and Burma (FAO, 1971).

The pituitary glands, immediately after collection, are preserved in absolute alcohol. The weights of dried preserved gland show variation from 7.0 to 18.8 mg in rohu of 1.0-3.6 kg in weight and 3.0-22.8 mg in mrigal (0.3-3.5 kg in weight). At the time of injection of breeders, the required quantity of alcohol-preserved glands, dried for 2 minutes, are triturated with the help of tissue homogenizer either in distilled water or 0.3 percent saline. Further, dilution is usually made by adding the same fluid to render the total solute at the rate of 0.2 ml per kg weight of the breeders. Usually, the volume of the dose does not exceed 1 ml. The gland suspension is then centrifuged and the supernatant fluid drawn into a hypodermic syringe for injection. Ibrahim and Chaudhuri (1966) have devised a method for preserving pituitary extract in glycerine. In this method, a known quantity of pituitary glands, after homogenizing in distilled water, is diluted with 1/3 of the total volume of extract calculated at the desired concentration and the suspension is kept under refrigeration for 24 hours. Pure glycerine is then added to make up the total volume of the extract (i.e., 3 ml of extract will have 1 ml water and 2 ml glycerine). The extract, with glycerine added, is again kept in the refrigerator for another 24 hours, after which it is centrifuged and the supernatant fluid is then transferred into ampoules for future use. This method has the advantage of hormone extraction from a large number of glands at a time, ensuring uniform hormone potency per unit volume of the extract, and saving time in the preparation of the dose for injection. Glycerine extract has been found to retain its potency from 9 to 61 days at room or under lower temperatures.

In usual practice, the female alone is injected with a stimulating dose of 2-3 mg/kg weight followed by a second dose of 5-8 mg/kg weight after a lapse of 6 hours. Two males (per female) are given a single dose, each of 2-3 mg/kg weight, at the time of second injection to the female. Both the injected males and one female are kept together in a breeding 'hapa' for spawning. Slight alterations in doses may occur depending on the stage of maturity of the breeders as well as environmental factors. When the males are not ripe enough, they also are injected with a stimulating dose (1 mg/kg) as in the case of the females (Alikunhi *et al.*, 1964). Das and Khan (1962) suggested the use of magur units (*Clarias batrachus*) for calculating the doses of glands to be given to carp breeders. They have also discussed the harmful effects of overdosage. Not only does the overdose inhibit spawning, but it may lead to premature release of sex products which either cannot fertilize or at best lead to deformed progeny highly susceptible to mortality.

Chaudhuri (1960) obtained success in induced spawning of 3 out of 7 sets of rohu injected with homoplastic pituitary extract in 1957 and the maximum successful dose which brought spawning in a female rohu weighing 4.8 kg in one injection was one full rohu gland. In 1964, Alikunhi *et al.* conducted successful experiments at temperature controlled at 28°C in the laboratory and observed that in controls the fish spawned successfully when the temperature rose only 1.8-2.3°C. During this period, these workers successfully spawned 16 out of 18 sets of rohu under controlled temperature in the laboratory and 11 out of 14 sets kept in hapas fixed in a pond.

In 1967, six sets of rohu were bred by means of hypophysation in the air-conditioned laboratory at a temperature 28°-31°C while among the controls, kept in ponds at a temperature of 30°-34°C, only four spawned (Central Inland Fisheries Research Institute, Barrackpore, Annual report 1967). Ibrahim *et al.* (1968) reported that the induced spawning of 391 sets of catla, rohu and mrigal occurred in a wide range of temperature from 26.5° to 35.0°C during 1964-1966. These authors did not find any correlation between water temperature and percentages of spawning success in induced fish breeding. Fishes, if given an effective dose of pituitary, spawned successfully even when there was a substantial increase or decrease in water temperature.

Tripathi (1973) successfully bred several sets of small-sized (215-270 mm), nursery-reared, three-year old rohu and mrigal obtained from the gill-net catches of Adhartal Lake in Madhya Pradesh, with only one injection to the females.

Indian major carps have been successfully induced-bred by injecting them with pituitary gland extract of another species from the same family or even from a different family. Recently, pituitary glands from catfishes, *viz.*, *Pangasius pangasius*, *Silonia silundia*, *Bagarius bagarius* and *Mystus seenghala* (Central Inland Fisheries Research Institute, Barrackpore, Annual report 1971) gave positive results in successful hypophysation of major carps. Ibrahim and Chaudhuri (1970) studied the role of sex specificity of teleost pituitary glands. They separately weighed pituitary glands of both male and female fishes in bulk and prepared their extracts

TABLE XVI

Results reported by various workers on the induced breeding of *L. rohita* during 1971 at various places

Sl. No.	Name of centre and state	Dose of injection given (mg/kg) 1st	2nd	No. of trials made Success	Failure	Average wt of spawned fish (kg)	No. of eggs laid Fertilized (lakhs)	Unfertilized (lakhs)	Matching hapa Size	No. of eggs/hapa (lakhs)	No. of spawn obtained (lakhs)	Authority
1	2	3	4	5	6	7	8	9	10	11	12	13
	Andhra Pradesh											
1	Regional Fish Seed Farm, Hyderabad (A.P.)	F 4 M 6	12 12	8	11	1.05	7.64	11.09	1.8x0.9x0.9m	0.75	1.29	Rao(1971)
2	Hyderabad	F 4 M 2	12 6	1	1	1.2	1.01	1.54	1.8x0.9x0.9m	0.51	0.0805	Rao(1971)
3	Balabhadrapuram	4	10	8	46	6.43	3.77	1.18	180x75x30" 100x100x30"	0.38–0.42 0.35–0.41	1.975	Datta(1971)
	Assam											
4	Gauheti (Assam)	F 3 M 1	9–10 3–4	35	6	3.5	120.43	30.77	1.5x1.4x1m	0.8–1.0	87.4	Das(1971)
5	Roha (Assam)	F 2–4 M 1–2	6–8 3–4	13	7	2.0	16.38	21.37	1.4x1.2x1m	0.8–1.0	8.40	Das(1971)
	Bihar											
6	Darbhanga (Bihar)	F 4 M –	8 4	8	1	1.5	11.95	0.75	2x1x1m	1.0	5.65	Banerjee(1971)
	Gujarat											
7	Prentij	F 2.0 M –	6.0 3.0	7	19	2.5	25.97	4.03	$5x2\frac{1}{2}x1\frac{1}{2}$'	0.5–0.6	21.0	Menon(1971)
8	Dentiwada	F 3.0 M –	9.0 3.0	7	2	3.5	9.95	15.63	$5x2\frac{1}{2}x1\frac{1}{2}$'	0.25–5.0	2.50	Menon(1971)
9	Godhra	F 3.0 M –	6.0 3.0	1	5	5.0	1.50	1.00	$5x2\frac{1}{2}x1\frac{1}{2}$'	0.25	1.00	Menon(1971)
10	Baroda	F 4.0 M –	6.0 3.0	1	3	2.0	2.40	1.60	$5x2\frac{1}{2}x1\frac{1}{2}$'	0.4	1.00	Menon(1971)
11	Debhoi	F 4.0 M –	6.0 3.0	1	–	2.0	0.51	1.53	$5x2\frac{1}{2}x1\frac{1}{2}$'	0.4	0.35	Menon(1971)
12	Kakrapar	F 3 M –	5.0 3.0	10	12	0.75	6.02	2.60	$5x2\frac{1}{2}x1\frac{1}{2}$'	0.5	4.00	Menon(1971)
	Maryana											
13	Kernal	2–3	5–8	3	–	1.02	2.298	0.905	134x72cm	0.51	0.62	Khanna(1971)
	Kerala											
14	Malampuzha	2	4	11	8	0.7	6.0	2.00	145x60x40cm	0.45	4.00	Meeran and Sebastian(1971)

Continued

Table XVI concluded

1	2	3	4	5	6	7	8	9	10	11	12	13
Madhya Pradesh												
15	Patra	F – M 3	6 3	1	–	1.05	4.43	0.17	7.36x2.44m	0.5	0.001	Bhatia(1971)
Maharashtra												
16	Telangkhedi	2.6	2.15	11	27	1.0	1.7	7.5	6x3m	0.20	0.65	Joshi(1971)
17	Kelzar	2.3	4.12	2	22	0.8	0.66	0.44	6x3m	0.20	0.20	
Mysore												
18	Tungabhadra Dam	3	4	19	83	3.0	49.45	19.42	6x3x3'	0.6–0.8	12.30	Chandrasekhar (1971)
19	Vanivilasapura	3.8	4.6	50	55	1.7	85.86	55.14	2x1m	0.4–0.6	29.50	Prasad(1971)
Orissa												
20	Sombalpur	2–3	5–8	289	7	1.4	716.0	14.0	5x2½x1'	0.4–0.7	298.0	Panda(1971)
21	Kaushalyaganga	F 3 M 3	7	72	5	3	193.55	80.0	1.5x0.9m	0.75	137.5	
Panjab												
22	Patiala	2–3	5–10	3	6	1.23	7.14	1.85	1.5x0.9x0.3m	–	0.66	Malhotra(1971)
Tamil Nadu												
23	Thanjavur	2	7	4	36	1	1.5	0.2	6x3x3'	0.70	3.00	Menon *et al.* (1971)
24	Poondi	2	8	6	22	1	1.0	0.15	6x3x3'	0.70	6.00	
25	Manimuthar	3	7	8	32	1.5	1.5	0.25	6x3x3'	0.70	10.00	
26	Sathanur	2	6	2	9	2.0	1.00	0.25	6x3x3'	0.50	2.5	
Tripura												
27	Udeipur	0.7–8.85	5–9	130	5	1.8	197.5	61.3	3.1x1.6x0.9m	0.9	118.77	Ghosh(1971)
28	Agartala	2	4–5	16	9	2.25	46.40	13.92	3.1x1.6x0.9m	29.00	–	
Uttar Pradesh												
29	Matatila	4	7	6	2	1.5	1.235	1.04	6x3x3'	0.30	1.22	Chitravanshi and Verma(1971)
30	Laramda	6–15	10–30	10	–	1.7	27.20	4.56	3½x2½x1½'	0.20–0.50	21.44	
31	Dulhapur	5–6	6	1	4	1.0	0.62	0.45	3½x2½x1½'	0.355	0.15	
32	Atkohan	3–6	5–10	2	18	1.7	2.13	0.62	6x3x3'	0.50	1.35	
33	Chaubepur	2–5	5–10	5	12	1.4	2.765	2.86	3½x2x1½'	–	1.10	
34	Robertsganj	4–6	8	4	–	1.10	11.51	1.05	–	–	5.91	
35	Balrampur	3–4	8–10	1	4	1.5	0.60	0.15	3½x2x1½'	0.20	0.50	
36	Banki	3	6–8	1	7	1.40	7.17	0.63	3½x2x1½'	0.20	4.40	
37	Tamba	6	–	2	–	1.00	2.25	–	3½x2x1½'	0.20	1.135	
38	Gujertal	3–4	8.12	2	–	0.975	1.55	0.25	8x4x2½'	0.20	0.20	
West Bengal												
39	Kalyani	2–3	5–7	4	–	0.525	4.74	0.17	5x2½x1½'	0.60	2.68	Sen Gupta(1971)
40	Jaunput	2	6–8	9	3	0.87	1.779	0.13	5x2½x1½'	0.45	0.67	
41	Jaunput	F 1–2 M –	9–20 2–6	22	2	0.8	26.5	10.5	1.5x0.75x0.45m	0.5–1.0	10.9	Singh and De (1971)
42	Krishnanagar	F 3–6 M –	8–10 4–5	2	2	1.675	0.396	0.64	1.2x0.76x0.45m	0.42–0.61	0.25	Bhattacharya (1971)

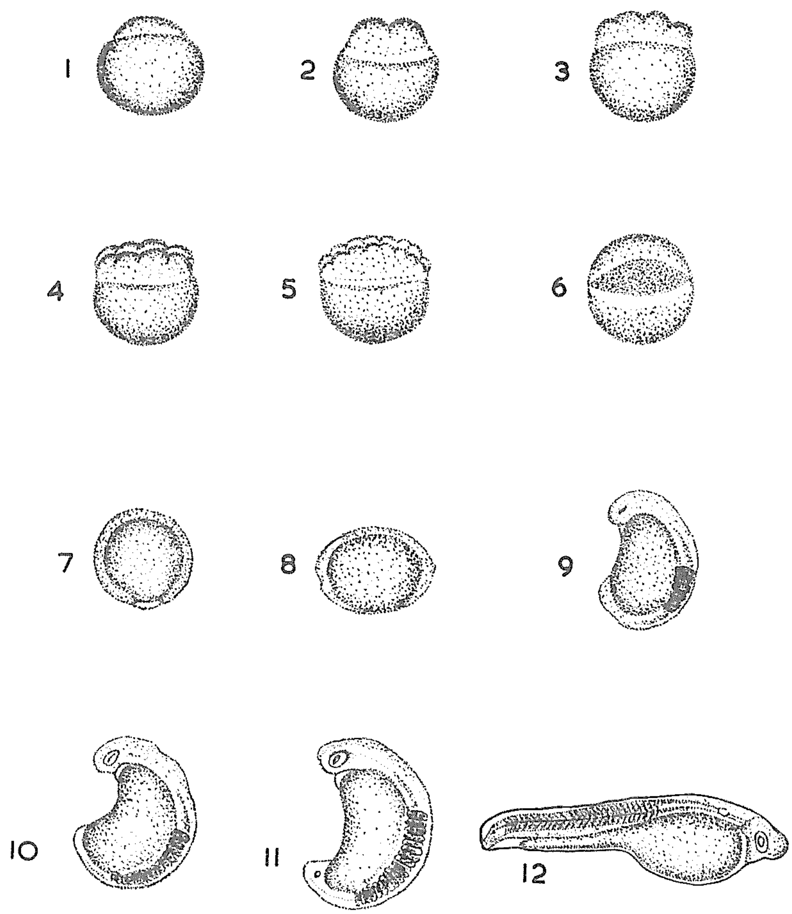

Figure 4 Embryonic development of Labeo rohita. Fertilized eggs: (1) Blastodisc just formed; (2) Two-celled stage; (3) Four-celled stage; (4) Eight-celled stage; (5) Sixteen-celled stage; (6) Morula stage; (7) Yolk-plug stage Embryo; (8) Elongation of yolk mass; (9) With six somites; (10) Appearance of optic cups; (11) Elongation of tail from yolk mass, formation of Küpffer's vesicle; (12) About 2 h before hatching.

TABLE XVII

Development of fertilized eggs

Developmental feature	Time after fertilization
Segmentation (Figures 4.1 and 4.2)	Regular after 35 min (Mookerjee, 1945); first cleavage in 45 min, followed within 5-7 min by the second cleavage (Chakrabarty and Murty, 1972).
8-celled stage (Figure 4.4)	70 min (Mookerjee, 1945); 65-77 min (Chakrabarty and Murty, 1972).
16-celled stage (Figure 4.5)	1 h and 35 min (Mookerjee, 1945).
32-celled stage	2 h and 10 min (Mookerjee, 1945).
Completion of yolk invasion and formation of blastopore (Figures 4.6 and 4.7)	5 h and 45 min (Mookerjee, 1945). Yolk invasion half completed in 2 h and yolk-plug stage reached after 3 h (Chakrabarty and Murty, 1972).
Appearance of embryonic rudiment (Figures 4.8 and 4.9)	8 h (Mookerjee, 1945); 4 h (Chakrabarty and Murty, 1972). Yolk mass starts elongating in 5 h followed by the appearance of myotomes in 6 h. Head and tail regions formed (Chakrabarty and Murty, 1972).
Appearance of optic rudiment (Figure 4.10)	10 h and 35 min (Mookerjee, 1945); 5 h (Chakrabarty and Murty, 1972). 7-10 myotomes also formed.
Appearance of heart rudiment	15 h and 5 min (Mookerjee, 1945) and pulsation of heart begins after 15 h and 20 min.
Appearance of gill rudiment	15 h and 50 min (Mookerjee, 1945).
Appearance of pectoral fin buds	14 h and 30 min (Mookerjee, 1945).
Appearance of otocyst rudiment	13 h and 20 min (Mookerjee, 1945).
Commencement of movement of embryo	9 h. Seventeen myotomes and Küpffers vesicle seen (Mookerjee, 1945).
Period of incubation	17 h and 15 min (Mookerjee, 1945); 14-17 h at 23-28°C (Chakrabarty and Murty, 1972); 15-20 h at a water temperature ranging between 24-31°C (Chaudhuri, 1960).

TABLE XVIII

Larval stages of rohu up to 48 h after hatching
(Chakrabarty and Murty, 1972)

Characters	Time (h) after hatching					
	0	6	12	24	36	48
Total length (mm) : Average	3.78	4.70	5.31	5.49	5.85	6.20
Range	3.62–3.83	4.62–4.78	5.22–5.40	5.25–5.84	5.71–5.99	6.07–6.33
Length of yolk sac (mm)	2.52	2.94	3.15	2.79	2.52	2.90
Maximum height of yolk sac (mm)	0.72	0.70	0.75	0.45	0.45	0.36
Height of body at pectoral level (mm)	0.90	1.00	1.08	0.90	0.90	0.90
Number of pre-anal myotomes	26	26	26	26	26	26
Number of post-anal myotomes	14	14	14	14	14	14
Diameter of eye (mm)	0.18	0.20	0.27	0.28	0.28	0.30
Colour of eye	Faint yellowish	Yellowish brown	Black at the centre	Black at the centre	Thick black	Black with dark centre
Length up to hind tip of notochord (mm)	3.62	4.50	5.04	5.35	5.53	5.80
Directive movement	Irregular movement occasionally coming up; otherwise lies laterally at the bottom	Irregular movement coming up from the bottom where it otherwise rests	Vertical movement	Periodic slow jerky movement	Horizontal jerky movement	As in 36-hour stage
Pectoral fin	Absent	Absent	Absent	Absent	Present	Present

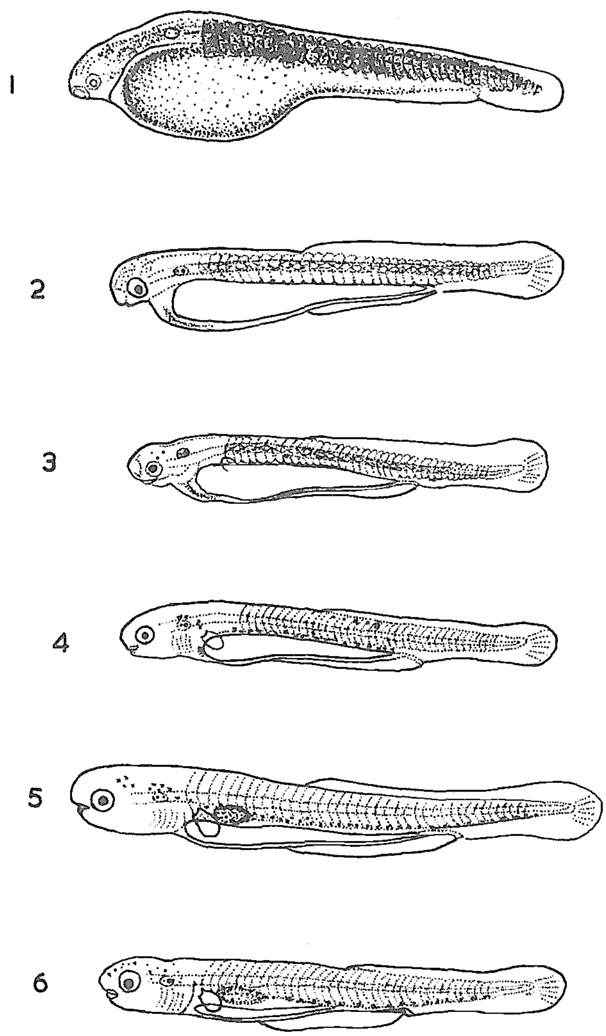

Figure 5 Larval development of Labeo rohita. (1) Hatchlings; (2) 12-h old larva; (3) 24-h old larva; (4) 36-h old larva; (5) 48-h old larva; (6) 72-h old larva.

TABLE XIX

Larval development of rohu

Larval stage (h after hatching)	Development
1	2
6	Pectoral fin rudiment. Irregular movements of embryo occasionally coming up from the bottom where it rests otherwise (Chakrabarty and Murty, 1972).
12 (Figure 5.2)	Chromatophore seen in the eyes only. Embryo shows vertical movements (Chakrabarty and Murty, 1972).
24 (Figure 5.3)	Average size 5.49 mm. A few black chromatophores seen on the head above eyes. Embryo pale yellow in colour. Anal distinct. Auditory concretions clear. Yolk sac sharply ending distally to a point. Striations seen in the caudal. Pectoral without rays. Notochord turned upward only at the very end (Chakrabarty and Murty, 1972).
36 (Figure 5.4)	Average size 5.85 mm. Lower lip clear. Pectoral fin prominent. Anterior profile of yolk sac more or less straight. A few black chromatophores on dorsal margin of the yolk sac throughout its length, a few on the head and on the dorsal fin. No chromatophores on caudal region. Dorsal and ventral sides of embryo pale yellow in contrast to the deep yellow colour of the caudal region posterior to the anus. Notochord slightly upturned at the tip. Mouth as a slit (Chakrabarty and Murty, 1972).
48 (Figure 5.5)	Average size 6.20 mm. Yolk sac convex anteriorly. Embryo yellow in colour. Air bladder distinct. Pectoral fin prominent. A few black chromatophores on the head behind the eyes and in the auditory region. No chromatophore on the ventral side of the air bladder. Black chromatophores in a row from the area posterior to the auditory concretions up to the base of the caudal fin. Large black chromatophores on head prominent. Ventral embryonic fin originates in advance of the dorsal fin fold. Gills prominent. Air bladder elliptical. Head dark and body faint yellow (Chakrabarty and Murty, 1972).
72 (Figure 5.6)	Average size 6.95 mm. Pale yellow. Black chromatophores on the head with a few in between the eyes. Dorsal profile of embryo bright yellow till the anal region. Caudal region above the notochord yellow. No reddish glow on the opercular margin (Chakrabarty and Murty, 1972).
Post-larval stages (length in mm)	
7.57 (Figure 6.1)	Yolk sac completely absorbed on the 4th day after hatching. Lip margins gently fimbriated. Distinct black chromatophores seen behind the eyes on the head region. Opercular outline distinct. Notochord bent at the tip. Crescent-shaped semicircular area below notochord in the caudal region formed of black chromatophores in rows; the straight line of the semicircle made of closely placed chromatophores with a clear area at the centre; the area of the semicircle well defined. Dorsal and ventral fin folds persistent. Commencement of caudal rays (Chakrabarty and Murty, 1972).
8.50 (Figure 6.2)	Fifth day after hatching. Air bladder elliptical and covered partly with black chromatophores. No chromataphores on dorsal and ventral embryonic fin folds. Caudal rays 8–10. Dorsal fin seen now, separating from the embryonic fold (Chakrabarty and Murty, 1972).

Continued

Table XIX continued

1	2
9.00	Three spots in the caudal region, of which 2 at the base of the caudal fin corresponding to each of the lobes and the third on the caudal peduncle near the origin of the caudal fin. Colour of the back light-yellowish oil-green. Fins white or light grey. Ventral and dorsal profiles from the snout to the end of the dorsal fin convex (Mookerjee, 1945).
10-10.5 (Figure 6.3)	Lower jaw bigger and upturned; gape of the mouth 1.7 mm, eye 1 mm; nostrils prominent (Mookerjee, 1945). After the 6th day from hatching: Dorsal fin with 9 rays; anal with faint rays; pelvic fin bud seen. Air bladder divided into 2, the anterior portion globular and posterior in the form of elongated triangle. Dorsal side of body yellow. Chromatophores form two crescents on the two lobes of the caudal fin separated by a small colourless area. Caudal rays 22. The ratio between total length and length of dorsal fin at base 6.4:1 (Chakrabarty and Murty, 1972).
11.00 (Figure 6.4)	Seventh day after hatching. Lips thick. Notochord sharply bending upward. Ventral embryonic fin fold stretching from abdominal region up to anus; dorsal embryonic fin fold visible as far forward as opposite to the anus. Two black chromatophore clusters at the caudal peduncle and two crescent-shaped patches on caudal fin; caudal fin with 22 branched rays; caudal fin less deeply forked; pelvic fin with 2-3 rays; dorsal with 2-11 rays. Ratio between total length and length of dorsal fin at base 6:1 (Chakrabarty and Murty, 1972).
12.00	Both jaws equal; the mouth at the top of the snout; gape of mouth 1.7 mm; nostrils prominent; eye 1.1 mm (Mookerjee, 1945).
12.5	Eighth day after hatching. Dorsal fin with 14 rays with sparsely distributed yellow pigment near base of the rays; anal with 7 rays; ventral embryonic fold ending in the anal region; caudal with 22 rays; two dark crescentric areas at the base of the caudal fin and a few black chromatophores on the caudal peduncle; a few black chromatophores and orange pigment spots on the embryonic fold connecting the caudal fin with the anal fin; pelvic fin with fin rays; body golden yellow, dorsal half more prominently. Prominent black chromatophores on the head; black chromatophores scattered all over the body exhibiting no distinct pattern; a few seen in the anal region. The ratio between total length and dorsal fin length at base 6.3:1 (Chakrabarty and Murty, 1972).
13.00-14.00	Head prominent; snout slightly longer than one diameter of the eye; maxillary barbels present. All fins differentiated; dorsal fin with 15-16 rays and prominently black spotted; anal fin spotted; a black blotch at the end of caudal peduncle covering the entire height (Devasundram, 1952). The maxillary pair of barbels observed in some individuals (Mookerjee <u>et al.</u>, 1944)
15.00	Jaws equal; mouth at the tip of the snout; lips fleshy, continuous; no taste buds; division of nostrils complete; eye 1.3 mm (Mookerjee, 1945).
15.5 (Figure 6.5)	Tenth day after hatching. Thick fimbriated upper lip overhanging the lower lip; no barbels. No pigmentation on dorsal fin margin. Two faint black chromatophore concentrations on caudal rays; black chromatophores forming a more or less broad based triangular area below the sharp bend of the notochord; each chromatophore being distinct. Dorsal with 14 branched rays; anal with 7 rays; pelvic with 7 rays; transparent fin fold persistent from the abdominal to the anal region; caudal with 30 branched rays. The ratio between total length and dorsal fin length at base 5.7:1 (Chakrabarty and Murty, 1972).
17.00-18.00	A constriction noticeable at the sides of the snout; barbels well developed; mouth ventral and lips fringed. Tail uniformly spotted with a tinge of red in the anterior portion of the tail; caudal spot unchanged (Devasundaram, 1952). Maxillary barbels fairly marked, either white or light grey in colour. A single distinct spot in the caudal region, lying partly on the caudal peduncle and partly on the fin (Mookerjee <u>et al.</u>, 1944).

Continued

Table XIX concluded

1	2
19.00	Twelvth day after hatching. Maxillary barbels present. The body golden coloured on the dorsal side and dirty yellow ventrally. Dorsal fin with 3-13 rays; anal fin with 7 rays, except for the anterior one, the rest are branched; ventral fin with 7 rays, except the anterior one, the rest are branched; ventral fin with 7 rays; caudal fin rays 34; a broad triangular black band on the caudal peduncle across its entire width with the apex facing the head. Ratio between total length and dorsal fin length at base 6.3:1 (Chakrabarty and Murty, 1972).
20.00-27.2	Lips fringed; lower lip deflected downward; thickened upper lip continuous and a bit in advance of the lower. Some scales below the lateral line present (Mookerjee et al., 1944)
21.00	Both jaws equal; mouth slightly ventral; taste buds present; gape of the mouth 2.5 mm; eye 1.8 mm (Mookerjee, 1945).
23.00	Fifteenth day after hatching. Anal fin with 2-5 rays; caudal rays 36; basal 2/3 of the dorsal fin pigmented; black chromatophore band in caudal region posteriorly prolonged from the centre passing through the origin of caudal rays and dividing the fin into two; scales not observed. Ratio between total length and dorsal fin length at base 5.8:1 (Chakrabarty and Murty, 1972).
24.00	Scales first seen, a few seen posterior to opercular margin up to the beginning of dorsal fin in 4 or 5 rows (Chakrabarty and Murty, 1972).
25.00	Eighteenth day after hatching. Body dirty yellow above lateral line and yellowish white below it. Scales present but not clear near the caudal peduncle and in the abdominal region. Black chromatophores on the anterior margin of the dorsal fin in the form of dotted line; ventral fin with 9 rays; 32 caudal rays; two prominent greyish crescents, one on each half of the caudal fin lobes behind the dark triangular area on the caudal peduncle (Chakrabarty and Murty, 1972).
26.00	Twentieth day after hatching. Body golden coloured. Scales prominent and fully covering the body. Two dark bands seen one above and one below the lateral line along the body up to the caudal region. Dorsal fin with 3-13 rays; caudal rays 34; rays covered with orange pigment dots; a black band along the entire width of the caudal peduncle concave posteriorly and irregular in shape along the anterior margin; behind this band, two faint crescentic areas separated by 2 colourless streaks (Chakrabarty and Murty, 1972).
30.00	Twenty-fifth day after hatching. Body golden coloured with coppery reflection from operculum. Barbels prominent. Upper margin of eye faintly orange. Dark band in caudal peduncle quite prominent. Upper lobe of caudal fin larger and pointed compared to somewhat round edge of smaller lower lobe (Chakrabarty and Murty, 1972).
40.00	Mouth ventral in position; gape of the mouth 2.6 mm; eye 2 mm (Mookerjee, 1945).
42.00	Dorsal surface greenish-white; sides and ventral surface greenish-white; slight reddish tinge present on the dorsal and the caudal fins; dashes of black on all fins. Scales fully formed with black margins (Mookerjee et al., 1944).
72.00	Some vermilion-red colour on the caudal, dorsal and anal fins (Mookerjee et al., 1944).
Up to 100.00	Dark band at the caudal peduncle present. Reddish tinge present in the dorsal, pelvic, anal and caudal fins. Both caudal lobes with reddish tinge and dirty grey colour along the margins. Maxillary barbels prominent; a pair of rostal barbels present.

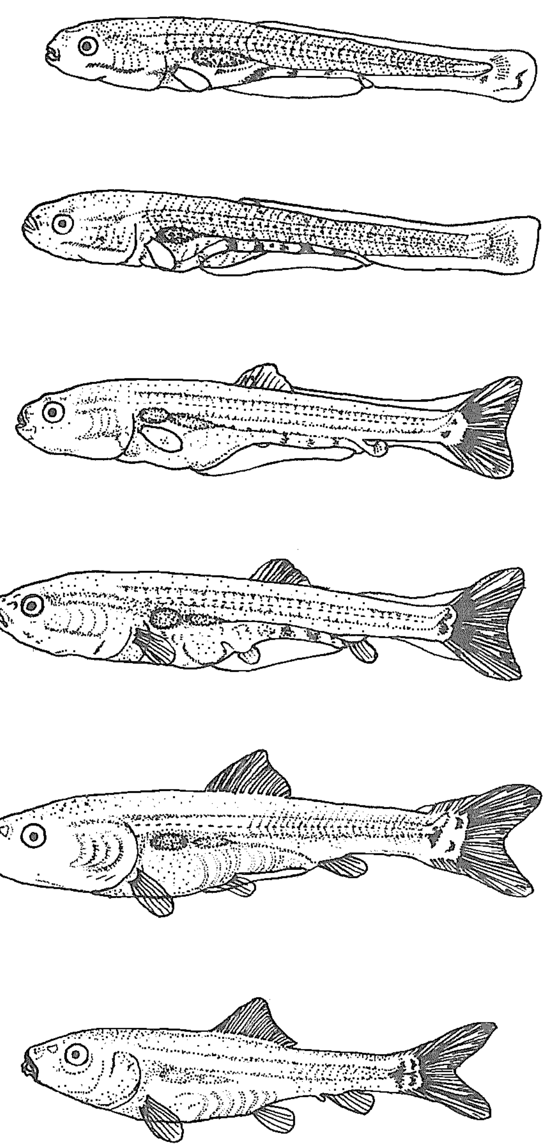

Figure 6 Post-larval development of Labeo rohita. (1) Fourth day after hatching; (2) Fifth day after hatching; (3) Sixth day after hatching; (4) Seventh day after hatching; (5) Tenth day after hatching; (6) Fifteenth day after hatching.

in distilled water and glycerine and injected them into equal number of breeders of the same size. On pooling all positive results of male and female glands in the case of rohu, common carp, mrigal and silver carp glands, they reported that 79.0 percent and 72.6 percent success was obtained in the case of female and male glands respectively.

Experiments conducted by numerous investigators on induced spawning of fishes have shown the relative effectiveness of fish pituitary extracts over mammalian pituitary hormones. Ranganathan et al. (1967) centrifuged pregnancy urine and induced spawning in one set of rohu. HCG, extracted from human pregnancy urine in the laboratory in combination with a threshold dose of carppituitary induced spawning in rohu. Similar results have also been obtained with synohorin. It was found that 4 mg of pituitary plus 25 rabbit units of synahorin per kg of fish gave positive results when injected to *L. rohita*, whereas with pituitary alone, 12 mg/kg of hypophysis were required to induce spawning of the fish. It was concluded that the addition of synahorin reduced the requirement of pituitary at least by 50 percent for induced spawning of the fish (Central Inland Fisheries Research Institute, Barrackpore, Annual report 1967 and Jhingran, 1969).

The use of chemicals for extraction of fish pituitary has been attempted quite recently. Experiments at Central Inland Fisheries Research Institute have shown that when pituitary glands were immersed for 6 h and 3 h in 1.25 percent and 2.5 percent trichloroacetic acid respectively, the minimum effective dose for successful spawning was 14 mg and 22-26 mg respectively (Bhowmick and Chaudhuri, 1970).

3.17 Spawn

Fertilized eggs of rohu are round, transparent, demersal, non-adhesive and red in colour. The yolk sphere contains no oil globule (Mookerjee, 1945). Fully fertilized eggs are 5 mm in diameter (Mookerjee, 1945 and Mazumdar, 1957), 4.1-4.8 mm with an average 4.4 mm (Chakrabarty and Murty, 1972) and 4.5-4.8 mm (Chaudhuri, 1960b). No information is available on the parasites of rohu eggs in nature. During experiments on hypophysation of rohu, mortality of developing eggs has been reported due to fungal infection. When developing carp eggs are left in breeding hapas fixed in such ponds which contain common carp, they are subject to heavy destruction by this fish. Common carp has been observed to hover around the hapa and nibble and suck at it repeatedly with their protusible mouth. Rohu eggs, being demersal, settle down in the hapa and, as the fish suck from outside, the egg shells apparently break and ultimately the developing embryos die (Panicker et al., 1969). *Tilapia mossambica* has also been reported to destroy carp eggs.

3.2 Pre-adult phase

(Defined as from fertilization of egg to sexual maturity)

3.21 Embryonic phase

(Defined as from fertilization to hatching, i.e., during incubation period)

The developmental feature of fertilized eggs of rohu are given in Table XVII.

3.22 Larval phase

- General features of development

The newly hatched larva measures 3.5-4.5 mm (Mookerjee, 1945) or 4.4-4.5 mm (Chaudhuri, 1960b) or 3.62-3.83 mm with an average length of 3.78 mm (Chakrabarty and Murty, 1972).

It has a transparent, laterally compressed body and is characterized by the presence of conspicuous eyes, otocysts, rudiments of gill slits, pectoral fin and median fin fold (Mookerjee, 1945). According to Chakrabarty and Murty (1972), the yolk is gradually tapering, with a prominent anterior bulbous portion and elongated and narrow posterior blunt end, having slight pinkish hue on its dorsal part (Figure 5.1). The hatchling has faint yellowish-brown eyes and shows irregular movements occasionally coming up or otherwise lying laterally at the bottom of the container. Larval stages of rohu up to 48 h after hatching are given in Table XVIII.

Post-larvae, just after absorption of yolk, measure 6.4-6.5 mm (Chaudhuri, 1960b) or 7.57 mm (Chakrabarty and Murty, 1972). According to Mookerjee (1945), rudiments of dorsal, anal and pelvic fins appear on the 8th, 12th and 18th day respectively after hatching. Scales make their appearance on the 30th day, barbels on the 21st day and liver on the 28th day after hatching. According to Mookerjee (1945), the air bladder originates 2½ days after hatching.

The different stages in the larval development of rohu are presented in Table XIX and Figures 5 and 6. Details of the development and stages of coiling of the alimentary canal, formation of gill rays, gill filaments, gill rakers and the food of rohu spawn and fry from the first day till the 19th day after hatching are presented in Table XX.

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

Oxygen requirements of rohu fry (22-46 mm long) have been studied by Motwani and Bose (1957), who observed that oxygen consumption rate appeared to be dependent on the total mass of test fry

TABLE XX

Development of alimentary canal, gill rays, gill filaments, gill rakers and the food consumed by larval and post-larval stages of Labeo rohita (Kamal, 1967)

Age after hatching (days)	Average total length (mm)	S.D.	Average length of intestine	S.D.	Ratio of alimentary canal to total length	Coiling stage of gut	No. of gill arches	No. of gill filaments	No. of gill rakers	Food (%)		REMARKS
										Phytoplankton	Zooplankton	
0	4.3	0.2449	3.0+		0.714							
1	5.2	0.4092	3.0+		0.576							
2	5.8	0.2498	3.0+		0.517		4	11				
3	6.0	0.1356	3.0+		0.500		4	11				
5	6.9	0.0866	3.3	0.0433	0.471	I	4	13	10–11	10	90	Cladocerans dominant
7	9.0	0.8160	4.0		0.444	II	4	13–15	10–11	Nil	100	Copepods dominant
9	12.5	0.6659	7.0	0.7071	0.560	III&IV	4	19–21	10++	5	95	Copepods dominant
13	14.2	0.2358	10.7	0.4715	0.753	V&VI	4	23–24	13–14	Nil	100	Copepods dominant
15	14.8	0.2358	11.8	0.2429	0.797	VII	4	24–25	15	Nil	100	Copepods dominant
17	19.0	0.7071	26.3	3.8694	1.384	VIII	4	33–35	20–21	Nil	100	Copepods dominant
19	19.0		24.0		1.263	IX	4	35	21	Nil	100	Copepods dominant

\+ In these stages alimentary canal is not functionally complete and yolk-sac persists

++ In a few specimens examined, only 10 gill arches were observed rather than the number, suggesting that "grouping" effect on the respiratory rate was not apparent. The mathematical equation derived by them is $\log O_2 = 2.224764 + 0.9667676 \log W/10^3$ (where O_2 is the oxygen consumed in mg at resting level in 20 minutes and W is the combined weight of fry in g). For practical utility of these results, length-weight studies relating to fry of L. rohita were made by these authors, who expressed the length-weight relationship as: $W = 0.205385 \times 10^{-5} \times L^{3.432022}$. On the basis of these two equations, a table (Table XXI) was prepared by them which shows oxygen consumption per h x 1 000 fry of L. rohita of different size ranges at resting and active levels of respiration at normal pressure at 35°C. This table is of much help to the worker engaged in transport of fry.

Das (1958b) reported that when carp spawn was reared in manured nurseries and given various artificial feeds with different combinations of protein, fat, carbohydrate, roughage, vitamins, etc., the maximum growth of spawn was obtained with the feed having a combination of hydrolysed protein and carbohydrates (50:30). Complex proteins and pure carbohydrates gave poor results. Das (1965) found that among the micro-nutrient treatments employed, yeast was found to increase the growth most, followed by vitamin B-complex, ruminant stomach extract with cobalt chloride and vitamin B_{12}. Comparison of dosage levels of yeast showed that yeast enhanced survival in a qualitative all-or-none manner and growth in a quantitative manner. These results suggest that carp hatchlings in the phase immediately following hatching are more sensitive to treatments with some component(s) of the B-complex, from either standardized or natural sources. The survival of fish during the post-embryonic stage of life may be affected by vitamins present in the medium. Das (1965) postulated that yeast, which is a rich source of vitamins in the form of B-complex and plays important roles in the metabolism as coenzymes, acts as a vitamin in promoting survival. Yeast also acts as a growth-promoting substance. After the latent period of carp hatchling has elapsed, carp fry begin to grow rapidly and yeast significantly enhances their growth. Yeast is rich in amino acids which are essential for growth and perhaps the more rapid growth in the yeast-treated carp results from the addition of dietary amino acids in varying amounts at different dosage levels.

Based on results stated above, Das (1968b) formulated an equation for projecting yield after a specified period of time. He defined yield as a function of the initial number of one-day-old spawn, the proportion surviving for a given density and treatment and the expected weight of any fish of a given species and age group. The equation is: $Y'(t/n_o, d, Tr) = (n_o, P_d, Tr)\bar{w}_t, Tr$ where Y' = yield, n_o is the initial number of one-day-old spawn, P_d, Tr is the proportion surviving under specified density and treatment in the post-embryonic period, $\bar{w}_t$, Tr is the mean weight after time period t for all fish receiving treatment Tr.

Das (1968a and b) carried out biochemical determinations of total protein, non-protein nitrogen, acid phosphates and alkaline phosphatase for untreated spawn and spawn treated with yeast. Treatment with yeast has a statistically significant effect on total protein and non-protein nitrogen. A significant change in total protein, acid phosphatase and alkaline phosphatase occurs with age. The significant regression of weight on total protein decreases with yeast

TABLE XXI

Oxygen consumption per h x 1 000 fry of L. rohita of different size ranges at resting and active levels of respiration (Motwani and Bose, 1957)

Length of fry (mm)	Weight of 1 000 fry (g)	Oxygen consumption per h x 1 000 fry at: Resting level		Active level	
		mg	litre at 35°C and normal pressure	mg	litre at 35°C and normal pressure
20	60	27.31	0.0191	40.57	0.0284
25	123	55.99	0.0391	83.18	0.0582
30	240	109.25	0.0765	162.31	0.1136
35	398	181.17	0.1268	269.16	0.1884
40	645	293.60	0.2055	437.21	0.3060

TABLE XXII

Survival of rohu fingerlings at various temperatures (Mookerjee *et al.*, 1946)

Length (mm)	Temperature (°C)	Period of survival (minutes)	Remarks
70	12	4	Survival period very short; temperature unsuitable.
70	14	20	Survival period increases but due to mortality within 20 minutes, temperature unsuitable.
70	15.1	400	Survival period increases but as mortality takes place, temperature unsuitable.
65	16.8	No mortality	No mortality but, when kept in this temperature for 15 days, a decrease in body weight takes place.
65	18.3	No mortality	No mortality or decrease in weight.
70	37.8	No mortality	No mortality or decrease in weight.
65	38.9	No mortality	Marked decrease in weight when kept in this temperature for 15 days.
70	39.5	375	Mortality begins.
70	40.5	15	Survival period decreases.
70	41.1	8	Survival period decreases rapidly.
65	50	2	Survival period very short.

treatment. As yeast treatment decreases the total protein per g dry weight but increases the total weight, it appears to make fry more efficient as weight-gaining units.

In preliminary screening conducted at Pond Culture Division of the Central Inland Fisheries Research Institute in the laboratory and yard trials using 15 growth-promoting substances for enhanced survival and growth of rohu spawn and fry, cobalt chloride at the rate of 0.01 mg per day per fish gave satisfactory results. In a field experiment conducted in 1970, using cobalt chloride for rohu and mrigal spawn stocked at the rate of 25 lakhs/ha, survivals of 87.3 percent in rohu and 66.3 percent in mrigal were recorded in treated ponds as against 60.4 percent and 65.3 percent respectively in control ponds. In 1971, survival of 74.3 percent was obtained in respect of rohu spawn stocked at 37.5 lakhs/ha in treated ponds as against 66 percent in the control ponds (Sen, 1972).

The water temperature has a profound effect on the survival of rohu spawn. According to Mookerjee *et al.* (1946), 60-70 mm rohu juveniles, as in catla, thrive well in the temperature range 18.3-37.8°C. Table XXII shows the survival of rohu fingerlings at various temperatures.

There is no parental care in *L. rohita*.

Spawn, fry, fingerlings and adults of live major carps, during transportation over long distances or even by rough handling, which get mechanically injured or bruised, are liable to fungal attack (*Saprolegnia parasitica*), unless properly disinfected. Karamchandani (1956) observed mortality of major carp fry (6-9 mm long) caused by the ciliate *Trichodina* sp., which affected the body of the fry on or near the fins. Tripathi (1954) reported that fry of major carps are more susceptible to infection by *Trichodina indica* than *Scyphidia pyriformis* or *Bodomonas rebae*. The incidence and intensity of infection was higher in rohu than in other carps. He also observed that gills of major carp fry below 1.8 cm in length were not infected with any of the above parasites. Other afflictions which are common to fingerlings and adult rohu are described under 3.35.

Major carp hatchlings are subject to depredation by *Mesocyclops* sp. Lakshmanan (1969) reported that mortality of hatchlings in the nursery pond depends, besides other factors, on the concentration of *Cyclops*. He observed that spawn are fatally wounded and the attacking *Cyclops* are seen firmly attached to the latero-ventral part of the head of spawn. Even before the dying spawn settle at the bottom, a host of other *Cyclops* join and start devouring them. For the role of other predators such as insects and their larvae, weed and predatory fishes, frog and tadpoles, refer to Jhingran (1968).

- Time of first feeding

Kamal (1967) reported that rohu spawn start feeding on plankton from 5th day after hatching. The mouth in the larvae of rohu appears, at the time of hatching, in the form of a small notch just above the yolk sac and is closed at that stage. One day after hatching, the mouth opens and on the second day after hatching, it moves upward, assuming a perfect anterior position. The gill filaments and gill rakers increase in number with the size of the fish (Table XX).

- Type of feeding

Alikunhi (1957) found that the structure of the gill rakers in rohu is such that they are not adapted to filtering minute organisms. He (1958) also observed that carp fry could distinguish the desirable from undesirable items of food and therefore concluded that feeding was selective. He further suggested the possibility of feeding among carp fry by contact as evidenced by their limited feeding in darkness. Kamal (1967) stated that gill rakers do not seem to play any important role in the selection of food organisms by rohu spawn and fry.

The structure of alimentary canal indicates carnivore feeding habitsof rohu spawn. On the 5th day after hatching, when rohu spawn starts feeding on plankton, the alimentary canal of the larva averages 3.3 mm in length as against its average body length of 6.9 mm. The gut of rohu fry is shorter than the body length up to the 15th day after hatching and, therefore, it increases in length at a faster rate than the body (Table XX). In the adult stage, the ratio of gut to the total length is around 12 (Das and Moitra, 1955 and 1956) and 11-13 (Khan, 1972).

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

Mookerjee (1944) reported that all major carps of India and all other smaller types "are cannibalistic in habit during their fry stage". He, however, did not give any details. Alikunhi *et al.* (1952) reported that among the major carps, certain specimens of *Catla catla* (6.5-20 mm), *L. rohita* (12.5-21 mm) and *Cirrhina mrigala* (13-20.5 mm) were found to have 1-3 carp fry (5-6 mm). According to Mookerjee (1944 and 1945), 5-10 mm long rohu fry feed exclusively on unicellular algae; 10-20 mm long ones on protozoans of various nature; 20-100 mm long individuals on unicellular algae (35 percent), protozoans and rotifers (15 percent), crustaceans (40 percent), sand particles (2 percent) and unidentified mass (8 percent). Kamal (1967) observed that food of rohu spawn consisted entirely of zooplankton. Apart from the

TABLE XXIII

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

Length (mm)	Average percentage of items of food generally encountered in the stomach and gut					
	Unicellular algae	Filamentous algae	Vegetable debris	Animalcules and water fleas	Insects	Sand or mud
11-20	-	-	20.0	60.0	-	20.0
21-40	14.9	4.0	7.0	37.1	-	37.0
41-100	14.0	12.5	41.5	18.0	-	14.0
101 and longer	27.9	0.7	56.0	0.5	0.4	14.5

initial feed on the 5th day when cladocerans formed the chief item of food, the copepods dominated the food items in the gut from the 7th till 9th day after hatching, with only comparatively smaller quantities of cladocerans, insect larvae, rotifers and nauplii. Kamal (1967a) also noticed coleopteran larvae in the diet of rohu spawn till the fingerling stage. According to Alikunhi (1952) zooplankters, particularly Entomostraca and rotifers, appear to constitute the "main food" of carp spawn and fry (15-20 mm size range) of the Indian major carps and majority of other culturable species, with phytoplankton forming the "emergency food". Spawn and fry with a small, short and straight intestine, appear to digest rotifers and cladocerans fairly rapidly and fry appear to digest zooplankton very well. Phytoplanktonic algae are not so easily digested and, at least, some algal forms (Euglena, Phacus, Eudorina, Oscillatoria, Microcystis, filamentous green algae, etc.) remain undigested, being ejected intact along the faecal matter. Alikunhi (1957) stated that rohu fry from 11-41 mm feed mainly on animalcules and water fleas.

3.23 Adolescent phase

Rohu fry, with the differentiation of all fins, acquire all the characteristics of the species, except the adult body proportions and colouration, very rapidly under optimum environmental conditions. Rate of development from the post-larval to adolescent stage depends on genetic factors and environmental conditions such as temperature and other physico-chemical characteristics of water and soil, pond fertility, fish food (both natural and artificial) and their availability, quality, etc.

Common predators of carp fry, fingerlings and adolescents in ponds are the same as those described for Catla catla (refer to Jhingran, 1968). For feeding habits, refer to section 3.42.

3.3 Adult phase

3.31 Longevity

Day (1878) has recorded rohu attaining a maximum length of 91.11 cm. Based on the scale studies, Khan (1972) determined the age of rohu up to +10 age groups in the commercial catches of rivers, the maximum total length of fish in their sample being 96 cm and weighing as much as 11.5 kg. Shaw and Shebbeare (1937) recorded the maximum size of rohu as 73.7 cm. The maximum size group of rohu in the commercial catches from River Yamuna was observed to be 1 011-1 030 cm.

3.32 Hardiness

Same as in Catla catla (refer to Jhingran, 1968). Rohu has not been recorded from low salinity zones of the Chilka Lake or in Khakhra Dhand. Major carps have been reported to grow up to a salinity level of 14°/oo (Saha et al., 1964). Gosh et al. (1972) reported that early fry of major carps (average length: 17 mm) could tolerate salinity up to 3.28°/oo and, at 7.9°/oo, exhibited signs of extreme restlessness and apathy for food and with further rise of salinity up to 10°/oo, they ultimately died. Advanced fry (average length: 26 mm) exhibited tolerance up to 10°/oo with 50 percent mortality. Their total mortality was observed at 13°/oo and above. They also reported that fingerlings of L. rohita and Catla catla could tolerate salinity up to 12.5°/oo at 48 percent mortality. Best growth rates for both species were recorded at the salinity level of 5°/oo, the growth rate of rohu and catla being 14-55 mm and 18-20 mm per week respectively.

3.33 Competitors

During 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 an inter-specific competition of a high degree. Rohu fingerlings and adults are bottom-column feeders. The notable competitors of rohu are Cirrhinus mrigala, Labeo calbasu, L. fimbriatus, etc., which also feed on vegetable debris, microscopic plants and detritus.

3.34 Predators

Among fishes, Wallago attu and Channa marulius only are perhaps most predacious to adult rohu of more than 0.5 kg weight. Smaller rohu encounter many predators, notably Wallago attu, C. marulius, Notopterus chitala, Silonia silondia and Channa striatus. Crocodiles, cormorants, gulls, kingfishers, kites, herons, storks, water snakes, etc., are other predators. Otters can destroy rohu of all sizes.

3.35 Parasites and diseases, injuries and abnormalities

\- Parasites and diseases

Rohu is afflicted by a variety of parasites and diseases (Southwell and Prashad, 1918; Chakravarty, 1939; Khan, 1939 and 1944; Rawat, 1948; Chauhan and Ramkrishna, 1948; Karamchandani, 1952; Tripathi, 1954, 1955, 1957 and 1973; Alikunhi, 1957; Gopalakrishnan, 1963, 1964 and 1968; Gupta, 1960; Pal, 1972; Jhingran, 1968 and 1973; Gopalakrishnan and Jhingran, 1971). Alikunhi et al. (1951) reported that 20 mm long major carp fry suffered from gas disease or "air embolism" under condition of supersaturation of oxygen. Affected fishes, showing small bubbles beneath the skin or fins, around the eyes, in the stomach and intestine or in blood capillaries, were found to swim at an angle of about 45, with the head pointing down. Eventually, these fish lost their balance and died.

TABLE XXIV

Percentage of different food items in the gut contents (ri), in the environment (pi) and electivity index (E) of Labeo rohita from pond moats(Khan, 1972)

Food items	FINGERLINGS			ADULTS		
	% in gut contents (ri)	% in environment (pi)	Electivity index (E)	% in gut contents (ri)	% in environment (pi)	Electivity index (E)
1	2	3	4	5	6	7
Oedogonium	-	1.3	-1.000	2.6	2.5	0.020
Pediastrum	2.0	2.4	-0.090	4.0	1.1	0.570
Selenastrum	3.0	1.5	-0.333	3.1	0.6	0.690
Ankistrodesmus	-	3.3	-1.000	3.6	1.2	0.500
Scenedesmus	1.0	1.3	-0.130	2.6	0.8	0.530
Zygnema	-	3.0	-1.000	5.7	2.1	0.461
Spirogyra	-	4.1	-1.000	4.9	2.0	0.420
Ulothrix	-	2.1	-1.000	2.8	1.1	0.433
Tetraspora	-	1.0	-1.000	2.7	1.0	0.447
GREEN ALGAE	6.0	20.0	-0.538	32.0	12.4	0.441
Stephanodiscus	-	2.1	-1.000	1.6	1.0	0.230
Cyclotella	3.0	4.0	-0.143	4.4	0.5	0.796
Diatoma	-	0.5	-1.000	2.9	2.0	0.183
Fragillaria	1.0	0.8	-0.111	-	0.5	-1.000
Surirella	-	0.3	-1.000	-	0.4	-1.000
Nitzschia	-	3.3	-1.000	3.8	0.8	0.652
Synedra	-	2.5	-1.000	2.5	0.8	0.515
Naviculla	3.0	3.3	-0.047	10.1	2.2	0.642

Continued

Table XXIV concluded

1	2	3	4	5	6	7
DIATOMS	7.0	16.0	-0.411	25.3	8.2	0.510
Nostoc	-	5.3	-1.000	2.4	2.2	0.043
Anabaena	-	4.4	-1.000	2.2	2.6	-0.083
Oscillatoria	-	3.2	-1.000	1.7	2.0	-0.081
Microcystis	0.5	11.2	-0.914	3.7	5.2	-0.168
Phormidium	1.5	5.0	-0.538	2.1	3.2	-0.200
BLUE GREEN ALGAE	2.0	29.1	-0.871	12.1	15.2	-0.113
Cosmarium	4.0	2.5	-0.230	1.9	1.5	0.118
Closterium	6.6	2.6	0.395	3.2	3.6	0.058
DESMIDS	10.6	5.1	0.324	5.1	4.1	0.118
Volvox	3.0	2.0	0.176	1.0	2.7	-0.042
Euglena	7.0	2.0	0.555	4.0	3.6	0.052
PHYTOFLAGELLATES	10.0	4.0	0.428	5.0	6.3	-0.115
ALGAL SPORES AND ZYG.	8.0	3.0	0.454	8.8	5.4	0.240
Arcella	5.1	2.7	0.307	3.1	7.7	-0.426
Difflugia	5.0	2.3	0.370	1.3	2.4	-0.300
PROTOZOANS	10.1	5.0	0.337	4.4	10.1	-0.390
Keratella	13.1	5.1	0.439	2.0	15.0	-0.764
Brachionus	7.1	3.9	0.291	1.5	7.2	-0.678
ROTIFERS	20.2	9.0	0.383	3.5	22.2	-0.727
Cyclops	13.0	3.4	0.586	1.7	8.7	-0.851
Daphnia	8.0	2.4	0.538	1.7	5.2	-0.507
Eubranchipus	5.1	2.6	0.325	0.4	2.2	-0.700
CRUSTACEANS	26.1	8.4	0.513	3.8	16.1	-0.618

TABLE XXV

Percentage composition of food of Labeo rohita, Cirrhina mrigala and Catla catla from two environments (Khan, 1972)

Food items	MOAT FISHES									RIVERINE FISHES								
	Fingerlings			Juveniles			Adults			Fingerlings			Juveniles			Adults		
	Rohu	Mrigal	Catla	Rohu	Mrigal	Catla	Rohu	Mrigal	Catla	Rohu	Mrigal	Catla	Rohu	Mrigal	Catla	Rohu	Mrigal	Catla
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Oedogonium	–	–	–	1.0	0.5	1.0	1.9	1.0	0.8	–	0.2	–	1.3	1.0	1.2	1.1	2.5	1.3
Pediastrum	2.0	0.5	–	4.0	1.3	0.8	3.5	2.0	–	–	–	–	3.1	1.8	4.2	4.2	3.0	1.0
Selenastrum	3.0	0.5	0.6	3.0	1.0	–	2.4	1.5	–	1.5	1.3	–	2.2	0.5	0.5	2.2	1.2	0.2
Ankistrodesmus	–	2.0	–	2.0	–	0.4	2.9	1.0	1.0	0.5	–	–	2.0	1.3	–	1.6	2.0	–
Scenedesmus	1.0	–	1.0	2.0	0.8	1.1	1.9	2.0	0.5	3.2	3.0	1.0	5.0	0.6	–	2.0	1.3	1.0
Zygnema	–	–	–	2.1	2.0	0.3	5.0	–	0.8	0.1	–	–	0.5	–	2.1	1.6	2.0	0.5
Spirogyra	–	–	0.5	2.0	0.6	0.9	5.2	1.5	2.1	0.3	–	–	4.3	0.7	–	10.1	1.8	3.0
Ulothrix	–	–	–	1.0	–	0.2	2.3	1.0	1.0	–	–	–	1.0	–	–	1.1	–	–
Tetraspora	–	–	–	1.1	–	0.2	2.0	–	–	–	0.6	–	0.8	–	–	1.0	0.4	–
GREEN ALGAE	6.0	3.0	2.1	18.1	6.2	5.1	27.1	10.0	6.2	5.6	5.1	1.0	20.2	5.9	8.0	24.9	14.2	7.0
Stephanodiscus	–	0.3	–	2.0	1.0	0.5	0.9	–	–	–	–	–	4.6	2.3	3.2	1.4	2.1	–
Cyclotella	3.0	2.8	2.0	4.4	4.0	1.2	3.7	3.5	1.0	4.0	2.0	1.0	6.2	3.5	1.3	3.7	2.5	0.5
Diatoma	–	–	–	1.3	–	–	2.2	–	–	–	–	–	2.0	–	1.0	3.6	0.3	–
Fragillaria	1.0	2.0	–	–	1.3	–	–	1.0	0.5	–	–	1.0	1.6	–	–	0.8	0.5	–
Surirella	–	–	–	–	–	–	–	–	–	1.0	–	–	0.4	–	2.5	1.4	1.0	–
Nitzschia	–	–	–	4.2	1.8	0.5	3.1	2.0	0.9	–	1.3	1.6	1.9	0.4	1.5	1.6	2.0	2.0
Synedra	–	–	–	1.2	2.0	1.8	1.8	2.5	1.0	–	–	0.4	1.9	–	1.6	5.2	0.6	1.0
Navicula	3.0	1.4	1.1	6.0	1.9	2.0	9.4	4.0	2.0	2.5	1.0	–	7.0	2.0	–	5.8	1.8	2.5
Diatoma	7.0	6.5	3.1	19.1	12.0	6.0	21.1	13.0	5.4	7.5	4.3	4.0	25.6	8.0	11.1	23.5	10.8	6.0
Nostoc	–	0.5	0.5	1.0	0.6	0.2	1.7	0.6	–	–	0.5	–	1.0	–	0.5	2.8	0.5	0.2
Anabaena	–	–	–	0.8	1.0	0.5	1.5	1.3	0.5	–	–	–	0.3	0.5	–	1.6	0.8	–
Oscillatoria	–	–	–	0.2	0.3	0.3	1.0	0.5	0.2	–	–	–	0.8	0.5	–	1.6	0.3	–
Microcystis	0.5	0.5	0.8	1.3	4.0	2.0	3.0	5.1	1.5	–	–	–	1.2	2.0	1.0	3.4	2.0	0.8
Phormidium	1.5	1.0	–	0.7	1.1	1.0	1.4	2.0	1.0	–	0.5	0.5	2.1	1.0	1.0	2.0	2.7	1.0
BLUE GREEN ALGAE	2.0	2.0	1.3	4.0	7.0	4.0	8.6	9.5	3.2	–	1.0	0.5	5.4	4.0	2.5	11.3	6.3	2.1
Cosmarium	4.0	2.0	1.0	1.3	1.9	0.4	2.0	2.5	0.2	4.0	1.1	–	1.3	–	–	1.3	0.2	–
Closterium	6.6	4.0	1.0	3.7	3.2	1.7	1.2	1.6	1.0	7.0	3.0	1.0	2.8	4.1	1.0	0.7	2.8	1.0
DESMIDS	10.6	6.0	2.0	5.0	5.1	2.1	3.2	4.1	1.2	11.0	4.1	1.0	4.1	4.1	1.0	2.0	2.0	1.0
Volvox	3.0	2.9	0.3	2.3	3.0	1.0	0.7	2.5	–	4.4	0.5	0.6	3.5	2.1	–	2.7	1.0	0.5
Euglena	7.0	5.6	3.1	3.0	5.1	2.3	3.5	4.5	1.2	8.8	2.5	1.0	4.5	4.0	2.0	0.7	3.1	1.5
PHYTOFLAGELLATES	10.0	8.5	3.3	5.3	8.1	3.3	4.2	7.0	1.2	13.2	3.0	1.6	8.0	6.1	2.0	3.4	3.9	2.0
ALGAL SPORES AND ZYGOTES	8.0	3.7	1.0	12.0	3.0	2.0	8.1	3.8	2.0	10.2	1.5	3.8	9.5	3.6	1.0	8.0	5.9	1.0
MACROVEGETATION	–	1.2	2.5	9.5	1.0	3.8	11.0	–	2.8	1.5	–	–	5.7	2.1	2.0	11.8	1.0	1.1
DECAYED ORGANIC MATTER	–	15.5	3.0	6.4	19.5	4.3	8.6	31.1	2.4	3.4	12.3	2.0	6.5	22.3	1.5	10.7	30.0	0.5
Arcella	5.1	2.5	6.0	3.1	4.0	2.0	2.4	1.6	1.0	6.8	2.0	8.0	3.0	1.0	3.0	0.8	1.0	1.0
Difflugia	5.0	3.5	5.3	2.0	1.0	3.0	0.6	1.2	–	4.7	4.3	6.1	1.2	3.3	6.0	0.7	0.3	2.0
PROTOZOANS	10.1	6.0	11.3	5.1	5.0	5.9	3.0	2.5	1.0	11.5	6.4	14.1	4.2	4.3	9.0	1.5	1.3	3.0

Continued

Table XXV concluded

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Keratella	13.0	7.3	10.8	3.0	6.5	7.1	1.3	1.0	7.0	9.3	10.1	10.1	2.1	3.0	6.5	1.0	1.3	12.0
Polyarthra	–	3.4	4.5	–	0.6	3.2	–	–	4.2	–	2.0	5.1	–	3.2	2.0	–	–	3.0
Brachionus	7.1	4.5	6.0	2.2	3.0	6.0	0.8	2.0	4.0	3.2	4.0	6.3	1.7	2.1	4.5	0.4	0.2	4.3
Filinta	–	–	2.7	–	–	2.1	–	–	2.0	–	3.0	8.0	–	–	3.1	–	0.5	4.7
ROTIFERS	20.1	15.2	24.0	5.2	10.1	18.4	2.1	3.0	17.2	12.5	19.1	29.5	3.8	8.3	16.1	1.4	2.0	24.0
Cyclops	13.0	5.3	21.0	4.0	5.0	15.1	0.8	1.0	11.5	12.1	10.1	17.1	3.0	5.0	11.0	0.4	1.0	20.0
Diaptomus	–	2.1	5.0	–	–	6.0	0.2	1.0	7.2	7.3	8.0	6.2	2.5	3.1	7.0	–	1.0	8.5
Eubranchipus	5.0	3.0	2.0	5.0	1.0	3.0	0.3	–	3.5	3.6	3.4	4.0	1.0	2.8	3.5	–	0.6	2.0
Daphnia	8.0	5.0	7.3	–	4.0	9.5	–	–	12.4	–	5.8	6.0	–	3.2	11.3	0.4	–	6.5
Sida	–	1.0	2.0	–	–	4.0	–	–	7.3	–	–	2.0	–	–	2.2	–	–	2.0
Cypris	–	–	2.1	–	–	3.5	–	–	5.5	–		3.7	–	1.0	3.0	–	–	1.3
CRUSTACEANS	26.1	16.4	39.4	9.0	10.0	41.1	1.3	2.0	47.2	23.6	27.3	39.0	6.5	15.1	38.0	0.8	2.5	40.3
SAND AND MUD	–	16.4	2.0	1.3	13.0	1.0	1.7	14.0	5.5	–	1.6	–	0.5	16.0	4.8	0.7	20.1	1.5
INSECT LARVAE	–	–	2.5	–	–	2.0	–	–	3.0	–	–	2.5	–	–	3.0	–	–	4.4
INVERTEBRATE EGGS	–	–	2.5	–	–	1.0	–	–	2.0	–	–	1.0	–	–	–	–	–	6.0

The following parasites have been recorded from rohu:

Bacteria	Aeromonas sp. (from body cavity, scales).
Fungi	Saprolegnia parasitica Coker (from any part of the body).
Protozoa	Mixobolus calbasu Chakravarty, (from gall bladder).
	M. catlae Chakravarty, (from gills).
	Thelohamellus rohitae (Southwell and Prashad) (from gills).
	T. seni (Southwell and Prashad) (from median and caudal fins).
	Bodomonas rebae Tripathi (from gills).
	Trichodina indica Tripathi (from gills).
	Scyphidia pyriformis Tripathi (from gills).
	Ichthyophthirius multifiliis Fouguet (from skin).
Copepoda	Argulus siamensis Wilson (from body and fins).
	Ergasilus batai Karamchandani (from gills).
	Lernae chackoensis Gnanamuthu (from gills and body).
Trematoda	Gyrodactylus elegans indica Tripathi (from skin and gills).
	Paradactylogyrus batai Tripathi (from gills).
	Aspidogaster piscicola Rawat (from intestine).
Cestoda	Ligula intestinalis (Linnaeus) (from intestine).
Acanthocephala	Acanthogyrus acanthogyrus Thapar (from intestine).
Hirudinea	Hemiclepsis marginata (from body).

- Injuries and abnormalities

Kapoor and Sarkar (1955) reported deformities in 4 specimens of rohu, measuring 13.7 cm-30.8 cm in length, which were collected from River Yamuna and its neighbouring ponds during the months of October to December, 1953. In two specimens, there was coalescence of vertebral centra resulting in bends, while in the other two, bends were without any coalescence of the vertebral centra. External deformities were seen limited to the dorsal and lateral sides of the body. The reasons for these deformities were due to mechanical injury in the first two specimens and due to congenital defect in the other two.

3.4 Nutrition and growth

3.41 Feeding

Hora (1944) regarded rohu as a surface feeder, although Skene Dhu (1923) considered it essentially a bottom feeder and assigned this reason for it not being caught in rivers. Das and Moitra (1955) stated that L. rohita is a herbivorous mid-surface or column feeder and subsists mainly on aquatic algae and higher plants. Alikunhi (1957) designated the species to be bottom-column feeder. Khan (1972) observed that while the fish mainly feeds on mid surface, it also explores other zones of environment. He stated though the dominant occurrence of algae and submerged vegetation supported its column feeding habit, but the occurrence of decayed organic matter and sand and mud suggested its bottom feeding habit. Khan (1972) supported the view of Larkin (1956), who stated that a sharp demarcation of the fish fauna is not possible in different ecological zones in freshwater environment and concluded that freshwater communities would seem to be characterized by more breadth than height in the pyramid of food chain - a complexity in horizontal organization and, probably due to this reason, rohu was found to feed on the food organisms of other zones also (Khan, 1972).

Mookerjee and Ganguli (1948) described rohu as a member of taste-feeding type, possessing opposite characters to the sight feeders, the latter having large eyes and a big upturned mouth without sensory papillae and barbels. The nibbling type of mouth with soft fringed lips, sharp cutting edges and absence of teeth in bucco-pharyngeal region, indicate that fish subsists on soft aquatic vegetations which do not require seizure or crushing. The gill rakers, which constitute the food sieving organs, are attached to both the sides of the gill arches and are very thin and hair-like. The gill rakers of both sides meet at a place in the floor of buccal cavity near the anterior pharynx. The modified gill rakers show that fish also sieve the water and feed upon minute plankton (Sarbahi, 1939; Khan, 1972). Das and Moitra (1956) suggested that in L. rohita, the usual method of obtaining food is by sight, but those fishes are capable of occasionally resorting to filter feeding, a mode of feeding in young stage.

Khan (1972) studied the periodicity of the food uptake of rohu in pond moats. He observed 2 definite maxima in feeding, first at 08.00 h and second at 16.00 h. There was a gradual decrease in the feeding intensity and increase in the percentage of empty guts from 10.00 h and onwards till 16.00 h. The intensity of feeding was lowest at 14.00 h.

Feeding intensity of rohu, in relation to its size, sexual cycle, sex, season and environment, has been studied by Khan (1972). He reported that feeding intensity was high in size class II (51-100 mm) and III (101-200 mm), followed by a drop in size class IV (201-300 mm) and V (301-400 mm). A slight improvement was noticed in size class VI (401-500 mm). Thereafter, the intensity dropped sharply in size class VII (501-600 mm). In riverine fishes, a slight improvement was again noticed in size class VIII (601-700 mm). During rest of the life, feeding intensity was comparatively poor.

Feeding intensity of adults was affected by the maturation and spawning. Both sexes, i.e., male and female, were observed to feed well when they are immature (stage I). The maturing fishes (stage II) showed considerable increase in the feeding intensity. Fishes of stage II and IV showed a slackening in feeding. Spent fishes (stage V) were again found to feed actively. This increase and decrease was more prominent in females than in males. A significant difference was found in the feeding intensity of the 2 sexes during the spawning period. Males exhibit better feeding than females during spawning months and, as a whole, feeding was found better in males throughout the year than the females. However, females fed more actively during post-spawning months than the males.

The intensity of feeding was high throughout the year in juveniles. A slight drop was noted during December and January. A slight drop in the intensity of feeding in December and January may have been due to low temperature during these months.

Table XXIV shows the percentage of various food items and percentage of the same items in the environment and electivity index of fingerlings and adults of rohu. In the case of fingerlings, a strong positive selection was observed for all the zooplanktonic organisms and for some smaller phytoplankters like desmids (Cosmarium and Closterium), phytoflagellates (Euglena and Volvox) and algal spores and zygotes. Rest of the phytoplankton, which include green algae, diatoms and blue green algae, were avoided. Among crustaceans, there was a strong preference for Cyclops and among rotifers, Keratella was consumed heavily. In the case of adults, a strong negative selection was observed for all zooplanktonic organisms and a strong positive selection for most of the phytoplanktonic organisms.

3.42 Food

Mookerjee (1945) reported that rohu fingerlings 100-250 mm long subsisted upon unicellular and filamentous algae - 15 percent; rotten vegetable - 55 percent; rotifers and protozoans - 2 percent; crustaceans - 8 percent; sand particles - 5 percent, and unidentified mass - 17 percent; and individuals above 250 mm length fed on unicellular and filamentous algae - 3 percent; rotten vegetable - 57 percent; Protozoa and rotifer - 2 percent; crustaceans - 8 percent; sand particles - 5 percent, and unidentified mass - 25 percent.

Chacko (1951) reported that rohu young ones feed on Oscillatoria, Chaetophora, Oedogonium, Cosmarium, Spirogyra, Chlorella, Chlorococcus and Closterium; Cyclotella and Synedra; Paramaecium, Euglena, Glauconia, Epistylis, Chilidon, Vorticella and Stylonichia; daphnids, copepods, rotifers and dipteran larvae. According to him, adult fishes are bottom and column feeders.

Das and Moitra (1956) stated that rohu is a column feeder and its diet consisted of unicellular algae (6.3 percent), multicellular algae (6.6 percent), higher aquatic plants (70.6 percent), rotifers (0.5 percent), insects (0.5 percent), crustaceans (1.5 percent) and sand and mud (14 percent). According to Alikunhi (1957), while rohu fingerlings consume vegetable debris, microscopic plants, few water fleas, debris and mud, adults take in vegetable debris, microscopic plants, detritus and mud. He described rohu as bottom-column feeder.

Hora and Pillay (1962) stated that rohu specimens up to 250 mm length took in decayed vegetable matter, including higher plants, forming more than half the bulk of the diet. Khan (1972) studied the food of rohu fingerlings and adults collected from moats and rivers. Results are embodied in Table XXV.

George (1963) showed that although major carps ingest a variety of phytoplankters, zooplankters and higher aquatic plants, catla prefers to subsist on plankton, mainly zooplankton, while rohu and mrigal prefer to feed on plant matter, including decaying vegetation. Ranade and Kewalramani (1967) confirmed that catla can utilize animal food better than mrigal and rohu, and showed that the latter is less adapted for it even than mrigal. Utilization of plant matter, however, is considerably better in mrigal and rohu than in catla. Table XXVI shows the retention of various food items in the intestine of rohu, mrigal and catla. From this table, it is evident that filamentous algae such as Spirogyra and Ulothrix, higher aquatic plants such as Lemna, decayed vegetation and zooplankters such as Daphnia, Cyclops, Diaptomus and Brachionus are more rapidly digested and would therefore be more efficiently utilized.

3.43 Growth rate

Rohu is very quick growing fish though having relatively a little slower growth than that of catla. Bukht (quoted by Hora, 1943a) studied the growth of catla, rohu and mrigal in 4 experimental tanks in Bidyadhari spill area. Each pond measured 30 x 12 x 1.2 m. The first pond contained Ceratophyllum demersum, the second one Lemna minor; the third pond Potamogeton crispus and the fourth pond Wolffia sp., Panicum sp. and Pithophora sp. In each pond 100 fingerlings of each of rohu, catla

TABLE XXVI

Retention time of various food items in the intestine of Labeo rohita, Cirrhina mrigala and Catla catla (45 cm long and ca 1 year old) (Ranade and Kewalramani, 1967)

Food items	Retention time (h)		
	Labeo rohita	Cirrhina mrigala	Catla catla
Microcystis	48–54	54–60	42–48
Anabaena	48–54	54–60	48
Scenedesmus	48–54	54	48
Chlorella	48	54–60	48
Spirogyra	36	24	42
Ulothrix	36	24	42
Anacharis	42	36	48–54
Vallisneria	42	36	48
Ottelia	42	30–36	48
Lemna	30	24	30–36
Decayed Microcystis	36	30	42
Decayed Anacharis	36	30	42–48
Daphnia	24–30	24	18
Brachionus	24	18–24	18
Cyclops and Diaptomus	24–30	24	18
Cypris	36	30	18
MOSQUITO LARVAE	42	36–42	30–36
CHOPPED PRAWN	54	48–54	42–48
CHOPPED PRAWN (without chitin)	36	30–36	30

and mrigal (50 mm in size) were released on 15 July 1937. Each pond was manured once in a week with 4.5 kg of cowshed refuse, and twice a week, the fish were given exercise for 10 min with the help of a drag net. After three months, the following growth of individual species was recorded:

	Pond I	Pond II	Pond III	Pond IV
catla	11.25 cm	13.75 cm	13.75 cm	15.6 cm
rohu	10.00 cm	10.00 cm	10.00 cm	13.75 cm
mrigal	8.75 cm	8.75 cm	8.75 cm	8.75 cm

Hora (1943a) concluded that growth of catla and rohu was better in Pond IV due to the presence of Wolffia which forms their food.

Mitra (1942) studied the variations in the rate of growth of rohu and catla in different districts of Orissa. Hora (1944) mentioned that rohu (25 mm long) attained 43.75 cm in length and 1.23 kg in 9½ months in Kurla tank and 33.75 cm in length and 0.681 kg in 6¼ months in Bandra tank respectively. Hora (1947) reported growth of rohu to be about 20 cm in length in a tank at Dacca in 30 days. Maximum growth in the first year of life of rohu reared in tanks in Madras was reported to be 65 cm long and 2.95 kg in weight (Chacko, 1948). Ganapati and Chacko (1950) stated that under normal growth condition, rohu will attain a length of 38–48 cm and a weight of 680 g in one year. Rohu has also been reported to grow to 35 cm in five months in the departmental farm at Ichapur. At Vellore Fort moat farm, rohu is said to have attained 75 cm in length and a weight of 6.8 kg, but the duration period is not clear (Fish.St.Rep.Madras, 1945-55). A maximum growth of over 65 cm in one year is also recorded (ICAR Pamphlet No. 25). Alikunhi (1957) stated that in well stocked ponds a growth of 34-40 cm can be expected in one year. Hora and Pillay (1962) reported that rohu attains a length of 35-45 cm and a weight of ca 675-900 g in one year, 2.6 kg by the second year and a weight of 5.4 kg by the third year.

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

$$\text{Log } W = 0.821474 + 0.004377\, t - 0.00000934\, t^2$$

Das (1960) studied the growth of rohu for the first two years of life in three tanks in Baranagar (West Bengal). Second degree polynomials were fitted to mean weight in logarithms. The fitted equation for rohu with time, t, in two-week units, were as follows:

Tank No.	Fitted equation
1	$\text{Log } W = 0.105763 + 0.020935\ t - 0.000229\ t^2$
2	$\text{Log } W = 0.311391 + 0.041271\ t - 0.000619\ t^2$
3	$\text{Log } W = 0.266183 + 0.025251\ t - 0.000442\ t^2$

For tanks 1 and 2, t = 0 at 50 days of age, and for tank 3, t = 0 at 142 days of age

Khandker and Hoque (1970) studied the age of rohu from its scale. They found annual rings on the scale as light bands in the form of grooves. These authors collected scales from 72 fishes from rivers Meghna, Gumti and Kattalia at the sampling centre Dudkandi of Comilla district (Bangladesh) between the period December 1967 and July 1968. These authors found a linear relationship between the fish length and their scale length. The regression formula derived is:

$$Ls = -0.506106 + 0.0228119\ Lf$$

(where Ls is the scale length and Lf the total length of fish). Standard error of the estimate is ± 22, confidence interval of the regression at 5 percent level was 0.23112. The correlation coefficient (r) of the regression was 0.985. Table XXVII shows length of fishes derived at each annulus.

TABLE XXVII

Fish length against growth rings (Khandker and Hoque, 1970)

Growth rings	Frequency (No. of fish where from scales studied with constancy of observation)	Range of total length (mm)	Mean total length (mm)
0	30	150–300	245.60
I	3	263–304	283.33
II	2	280–442	361.00
III	12	415–571	507.08
IV	9	510–598	558.78
V	2	552–640	596.00
VI	2	640–722	681.00

Khan (1972) determined the age and growth of rohu from its scale. He observed that the scales of rohu showed growth rings in the form of carved-out grooved rings which were found to be annular and hence were suitable for age determination (Figure 7). In the first class fishes (termed here as juveniles) the annulus formation was influenced by only feeding intensity. In fishes collected from moats, maximum number of scales with marginal rings were found in the months of March and April in case of first year class and April and May in case of second year class. By the end of July, all of the scales of first year class fish were found to possess growth rings. In case of riverine fishes, new growths rings began to appear from March and, by August, all fishes were found to contain new growth rings. In adults, ring formation started from March and continued till September. The maximum number of scales with marginal rings were found during April-May in case of juveniles and during April-May in case of adults. Ring formation took place earlier in smaller fishes and later in larger fishes.

The length : scale length relationship was worked out by Khan (1972) by regression analysis. The relationship was found to be:

$$y = -1.5582 + 0.0256\ X \text{ (moat fishes)}$$

and

$$y = -1.4000 + 0.0026\ X \text{ (riverine fishes)}$$

where X = total length of the fish and y scale length. Table XXVIII shows calculated length at each annulus as determined by back calculation in riverine fishes. Rohu was found to attain an average length of 310 mm, 500 mm, 650 mm, 740 mm, 800 mm, 850 mm, 890 mm, 920 mm, 940 mm and 960 mm

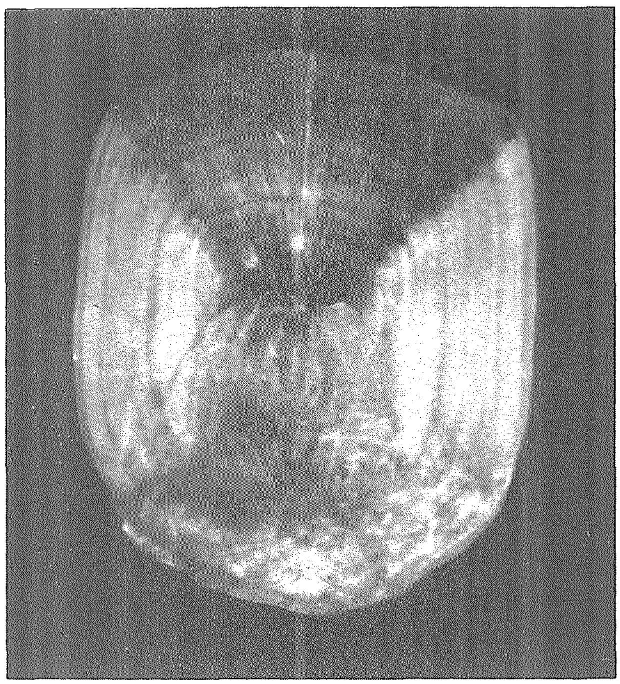

Figure 7 Scale of *Labeo rohita* (820 mm long) showing 5 age rings (Khan, 1972).

at the end of the first to the tenth year of life. Von Bertalanffy's growth fit, according to Khan (1972) describes the growth pattern in rohu. The theoretical growth equation applying to rohu was found to be:

$$Lt = 1\ 015\ [1-e^{-0.276(t+0.333)}]$$

ages 9 and 10. Occurrence of very rapid growth in length was indicated in first four years of life followed by a period of slow growth up to seven years and slowest in the rest of age growth. The percentage annual increment (relative growth) varied from 32 percent during the first year of life to 2.1 percent during the tenth year of life. About 93 percent of the total growth of fish was covered in the first seven years of life (Khan, 1972).

TABLE XXVIII

Calculated length at each annulus as determined by back calculation riverine fishes

Age	Calculated length at different annuli (mm)									
	I	II	III	IV	V	VI	VII	VIII	IX	X
1	380									
2	325	516								
3	320	510	663							
4	315	505	660	750						
5	310	513	657	747	814					
6	310	505	650	742	810	861				
7	305	507	651	740	802	860	900			
8	308	496	642	740	795	850	900	928		
9	290	483	638	731	791	848	889	920	943	
10	285	473	632	730	782	840	872	912	936	960
Grand mean:	310	500	650	740	800	850	890	920	940	960

The mean calculated length at each annulus, growth increment, relative growth and specific growth rate (instantaneous rate) of rohu are shown in Table XXIX. From this table, it is evident that growth rate commenced at 47 percent between ages 1 and 2, dropped to 25 percent in the next year and ultimately it is only 2 percent between

The seasonal growth curves of L. rohita in both the moats and rivers are very much influenced

TABLE XXIX

Mean calculated length at each annulus, growth increment, relative and specific growth rate of L. rohita

Riverine fishes					
Age groups	Back calculated length (mm)	Length determined by growth equation (mm)	Growth increment (mm)	Relative growth (mm)	Specific growth (%)
I	310	309.8	310	32.2	47.80
II	500	489.0	190	19.8	26.24
III	650	610.5	150	15.6	11.51
IV	740	700.9	90	9.4	9.26
V	800	789.0	60	6.3	6.06
VI	850	840.0	50	5.2	4.61
VII	890	885.0	40	4.2	3.25
VIII	920	915.0	30	3.1	2.20
IX	940	937.0	20	2.1	2.12
X	960	950.0	20	2.1	-

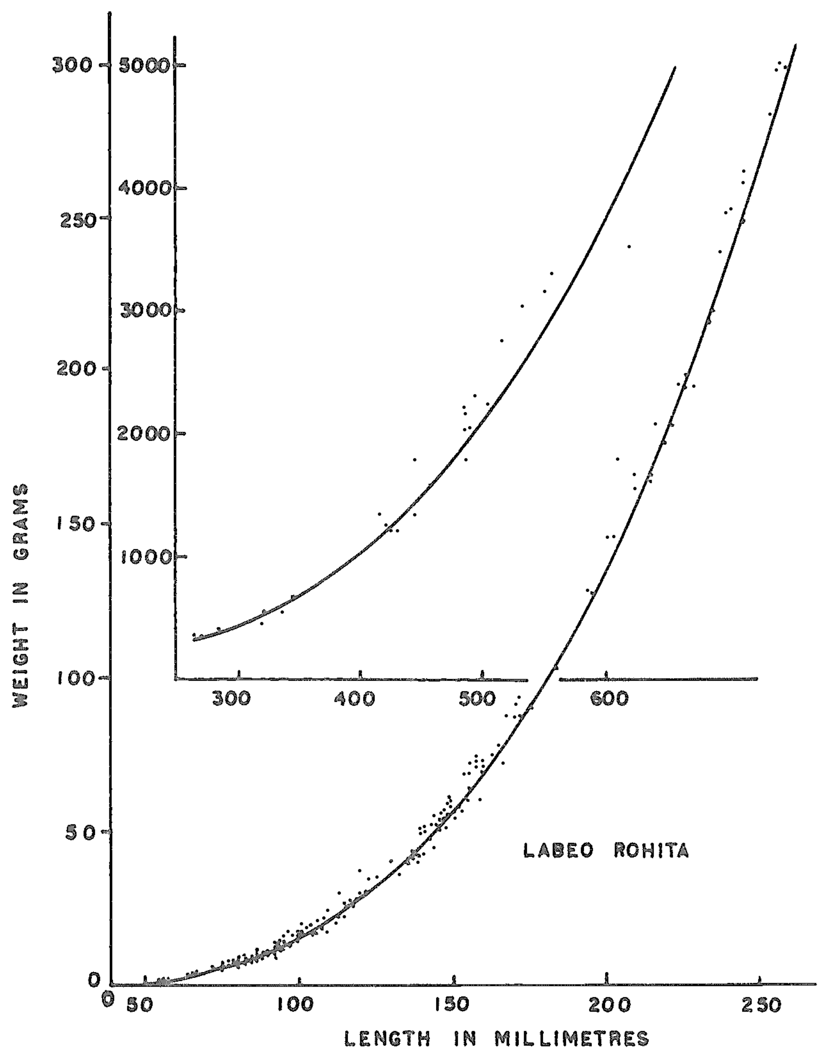

Figure 8 Curves showing length-weight relationship of Labeo rohita (Jhingran 1952).

by the feeding intensity and spawning cycle of the fish. The growth curve of first year class showed two maxima, first in October and second in April in moats; and first in October and the second in May in rivers. These two maxima also coincided with two peak periods of feeding. In mature fishes, the sharp drop in growth rate during the months April to June in riverine fishes was due to enlargement of gonads. An increase in post-spawning months was due to the better feeding (Table XXX).

Khan (1972) observed a positive correlation between the growth rate and conductivity, alkalinity and temperature in pond moats and Chau Tal. Table XXXI shows correlation between ecological factors and growth rate of L. rohita. The higher growth rate of Chau Tal fishes was attributed to high alkalinity of water, high production of the food and high feeding intensity of the fish. Table XXXII shows the limnological condition in pond moats and Chau Tal at Aligarh.

Khan and Hussain (1945) studied the length-weight relationship of L. rohita from the departmental fish farm at Chbenanan, Punjab (Pakistan) and concluded that the weight of the fish (in Chhataks) can be known at a certain length (cm) by multiplying the cube of the length with the weight-length factor which in the case of this fish is 0.000238.

Jhingran (1952), observed the length-weight relationship of rohu (Figure 8) in a general manner and empirically determined the value of the exponent n and the constant c in the general length-weight equation of fish, i.e., weight = c length^{n}. Specimens used for this study ranged in furcal length from 50 mm to 620 mm and in weight from 2.0 g to 4.989 6 g. The formula derived was:

$$\text{weight} = 1.554 \times 10^{-5} \times \text{length}^{3.0140028}$$

which in logarithmic form is:

$$\log \text{weight} = -4.80836464485 + 3.0149928 \log \text{length}.$$

The standard error of estimate in terms of logs is ± 0.0739. The coefficients of correlation between log length and log weight of L. rohita is 0.994. Among major carps namely Catla catla, Cirrhina mrigala and L. rohita studied by Jhingran (1952), L. rohita stands last and thus deviates least from the "cube law". In the order of heaviness C. catla comes first, next is L. rohita and last is C. mrigala.

Khan (1972) determined the length-weight relationship of rohu, based on 726 fishes collected from moats and 390 fishes from rivers, separately for juveniles, male, female, combined and different maturity stages for both the environments, but he did not find any significant difference between the fishes of different size, sex and maturity stages in a population. However, there was a significant difference between the fishes of moats and rivers. This was mainly due to significant population difference. The regression coefficient "n" of moat fishes ranged from 2.9743 (gutted fishes to 3.3823 (ripe females) in case of moat fishes and 3.0833 (gutted fishes) to 3.4569 (ripe females) in case of riverine fishes. As a whole, disregarding maturity stages and gutted fishes, it was highest in juveniles (3.3015 in moat fishes and 3.361 in riverine fishes) and lowest in females (3.1282 in moat fishes and 3.1439 in riverine fishes). Values of "n" estimated at 95 percent confidence intervals for male, female and juvenile were always higher than three in both the environments (Table XXXIII). Analysis of covariance (Table XXXIV) revealed that there was no significant difference at 5 percent level between the males, females and juveniles of any environment.

Average weights at different length intervals of riverine fishes are given below:

Total length (mm)	Weight (g)
100	10.9
200	98.1
300	354.5
400	882.4
500	1 789.0
600	3 190.0
700	5 198.0
800	7 936.0
900	11 530.0

Increase in weight in relation to length was not appreciable up to 150 mm length, was conspicuous between 150-200 mm and well marked above 200 mm. Females were heavier than males up to the length of 500 mm and males were heavier than females at higher lengths and the LW curves of the two sexes intersected at a point between 500 mm and 600 mm.

The weight-length relationship of rohu in different D.V.C. reservoirs, as determined by Pantulu et al. (1967) is given as follows:

Tilaya : $W = 0.0083618\ L^{2.6977}$

Panchet : $W = 0.0136210\ L^{2.5326}$

Konar : $W = 0.0062230\ L^{2.8079}$

The weight-length relationship in respect of rohu was significantly different at 5 percent level between different reservoirs.

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

Das (1960) found that the growth of rohu spawn

TABLE XXX

Mean monthly growth rate of Labeo rohita

Months	First year				Second year			
	Moat fishes		Riverine fishes		Moat fishes		Riverine fishes	
	Mean length (mm)	% of total annual growth	Mean length (mm)	% of total annual growth	Mean length (mm)	% of total annual growth	Mean length (mm)	% of total annual growth
August	-	-	-	-	330	-5.7	330	13.8
September	55	-	70	-	375	14.8	330	0.0
October	130	136.0	140	100.0	430	14.8	400	23.1
November	190	46.2	160	14.3	450	4.7	405	1.2
December	185	-2.6	165	3.2	450	0.0	400	-1.2
January	175	-8.1	150	-9.0	445	-1.1	360	-10.0
February	200	14.2	200	33.0	505	13.2	450	26.0
March	200	0.0	210	5.0	480	-5.0	400	-11.0
April	290	45.0	160	-23.8	485	-1.0	450	12.5
May	330	13.6	220	37.5	490	-1.0	420	-6.6
June	355	7.5	270	22.5	510	4.0	400	-4.2
July	350	-1.4	290	7.4	-	-	470	17.5

TABLE XXXI

Correlation between ecological factors and growth rate of L. rohita

Variable	Moat fishes		Chau Tal fishes	
	Correlation coefficient (r)	Probability of 't' at 13 D.F.	Correlation coefficient (r)	Probability of 't' at 6 D.F.
Growth rate and conductivity ($r_{1.2}$)	0.768	0.001	0.718	0.02
Growth rate and alkalinity ($r_{1.3}$)	0.892	0.001	0.990	0.001
Growth rate and pH ($r_{1.4}$)	0.080	0.90	0.875	0.001
Growth rate and D.O. ($r_{1.5}$)	0.080	0.90	0.875	0.001
Growth rate and temperature ($r_{1.6}$)	0.665	0.001	0.656	0.05

TABLE XXXII

Limnological condition in pond moats(I) and Chau Tal (II)

Months	Age months		Mean length (mm)		Conductivity (mhos/cm)		Alkalinity (ppm)		pH		D.O.(ppm)		Temperature (°)	
	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)
October (1967)	3	3	130	150	-	.000700	13	82	-	9.0	11.3	0.6	24.2	24.2
November	4	4	190	200	0.000726	.000706	19	90	9.4	9.0	10.8	3.4	21.0	21.0
December	5	5	191	200	0.000706	.000740	19	107	9.1	8.9	9.3	4.1	17.0	17.0
January (1968)	6	6	170	200	0.000806	.000840	17	88	8.9	8.8	8.8	0.3	13.0	13.0
February	7	7	200	270	0.000900	.000940	20	130	8.9	8.9	8.2	1.6	15.2	15.2
March	8	8	240	240	0.001027	.001310	24	161	8.9	9.8	12.2	1.8	20.1	20.1
April	9	9	290	310	0.001400	.002160	29	291	9.3	9.6	14.4	5.4	26.9	26.9
May	10	10	330	400	0.001730	.003570	33	494	9.8	9.7	10.2	9.5	32.0	32.0
June	11	11	360		0.001370		36		9.5		7.9		35.0	
July	12		350		0.001310		35		9.2		8.6		30.5	
August	13		340		0.001410		34		9.1		7.2		27.5	
September	14		390		0.001290		39		9.2		10.1		30.0	
October	15		430		0.001290		43		9.2		11.2		30.0	
November	16		450		0.001260		45		9.2		12.3		27.0	
December	17		440		0.001280		44		9.2		11.0		22.0	

TABLE XXXIII

Regression equations of weights and length of *Labeo rohita* and their test of significance (Khan, 1972)

Source	Regression coefficient ('b')	Intercept ('a')	Variance of 'b'	S.D. of 'b'	S.E. of 'b'	95% confidence limit of 'b'	S.E. of 'a'	Regression equation	Parabolic equation
Moat fishes									
Male	3.1706	-5.39150	0.1510	0.1510	0.0506	3.0714-3.2698	0.000002	Log W = -5.39150 + 3.1706 Log L	$W = 0.4060 \times 10^{-5} L^{3.1706}$
Female	3.1282	-5.27770	0.0240	0.1549	0.0611	3.0087-3.2477	0.000006	Log W = -5.2770 + 3.1282 Log L	$W = 0.5274 \times 10^{-5} L^{3.1282}$
Juvenile	3.3015	-5.58780	0.0251	0.1581	0.0530	3.1976-3.4054	0.000004	Log W = -5.58780 + 3.3015 Log L	$W = 0.2584 \times 10^{-5} L^{3.3015}$
Combined	3.0592	-5.08509	0.0239	0.1546	0.0259	3.0086-3.1099	0.000005	Log W = -5.08509 + 3.0592 Log L	$W = 0.8222 \times 10^{-5} L^{3.0592}$
Riverine fishes									
Male	3.2275	-5.48182	0.0178	0.1334	0.0568	3.1162-3.3388	0.00046	Log W = -5.48182 + 3.2275 Log L	$W = 0.3298 \times 10^{-5} L^{3.2275}$
Female	3.1439	-5.26520	0.0206	0.1435	0.0704	3.0059-3.2819	0.00073	Log W = -5.26520 + 3.1439 Log L	$W = 0.5284 \times 10^{-5} L^{3.1439}$
Juvenile	3.3611	-5.66244	0.0211	0.1449	0.0883	3.1880-3.5342	0.00080	Log W = -5.66244 + 3.3611 Log L	$W = 0.2176 \times 10^{-5} L^{3.3611}$
Combined	3.1689	-5.30005	0.0099	0.0995	0.0620	3.0474-3.2904	0.00044	Log W = -5.30005 + 3.1689 Log L	$W = 0.5012 \times 10^{-5} L^{3.1689}$

TABLE XXXIV

Analysis of covariance of length-weight data of Labeo rohita (Khan, 1972)

Character	D.F.	S.S.	D.F.	S.S.	M.S.	D.F.	S.S.	M.S.	Observed F	5% F	Significance
Moat fishes											
Male, female and juvenile	722	17.2819	720	17.1860	0.02387	2	0.0959	0.047950	2.0087	3.000	NS
Different maturity stages	223	0.4262	216	0.4216	0.00195	7	0.0040	0.006570	2.9703	3.230	NS
Riverine fishes											
Male, female and juvenile	386	7.5985	384	7.5495	0.01963	2	0.0490	0.02550	1.2990	3.000	NS
Different maturity stages	204	0.6825	195	0.6486	0.00333	9	0.0339	0.00377	1.1150	1.880	NS
Combined moat and riverine fishes	1 113	23.0704	1 112	21.6190	0.01944	1	1.4514	1.45140	74.6000	19.500	S

D.F. = Degree of freedom
S.S. = Sum of squares
M.S. = Mean square
NS = Not significant
S = Significant at 5% level

was influenced by the qualitative difference in food supply, such as the type of zooplankton and algae present in the pond. Growth and survival of major carp spawn when stocked in nurseries depend on the kind and dose of fertilizers used, supplementary feeding and stocking density. Inorganic fertilizers such as ammonium sulphate, urea, etc., have been found to enhance the survival and growth of major carp spawn.

Yard trials with 80 kg N/ha of ammonium sulphate, when applied to slightly acid, nutrient-deficient soil, gave 39 percent survival of major carp spawn during 1968 at Cuttack, when compared to 31 percent for control. During 1969, with the same dose of ammonium sulphate, the survival and growth of rohu fry in moderately acid soil (pH 4.8) were obtained to be 51 percent, 12.77 mm/16.87 mg when compared to 31 percent, 15.53 mm/15.75 mg in control. Almost identical results were obtained with the same dose of calcium ammonium nitrate (survival 48 percent, growth 15.0 mm/39.16 mg of rohu spawn) in moderately acid soil. In neutral soil, urea gave maximum survival (66 percent and growth 13.57 mm/20.67 mg) of rohu spawn (Central Inland Fisheries Research Institute, Barrackpore, Annual Reports 1968 and 1969). Statistically designed field experiments which were conducted at Cuttack during 1968 on the efficacy of ammonium sulphate, urea and calcium ammonium nitrate on primary productivity and spawn survival showed that of the three rates (20, 50 and 80 kg N/ha) of application, 80 kg N/ha was most effective, as it gave a uniformly high primary productivity of 2.23, 1.94 and 2.23 mg C/day and 57, 47 and 73 percent survival of major carp spawn respectively (Central Inland Fisheries Research Institute, Barrackpore, Annual Report 1968). In 1969, a very encouraging result in spawn survival was achieved in a nursery pond (soil pH 6.9) treated with only urea (80 kg N/ha) when, without artificial feeding, survival as high as 76 percent of rohu spawn was achieved as against control showing 13 percent.

During 1963 an experiment was conducted at the Cuttack Substation of Central Inland Fisheries Research Institute to study the effect of low-nutrient highly unproductive acid soil to different combinations of organic and inorganic fertilizers, and to evolve a suitable manuring practice for carp nurseries located on such soils. The ponds were first limed at 200 kg/ha. After that the fertilizer, viz., (a) purely organic (cowdung + mustard oilcake), (b) purely inorganic (N-P-K + ammonium sulphate) and (c) organic + inorganic fertilizer (mustard oilcake + N-P-K) on equivalent basis at 90-40-20 kg of $N-P_2O_5-K_2O$ per ha were applied in the ponds. Nine days after fertilization, the ponds were stocked with rohu spawn at 50 000 per 4.0 ha. The results obtained showed that maximum percentage of survival (over 65 percent) was attained in ponds treated with the purely inorganic combination of fertilizers, and the minimum (about 31 percent in ponds treated with the purely organic combination of fertilizers which indicated that purely inorganic fertilizer combination at 90-40-20 kg of $N-P_2O_5-K_2O$ per ha had a highly satisfactory response for this specific type of unproductive soil (Central Inland Fisheries Research Institute, Barrackpore, Annual Report 1964).

The growth of rohu fry and fingerling in relation to various factors such as fertilization of ponds, supplementary feeding of stocked fishes, their stocking density and ratios, etc., are dealt with in Section 5.6.5 under pond management. Khan (1972) found a positive correlation between the growth rate of rohu figerlings and some of the chemical parameters of water such as conductivity, alkalinity and temperature in pond moats and Chau Tal at Aligarh. This has been dealt with in Section 3.4.3.

3.5 Behaviour

3.51 Migration and local movements

Rohu, like catla, is said to be a local migrant, undertaking short journeys in search of suitable breeding grounds during the spawning season. For details refer to Jhingran (1968).

3.52 Schooling

In ponds and other enclosed waters, rohu could be seen schooling in shallows during the early fry and fingerling stages mainly for feeding purposes. In case of adults, this habit is not obvious.

4 POPULATION

4.1 Structure

4.11 Sex ratio

According to Khan (1972) the sex ratio of rohu is closely relation to 1 : 1 (1 : 0.98). A chi square test of heterogeneity at 5 percent level did not show any significant deviation from 1 : 1 ratio. There was an irregular pattern of occurrence of any sex. However, during the months of July and August, the percentage of females was more than males. In case of sex composition at various age groups, there was a significant preponderance of males over females in age group I and preponderance of females over males in age group VII. Rest of the age groups did not deviate significantly. Khan (1972) concluded that in case of rohu, the rate of survival of males of this species is low in comparison to the females at higher ages and deviation from 1 : 1 sex ratio at higher ages may be attributed to the progressive decrease of males in the population. Alikunhi et al. (1964) and Alikunhi (1971) recommended a release of breeders of rohu in the ratio 1 : 1 by weight and females to 2 males by numbers.

4.12 Age composition

Refer to Sections 3.12 and 3.31.

4.13 Size composision

The size composition of rohu, as revealed from random samples from the catches of River Yamuna at Allahabad, is given in Tables XXXVa and b.

TABLE XXXVa

Year-wise length frequency of rohu of River Yamuna at Allahabad

Length group (mm)	1961–62 f	1962–63 f	1963–64 f	1964–65 f	1965–66 f	1966–67 f
51–70	9	–				1
71–90	4	2		1		2
91–110	14	35	1	7		11
111–130	16	42	12	15		8
131–150	11	66	9	7		1
151–170	5	60	15	6		1
171–190	3	9	34	6		6
191–210	11	2	12	5		1
211–230	14	9	3	5		1
231–250	5	5	2	3		
251–270	3	12	3	5		
271–290	4	11	7	5	2	
291–310	4	32	10	5	1	1
311–330	20	42	7	16	1	5
331–350	13	54	15	6	8	4
351–370	25	49	23	24	13	6
371–390	23	80	24	22	24	11
391–410	16	84	30	28	20	10
411–430	10	90	27	36	24	9
431–450	18	65	27	30	18	30
451–470	24	99	36	31	16	30
471–490	20	123	40	32	14	31
491–510	25	104	43	46	24	33
511–530	25	82	52	54	20	34
531–550	28	80	52	51	35	28
551–570	24	88	81	76	47	33
571–590	27	84	80	63	49	42
591–610	25	133	100	71	65	40
611–630	31	117	122	91	59	39
631–650	33	166	131	88	75	38
651–670	27	97	105	82	75	49
671–690	22	107	100	60	73	52
691–710	22	76	65	72	59	47
711–730	25	49	56	60	61	47
731–750	25	28	23	39	58	38
751–770	22	24	21	27	38	18
771–790	19	24	14	18	32	20
791–810	7	11	8	7	6	8
811–830	2	2	4	5	7	9
831–850		3	4	7	11	6
851–870	1	10	6	11	3	1
871–890	2	12	7	8	9	2
891–910	5	7	7	5	8	4
911–930	6	5	6	11	13	3
931–950	1	3	6	4	12	2
951–970	1	5	5	2	8	3
971–990		4	5	1	5	3
991–1 010		1		5	4	2
1 011–1 030				1		1
Sample size	679	2 293	1 440	1 262	987	771

TABLE XXXVb

Monthly pooled percentage length-frequency distribution of rohu of River Yamuna for the years 1961-62 to 1966-67

Length group (mm)	March	April	May	June	July	August	Sept.	October	November	December	January	February
51-70						1	7					
71-90						2	4	2				
91-110						4	22	29	13			
111-130				1			21	23	46	1		1
131-150							9	11	40	33		1
151-170							2	11	16	54		4
171-190				1			1	21	27	6		4
191-210	1					1	24		11			4
211-230		3				3	2	18	2	1		5
231-250	1			2	3	2	2	3			1	
251-270				1	3	5	9	2	1	1	1	
271-290	1	1		8	4	6	7	2				
291-310			1	14	1	12	6	7	4	3	5	
311-330	1			8	7	29	8	19	4	3	12	
331-350	1		5	6	10	20	14	18	13	4	8	1
351-370	2	3	2	7	10	17	30	26	19	7	17	
371-390	1	2	6	16	10	17	40	23	30	7	27	5
391-410	1	8	8	15	12	23	29	24	22	11	31	4
411-430		14	5	14	16	11	32	34	29	20	18	3
431-450	4	20	12	8	18	13	40	21	20	8	21	4
451-470	7	24	14	17	24	20	43	29	15	23	15	5
471-490	8	17	22	9	16	13	49	30	45	18	25	8
491-510	13	23	21	15	21	19	40	38	31	25	21	8
511-530	17	29	24	18	12	22	26	40	24	18	28	9
531-550	21	22	30	26	19	20	25	22	36	12	29	12
551-570	27	38	41	19	28	22	38	38	29	16	32	21
571-590	37	44	40	25	26	25	21	29	22	16	39	18
591-610	42	65	73	35	19	31	29	25	35	22	33	25
611-630	49	66	53	55	34	19	30	29	35	30	39	20
631-650	69	88	67	57	37	23	30	34	18	29	39	40
651-670	50	63	57	47	22	18	21	24	27	31	39	36
671-690	34	47	59	57	30	13	21	29	19	34	33	38
691-710	27	38	52	35	18	17	16	23	27	35	25	28
711-730	23	25	26	37	14	9	28	28	28	39	18	23
731-750	15	16	25	14	6	7	25	17	20	24	28	14
751-770	6	12	14	4	6	10	10	13	18	23	23	13
771-790	5	6	14	4	8	9	7	19	7	16	14	8
791-810	2	5	2	3	2	5	5	2	5	8	5	3
811-830	3	2	2		3	2	3	3	4	2	3	2
831-850		7	4	2	4	2	4		3		2	4
851-870		7	3	2	3	2	3		1	5	1	5
871-890	2	5	3	5	7	3	1	2	2	3	2	5
891-910	5	4	5	8	2	3	1		1	2	3	3
911-930	4	6	7	7	6	1	3		3	2	1	4
931-950	2	4	1	4	8	2	1		1	2		3
951-970	2	2	5	4	7		1		2	1		
971-990	1	2	3	1	4				3	2	1	1
991-1 010	2				7					1	2	
1 011-1 030	1				1							
Total:	487	718	706	611	488	483	766	782	758	599	641	392

4.3 Natality and recruitment

4.31 Reproduction rates

Alikunhi (1971), setting an arbitrary production target of 10 millions of spawn (spawn of catla 3 millions, rohu 4 millions and mrigal 3 millions) in one breeding season through induced breeding of major carps, allowing 50 percent success in injection and 60 percent of the brood stock to attain the proper stages of receptivity for injections, recommended the following number of breeders, as shown in Table XXXVI.

TABLE XXXVI

Breeders required for producing 10 millions major carp eggs (Alikunhi, 1971)

Species	No. of fish to be injected				No. of fish to be available for selection				Total stock to be maintained for breeding	
	Female		Male		Female		Male		No.	Wt (kg)
	No.	Wt (kg)	No.	Wt (kg)	No.	Wt (kg)	No.	Wt (kg)		
Catla	30	90	60	90–120	50	150	100	150–200	150	350
Rohu	46	70	72	100–120	77	115	155	170–200	232	315
Mrigal	80	80	160	120–130	135	135	265	200–220	400	355
Total	156	240	312	370	262	400	520	620	782	1 020

Thus the actual number of fish required to yield a crore of spawn is only 78 females and 156 males and the stock of 1 020 kg. This stock can be safely produced in 0.5 ha pond.

4.33 Recruitment

The natural spawning of rohu may commence early or late depending on the onset of the southwest monsoon.

4.4 Mortality and morbidity

4.41 Mortality rates

Jhingran and Chakraborty (1958) determined the mortality rate of Cirrhina mrigala, Catla catla and L. rohita, between the fingerlings and yearling stages, in a 208 km-stretch of River Ganga, between Patna and Moghalsarai. A total of 305 512 specimens of all the three 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 percent, 36.2 percent and 11.5 percent of the total catch of carp juveniles respectively. By weight, catla, being the heaviest of the three, constituted 8.9 t (70.5 percent), mrigal 2.8 t (22.1 percent) and rohu 1 t (7.4 percent) 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 percent) specimens of mrigal, 87 028 (28.5 percent) specimens of catla and 74 877 (22.8 percent) specimens of rohu. By weight, the percentage contribution of mrigal, catla and rohu amounted to 4.41 t (29.4 percent), 8.32 t (55.5 percent) and 2.26 t (15.1 percent) respectively.

4.42 Factors causing or affecting mortality

Large-scale mortality of fishes caused by oxygen depletion has been observed in lakes, ponds and tanks, usually during summer when continuous sultry weather is followed by sudden showers. Other conditions which have been reported to cause severe mortality of fishes are highly alkaline condition of the water (570 ppm), drastic fall in the water temperature, etc.

4.43 Factors affecting morbidity

Refer to Jhingran (1968). The existing information on the conditions affecting morbidity of fishes has been reviewed by Jhingran (1971). George et al. (1965) evaluated the toxicity of the wastes of DDT Factory located at Delhi on River Yamuna in fish fry bio-assay experiments.

They reported that the effect of the DDT and chloral hydrate, present in these effluents, on the fish life is mainly by the process of coagulation of mucus in gills and opercular chamber of fishes under moderately acidic pH. The lowest tolerance limit recorded was 0.13 percent. The approximate dilution required for such a waste would be around 8 000 for the survival of fish. In case the waste is neutralized, dilution required could be brought down to about 10.15 times only. Investigations carried out by Ray and David (1966) in a 35-km stretch of the River Ganga indicated that, despite the considerable organic load, dilution of the order of 4 000-5 000 percent occurs in the river, which prevents the sludge from disintegration and creation of anaerobic conditions. The slight pollution occurring mainly on account of partial or total deoxygenation of the water is felt only toward the marginal areas downstream of the outfall. George et al. (1966) observed that the River Kali whose flow varies between 14 and 2 545 cfs receives wastes from many factories such as sugar, distillery, tin, glycerine, paints, soap works, spinning, rayon, silk and yarn. These authors reported an incidence of a large-scale fish mortality in a 160-km zone resulting in a loss of 300 quintals of fish. The mortality of fishes was attributed to depletion of oxygen over a stretch of 72 km. Bhaskaran et al. (1965) carried out a limnological survey in 921 km of stretch of River Gomati in the vicinity of Lucknow (Uttar Pradesh) receiving 19.84 mgd of wastes from pulp and paper factory, distillery and sewage. They reported that, despite self purification, through dilution of the order of 1:11 even during the summer months, the pullutional effects still persist with dissolved oxygen at some places showing below 5 ppm. Gopalakrishnan et al. (1966), while investigating the breeding of major carps in the Tilaya and Panchet Reservoirs, observed that the flow from Sindri nallah into which the effluents from Sindri Fertilizers Factory are discharged, adversely affect the fish spawn, particularly in the area surrounding the mouth of the nallah where dead fish spawn were collected. On the River Hooghly, the stretch of 90 km between Tribeni and Batanagar near Calcutta, is highly industrialized with various types of factories dealing with pulp and paper, distillery, tannery, textile (cotton and rayon), heavy chemicals, paints and varnishes, shellac, hydrogenated oil, matches, cycle rims, petroleum oil, tar pigment, insecticides and fungicides and other miscellaneous products flanking on both sides of the river. Of these, wastes from paper and pulp, distillery, heavy chemicals, textiles, shellac and a number of domestic outfalls contribute subtantially to the pollution complex. Recent studies in respect of the effluents of India Pulp Paper Co., have shown that the pollutional effects persist up to a distance of about 1.6 km from the outfall region (Gopalakrishnan et al., 1970).

Of all the chemicals used in fishery waters, chlorinated hydrocarbons are perhaps the most toxic to fishes. Many of them are stable compounds, not metabolized or excreted to any degree. Many also remain stored in fish tissues. Three chlorinated hydrocarbons, viz. aldrin (containing not less than 95 percent by weight of endo-exo isomer of 1, 2, 3, 4, 10, 10-hexachloro 1, 4, 4a, 5, 8, 8a-hexahydro-1, 4, 5, 8-dimethanonapthalene); dieldrin (containing not less than 85 percent by weight of the endo-exo isomer of 1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro 1, 4, 5, 8-dimethano - napthalene) and endrin (1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-exo- 5, 8-dimethanonapthalene), have been tested as ichthyocides. Aldrin and dieldrin are lethal to fishes at 0.2 ppm and 0.01 ppm respectively (Chaudhuri, 1960a). Endrin is the most poisonous chemical so far tried in India for eradication of fishes from a water body. In fields endrin has been found effective at 0.01 ppm to kill all fishes. The toxic effect of the chemical lasts for about six weeks.

Organophosphates are generally less toxic to fish when compared to chlorinated hydrocarbons, but they adversely affect other aquatic biota DDVP (O : O- dimethyl-2, 2- dichlorivinyl phosphate) killed fishes at a concentration ranging from 3-30 ppm (Srivastova and Konar, 1968). Konar (1965 and 1968) conducted experiments to determine the minimum lethal dose of thiometon and chlordane for L. rohita respectively. Details are given in Table XXXVII.

Detoxification of thiometon takes only eight days in the field and 40 days in the laboratory. Chlordane, however, is more toxic than thiometon and showed its toxicity beyond 100 days.

Konar (1970a and b) reported the 168-h LC_0, LC_{50} and LC_{100} values of heptachlor (1, 4, 5, 6, 7, 7a-tetrahydro-4, 7-endomethaniondene) a chlorinated hydrocarbon, in laboratory tests to be 0.01, 0.0168 and 0.02 ppm respectively. In the 60-day field test, when rohu was exposed to 0.01 ppm heptachlor, the fish showed severe pathological lesions in the liver and kidney. The safe application rate (SAR) of heptachlor was found to be 0.0084 ppm and no marked lesions were recorded in the stomach, intestine, gill, liver and kidney of rohu exposed to this concentration (Konar, 1971).

4.5 Dynamics of population

There is a false fear among the fishing community, especially of the Ganga River system, based on vague memories of the past landings, that the major carp fishery including that of rohu is dwindling year after year. Studies on the dynamics of rohu populations of the Ganga River system have been attempted. The average annual rohu landings

TABLE XXXVII

The LD_0, LD_{50} and LD_{100} values of thiometon and chlordane for rohu (Konar, 1965 and 1968)

Species	No.	Size range (mm)	Values (ppm) of			Time for complete kill (h)
			LD_0	LD_{50}	LD_{100}	
I. Thiometon L. rohita		24-26 60-70	0.13 0.64	0.3221 1.4200	0.56 2.00	15.0-39.0 9.5-23.5
II. Chlordane L. rohita	15	50-62	0.00004	0.0000709	0.0001	40

based on 11-year data for the period 1958-59 to 1968-69 along with average percentage contributed by the fish at different sampling centres on Ganga River system is shown in Table XXXVIII. Rohu was found to be the most dominant species in the upper and lower stretches of the Ganga and less important in the middle. Its average annual landing was recorded to be 12.01 t, 14.89 t and 5.54 t at Agra, Allahabad and Kanpur respectively. At Varanasi, Buxar and Ballia, rohu fishery dwindled to 0.82 t, 1.39 t and 0.96 t respectively. Further downstream, rohu became more abundant showing average annual landings of 7.23 t and 4.10 t at Patna and Bhagalpur respectively. Studies on the abundance of major carps in D.V.C. reservoirs, while taking catch/effort as an index abundance, revealed that *Catla catla* appeared to be the most dominant species in Maithon reservoir, *L. rohita* and *Cirrhina mrigala* were comparatively more abundant in Panchet. The abundance of mrigal and rohu was the least in Maithon where although mrigal occurred fairly in good quantitites, the abundance of rohu was practically negligible. In Tilaiya the abundance of all the three species was uniform (Pantulu *et al.*, 1967).

4.6 The population in the community and the ecosystem

In order to make best use of all the fish food available in different niches of pond, composite culture of Indian carps, which are of different feeding habits, is practised in Burma, Bangladesh, India and Pakistan. Jhingran (1968) has given some details of the practices commonly adopted for polyculture of Indian carps. However, in recent years, the compatibility of rohu with catla, rohu, mrigal and also with exotic fishes such as common carp, silver carp and grass carp, has been studied. The details are given in Section 6.41. The composite culture of Indian and exotic carps has been found to form a highly compatible community resulting in high fish production.

TABLE XXXVIII

Rohu: Annual arrivals of rohu and their percentages in total arrivals at different markets

Years[1]	Weight and percentage	Yamuna		Ganga					
		Agra	Allahabad	Kanpur	Varanasi	Buxar	Ballia	Patna	Bhagalpur
1958-59	Wt (t) %	47.65 15.5	7.22 5.0	12.76 13.7	1.65 3.5	5.41 5.0	3.41 3.1	3.08 5.6	0.18 0.4
1959-60	Wt (t) %	36.17 13.3	10.37 5.4	5.65 5.3	1.36 2.9	1.49 2.1	1.63 3.2	4.73 11.8	1.45 2.4
1960-61	Wt (t) %	6.08 10.5	12.58 6.3	7.38 9.0	0.64 0.9	1.42 2.6	0.85 1.0	11.64 12.1	2.57 3.6
1961-62	Wt (t) %	12.37 16.4	14.09 6.9	2.16 7.3	0.50 0.7	Incomplete data "	0.82 1.6	9.76 9.2	2.03 1.7
1962-63	Wt (t) %	3.38 5.6	21.81 8.3	6.46 12.3	0.11 0.1	Incomplete data "	0.47 0.6	11.11 8.6	3.41 3.5
1963-64	Wt (t) %	4.77 7.5	23.11 11.5	6.47 15.0	0.32 0.4	0.61 1.9	0.60 0.5	5.81 5.0	2.55 3.3
1964-65	Wt (t) %	4.75 8.2	26.78 10.4	4.45 13.2	0.55 0.8	0.46 1.5	Incomplete data "	5.95 7.7	4.27 5.6
1965-66	Wt (t) %	3.42 5.7	17.39 8.2	3.88 11.9	1.39 0.13	1.83 3.3	Incomplete data "	8.46 7.6	9.86 10.4
1966-67	Wt (t) %	3.91 7.1	10.10 5.4	5.88 12.1	1.57 1.6	0.53 0.8	1.31 2.6	7.02 5.9	6.68 8.0
1967-68	Wt (t) %	4.11 11.1	10.07 6.0	2.25 8.9	0.53 0.4	0.29 0.6	0.63 1.6	4.54 4.6	6.33 5.2
1968-69	Wt (t) %	5.50 6.5	10.98 4.8	3.57 9.0	0.43 0.3	0.53 0.4	0.91 2.2	7.39 6.7	5.78 4.1
Average:	Wt (t) %	12.01 9.7	14.89 6.7	5.54 10.7	0.82 1.2	1.39 2.0	0.96 1.8	7.23 7.7	4.10 4.3

1/ Year March to February

5 EXPLOITATION

5.1 Fishing equipment

5.11 Gears

Gears viz., drag, gill, drift, purse, cast and scoop nets along with traps and hook and lines, used to take rohu are same as those employed for catla (see Jhingran, 1968).

Rohu, like catla, is also caught by hand, when tanks are being dragged, a partyof fishermen follow the net and collect the fish escaping the net (Ahmad, 1954).

Rohu has been regarded as an excellent game fish (Thomas, 1897; Lacy and Cretin, 1905; MacDonald, 1948, etc.). Lacy and Cretin (1905) stated that for rohu fishing, a paste-bait should be used - ordinary atta is good enough, but a good paste is made of bread, mixed up with cheese and coloured yellow or vermilion with turmeric. The natives also mix Asafoetida with their bait. The same authors about rohu being on the rod while angling say "He plays in a more persistent and dogged fashion and keeps bossing away on the line, occasionally giving sharp jerks, or knocks which vibrate right up through the rod to one's hands".

MacDonald (1948) stated that rohu seemsto put up a much better fight in a river than in a tank. He described a method to catch fish in rivers on hook and line. According to him, a line 54 m long is wrapped criss-cross over a small dried vegetable marrow. To one end of the line is attached a 0.9 m long mount, made of a thick piece of string 3 mm thick and with a heavy weight on one end. Equidistant from the end are two pieces of line attached to the mount about 12.5 mm long with a large hook attached (size 4/0 in Limerick hooks) to each length. Hooks are baited with red juicy earthworm, as much as they can hold, and then enough line is collected off the bobbin and held in loops or laid in coils on the sand. The cast is then made into a slow flowing part of the river. The line is then fixed into a slotted bamboo peg of about 12.5 mm in height. The line is picked up as soon as a run is registered and the fish is played through the fingers. When the fish is tired and the mount comes into the hand, the fish is knocked on its head by a small club which is held by the chin against the chest. Generally, rohu comes to the surface and breaks the water with a loud swirl, after which he generally lets up two bubbles. In tanks, bottom fishing for rohu is also practised. According to MacDonald (1948), old tanks with weeds or masonry walls or steps that are land-bound with no water escape, will generally hold good fishes. The usual bait is paste, either flour or atta or nice red worms or eggs of white ants or wasps. But he mentioned that the best and the most pleasant bait is roasted mustard cake (two parts), mixed with bran (two parts), damp earth (one part) and water, made up into small size slabs, each being 100-125 mm in diameter and a couple of mm thick. Rohu goes off with a strong rush when hooked and will sometimes jump out of the water. The line should be struck when the float is going down or when the fish is stocking in the bait.

5.12 Boats

In the 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 net. In River Narmada, fishing is done from flat-bottomed boats 6-9 m long operated by three of four men. In River Godavari, open plank-built, undecked boats of ca 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 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 are used for operation of clap and dip nets.

5.2 Fishing areas

5.21 General geographic distribution

See Table IX, under Section 2.1.

5.22 Geographic range

Latitude 8°N to 32°N

Longitude 68°E to 100°E

5.23 Depth ranges

In rivers, fishing nets are operated both in deep and shallow waters depending upon the type of gear used. Drag nets are used in the depth 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 to June), but suspended during the southwest monsoon (May to October) because of excessively strong currents and greatly increased depths. During monsoon, fishing is concentrated in small tributaries, creeks, nullahs, drains, etc. From shallow inundated areas, juveniles are fished out in living condition for cultural operations by fine-meshed drag nets from September to December.

5.32 Dates of beginning, peak and end of season

See Section 5.31.

5.33 Variation in dates or duration of season

In summer, when the water level runs extremely low and most of the stream is reduced to a mere trickle, fishing nets can be easily operated in rivers and reservoirs and, consequently, there is usually more intensive fishing. During southwest monsoon when rivers are in spate, often overflowing their banks and inundating 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 extremely high demand for fresh water fish in the eastern states of India, especially Bengal, also influence the time and duration of fishing operations. Fishing activity in different parts of India, Bangladesh and Pakistan is suspended on certain religious festivals and ceremonial occasions.

5.4 Fishing operations and results

5.43 Catches

Table XXXVIII shows the annual landings of rohu and their percentage in the total arrivals at six urban assembly centres situated on River Ganga and at two on River Yamuna.

Table XXXIX depicts the average percentage distribution of annual landings of rohu in summer, monsoon and winter seasons at various fish landing centres for the period 1958-59 to 1965-66. The percentage composition of the seasonal market arrivals of rohu at various centres, based on 8-year data for the period 1958-59 to 1965-66, is shown in Table XL. The percentage contribution of different months to the average annual landings for the aforesaid period at various centres are delineated in Table XLI. It shows that seasonal fluctuations in rohu landings at Agra and Kanpur were extremely prominent, with its main fishery extending from November to July. While one peak period at Agra was in summer in March-April, the other higher peak was in the winter month of December. At Kanpur, on the other hand, the summer peak in April was higher than the winter peak in February. The summer landings of rohu in these uppermost zones were the maximum and accounted for 48.2 percent and 41.0 percent of the annual rohu landings at Agra and Kanpur respectively. The winter fishery of rohu in these zones was also sizable and formed about 39 percent of the annual landings of this carp at both these centres. However, Table XL illustrates that rohu's percentage at Agra was maximum in winter, At Allahabad, rohu was landed more in summer, although the summer percentage was only a little better than that of monsoon. Quite unlike the other zones of the upper stretches, Allahabad zone recorded almost equal landings in all the months, except in the peak monsoon month of August and in December, when hilsa landings were more dominant and perhaps the effort too had shifted to hilsa fishing (Jhingran et al., 1972).

In the zones of the middle stretches of the Ganga, the summer season contributed the maximum landings of rohu at Varanasi and Ballia, while it was minimum in case of Buxar. Table XXXIX shows that little less than 50 percent at Varanasi and a little more than 50 percent at Ballia of the annual landings in the two zones were made in summer season. But Varanasi had also a good monsoon landing, while Ballia had sizable landings in winter.

Varanasi had better rohu landings from April to July, while at Ballia it was conspicuous by its complete absence from August to October, but gave better yields from March to July and again in December. At Buxar, October alone accounted for 33.7 percent of annual landings of rohu in that centre (Table XLI).

In the Patna and Bhagalpur zones of the lower stretches, rohu fishery mainly flourishes from the middle of winter till about the middle of summer. While 40.5 percent at Patna and 47.0 percent at Bhagalpur of the respective centre's average annual rohu catches were landed in winter, the five-month period from December to April yielded 54.5 percent of the annual rohu landings at Patna and 65.9 percent at Bhagalpur.

Preliminary data were collected in 1962 from Ganga River system for 15 days per month at Allahabad and Agra on River Yamuna and at Varanasi, Buxar, Ballia, Patna and Bhagalpur on River Ganga. Table XLII shows the percentage composition of mrigal catch made by different nets throughout the period of study.

TABLE XXXIX

Average percentage landings of rohu in different seasons at various centres of Ganga River system

Season	Average percentage landings at							
	Agra	Allahabad	Kanpur	Varanasi	Buxar	Ballia	Patna	Bhagalpur
Summer	48.2	37.4	41.0	47.3	20.0	54.5	35.4	41.6
Monsoon	12.6	35.8	20.3	32.6	52.9	11.9	24.1	11.4
Winter	39.2	26.8	38.7	20.1	27.1	33.6	40.5	47.0

TABLE XL

Percentage composition of the seasonal market arrivals of rohu

Season	Percentage composition of the seasonal market arrivals at							
	Agra	Allahabad	Kanpur	Varanasi	Buxar	Ballia	Patna	Bhagalpur
Summer	10.9	9.3	8.4	1.6	1.6	1.9	9.5	6.6
Monsoon	11.3	6.2	11.6	1.1	5.3	0.4	7.6	1.6
Winter	15.6	4.9	13.0	0.6	2.5	2.2	8.2	5.3

TABLE XLI

Percentage distribution of average monthly landings of rohu in different zones

Zones	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Agra	15.2	14.3	5.8	12.9	10.9	0.3	0.4	1.0	8.1	16.1	9.8	5.2
Allahabad	10.2	8.9	9.2	9.1	9.1	5.8	8.2	12.7	7.1	5.7	7.8	6.2
Kanpur	5.4	17.4	13.4	4.8	8.7	1.9	3.4	6.3	7.5	11.7	7.3	12.2
Varanasi	5.8	12.1	10.1	19.3	15.3	9.4	6.7	1.2	3.1	5.4	5.8	5.8
Buxar	5.4	7.5	2.2	3.9	6.6	5.0	7.6	33.7	7.5	3.2	7.6	9.8
Ballia	16.0	14.0	16.2	8.3	11.9	0.0	0.0	0.0	5.3	13.1	9.3	5.9
Patna	12.1	11.2	4.7	7.4	8.2	6.4	5.1	4.4	9.3	11.8	8.8	10.6
Bhagalpur	9.6	12.0	9.8	10.2	5.2	0.2	2.2	4.0	2.5	12.8	16.9	14.6

TABLE XLII

Percentage of rohu by different gears at different centres in the Ganga River system (Jhingran et al., 1972)

Type of net	Local name of the gear	Centre	Season	% Composition of rohu
Drag net (major)	Mahajal	Sadiapur	Year round	0.3
	Mahajal	Bhagalpur	Late winter-early summer	15.6
	Paunrhi	Buxar	Winter-Summer	21.0
	Darwari	Sadiapur	Year round	0.4
	Chhanta	Mahendroghat	Year round	1.9
	Ghanaili	Buxar	Summer-Winter	0.3
	Ghanaili	Ballia	Year round	11.9
	Kaprajal	Bhagalpur	Late winter early summer	4.4
Purse	Sangel	Bhagalpur	Year round	1.5
	Kamel	Sadiapur	Year round	0.1
Scoop	Jali	Sadiapur	Monsoon	5.5
	Bishaljal	Bhagalpur	Winter	1.6
Traps	Kuriar	Mahendorghat	Summer-Monsoon	9.3
	Sikri	Bhagalpur	Late winter-early summer	0.7
	Anta	Bhagalpur	Year round	4.7
Long line	Jor	Bhagalpur	Year round	0.6

6 PROTECTION AND MANAGEMENT

6.1 Regulatory (legislative) measures

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 anicut at Dehri and Barun of 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 Caubery Bridge to its confluence with Ellis surplus Channel, Ullar River in Tanjore district, etc. Uttar Pradesh, Andhra Pradesh, Jammu and Kashmir and Madhya Pradesh also observe restrictions on fishing in prohibited waters.

Closed seasons: are followed in Bihar, Madras, Jammu and Kashmir, Madhya Pradesh, Mysore, etc. In all large reservoirs, fishing is closed from June-July to end of September so that fishes are not hampered during their breeding migration.

Limitations on size or efficiency of gear: in Delhi, since 1948 restrictions have been imposed on fishing except with rod and line, hand line and long line from 1 July to 31 August, every year or any other net of less than $1\frac{1}{2}$ in square mesh. Generally, the minimum mesh size of the nets permitted is 1 in in Indian reservoirs. However, nets of smaller meshes are permitted to be used 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 rohu, mrigal, mahaseer and catla of a size smaller than 25.4 cm long. 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 15 June to 31 July in the prohibited areas, except under a licence issued by the proper authority. In Madhya Pradesh, a size limit of 22.9 cm has been imposed since 1953 for the capture of rohu, mahaseer, mrigal and catla.

6.2 Control or alteration of physical features of the environment

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 levelling them at different elevations so that they could get flooded at different water levels in bundhs.

6.4 Control or alteration of biological features of the environment

6.41 Control of aquatic vegetation

Rohu subsists mainly on aquatic algae and higher plants and decaying aquatic vegetation.

Filamentous algae such as Spirogyra and Ulothrix and higher aquatic plants such as Lemna are easily digested and more efficiently utilized by the fish. Hence some weed growth in the pond will offer the food for the fish. Hora (1943a) reported that growth of rohu was better in ponds containing Wolffia which forms their food. However, excessive growth of aquatic weeds should be checked as they pose a serious problem to the fish culturists and are detrimental to the fish health. For details on the control of aquatic vegetation refer to Section 7.5.

6.44 Control of predation and competition

Refer to Section 7.5. Nursery, rearing and stocking ponds should be cleared of all predators before stocking rohu therein in order to ensure good survival. Once predators gain entry into stocked waters, measures should be adopted to control their multiplication and finally to eradicate them from such waters.

Periodic checking of the growth of stocked fish will reveal whether there is competition for food or for space. And accordingly, the stocking density of rohu will have to be adjusted either by reducing the number of rohu or of competing species.

6.45 Population manipulation

Fish production from a unit area is a product of individual growth rate and population density. High stocking density results in an increase of total fish production and reduction in the weight and size of the fish produced; conversely low stocking density shows an increase of individual growth of fish. However, there is a limit for stocking, as an excessive number will result in the cessation of fish growth, their weakening, etc. This may result in the mortality of fish, besides other factors being responsible for it. When the growth of fish becomes retarded, it is essential to adjust the fish population by harvesting of heavily stocked nursey ponds, or by culling and removal of larger specimens both in rearing and stocking ponds. This will hasten growth of small fish in the pond and increase production.

6.5 Artificial stocking

6.51 Maintenance stocking

Refer to Section 7.5

6.52 Transplantation; introduction

Refer to Section 2.1

7 POND FISH CULTURE

7.1 Procurement of stocks

Same as in Catla catla (refer to Jhingran, 1968). The stocking material of rohu required for pisciculture operations, is produced from natural sources by (i) collecting eggs from breeding grounds, (ii) collecting spawn, fry and fingerlings from rivers, (iii) breeding fish in bundh-type tanks, and (iv) breeding fish through hypophysation. Details of the methods of collection of fish seed from riverine sources have been given by Jhingran (1968a and 1973). Table XLIII shows the spawn collection centres prospected by the Central Inland Fisheries Research Institute from 1949 to 1956 and from 1964 to 1970.

Technique of procurement of stocking material from bundh-type tanks has been described by Chaudhuri (1967), Jhingran (1968) and Dubey (1969). With the attainment of first success by the Department of Fisheries, Government of Madhya Pradesh, during 1958 in dry bundh breeding of carps in "Sonar Talliya", many more dry bundhs with improved designs have been subsequently constructed. The most modern constructions are generally masonry structures with arrangements of a sluice gate in the deepest portion of the bundh and one or two waste weirs for complete drainage and overflow of excess water. In most cases, apart from the bundh itself, a dry bundh unit consists of storage ponds for stocking breeders, an observation post with arrangement for storing, necessary equipment and a set of cemented hatcheries (measuring 2.4 m x 1.2 m x 0.3 m) with a regular supply of water for handling a large number of eggs at a time. In some cases, the embankment is of a pucca stone masonry with a small sluice gate and a portion of the embankment itself serves as the waste weir (Dubey, 1969).

Breeding of fish by hypophysation has already been mentioned under Section 3.1.6. Subsequent to the fish having spawned, the fertilized eggs, after they have become water-hardened and preferably after the embryos contained therein have commenced performing movements, are transferred from the breeding to a hatching hapa. The hatching technique is the same as described by Jhingran (1968). Eggs are spread uniformly all over the inner hatching hapa. The number of eggs released in each hatching hapa varied from 75 000 to 100 000. Majority of eggs hatch out within 14-18 hours after fertilization. Hatchlings escape to the outer hatching hapa. Three days after hatchlings absorb their yolk sac, they are collected and stocked in nurseries. Recently, a simple hatchery comprising 40 glass hatching jars (Figure 9) under controlled temperature conditions and with circulation of water, has been set up at the Pond Culture Division of the Central Inland Fisheries Research Institute. Each glass jar has a length of 61.5 cm, inner diameter of 13.0 cm and a capacity of 6.35 l of water, is in the form of an inverted bottle and is provided with an inlet on its bottom and outlet on the top. Each jar can hold about 50 000 eggs of Indian major carps for hatching. The outlet of each jar is connected to a semicircular channel made of galvanized sheet, ultimately leading to a receptacle. Each receptacle has a number of cloth hapas fixed in it to hold hatchlings temporarily and is provided with arrangement for water shower in order to keep the

TABLE XLIII

Spawn collection centres prospected by the Central Inland Fisheries Research Institute from 1949 to 1956 and 1964 to 1970 (Jhingran, 1973)

Year of observation	Name of the Centre	Name of the River	Name of the State	Remarks
FROM 1949 TO 1956				
1949	Nimtita	Ganga	West Bengal	Observations were also made on the Dhuliyan stretch (West Bengal) of the Padma and Kosi-Ganga junction (Bihar)
1950	Naraj Bhagipur Ravipui Tikkerpara	Mahanadi	Orissa	114 km-stretch of the Mahanadi from Tikkerpara to Cuttack was investigated
1951	Sultanganj Mokamah Ghat	Ganga	Bihar	New spawn collection centres located for the first time
1952	Dighwara Buxar Kursela Karhagola Khagaria	Burhi Gandak	Bihar	Spawn yield at these five centres was assessed, of which Dighwara was found to be the best
1953	-	-	Bhopal (now Madhya Pradesh)	New spawn collection centres were located
1954	Jhansi	Betwa	Uttar Pradesh	A natural spawning ground of <u>Labeo gonius</u> was located
1955	Baratalab	Kulans	Bhopal (now Madhya Pradesh)	Investigations conducted for location of spawn collection centres
	Pidrai Baghpat Rajghat Narora Dankaur	Betwa " " "	Uttar Pradesh	Of the nine centres investigated on the Ganga, Yamuna and their tributaries in Uttar Pradesh, 2 very productive, 3 productive and the rest of lesser value, were located
	Bulwa (Saharsa district) Japhaha (Muzaffarpur district)	Burhi Gandak	Bihar	Spawning grounds of major carps were located
1956	Sakrigalighat Muzaffarnagar Saharanpur Bijnor and Dehradun districts	Ganga Ganga and Yamuna	Uttar Pradesh	Of the 10 sites investigated in 4 districts for location of spawn collection centres, none was found suitable as only small quantities of major carp spawn was available at these sites. Large quantities of fertilized eggs and fry <u>Labeo dyocheilus</u> and <u>L. dero</u> were available in the Yamuna near Kairana (Muzaffarnagar) and near Balawali (Bijnor) in the Ganga

Continued

Table XLIII concluded

Year of observation	Name of the			Index of spawn quantity (ml)	Index of spawn quality (%)		
	Centre	River	State		Major carps	Minor carps	Others
FROM 1964 TO 1970							
1964	Kishanpur	Yamuna	Uttar Pradesh	7 355.6	85.3	14.6	0.1
	Mahewa-Jamunapur	Yamuna	Uttar Pradesh	4 402.0	72.3	27.4	0.3
	Tajpur	Ramganga	Uttar Pradesh	3 351.2	2.8	96.7	0.5
	Sardanagar	Ramganga	Uttar Pradesh	965.6	5.9	94.0	0.1
	Baluha	Tons	Uttar Pradesh	28.4	–	–	–
	Sisodra	Narmada	Gujarat	7 128.4	70.6	29.3	0.1
	Rania	Mahi	Gujarat	85.2	37.4	51.1	11.1
1965	Anwara	Yamuna	Uttar Pradesh	3 493.0	81.0	19.0	–
	Dhumanpura	Yamuna	Uttar Pradesh	2 200.0	35.0	24.0	41.0
	Bansi	Rapti	Uttar Pradesh	4 715.0	77.7	21.6	0.7
	Dhundhua	Son	Bihar	637.0	3.5	94.9	1.6
	Dangwar	Son	Bihar	2 417.0	25.2	74.8	–
	Nanded	Godavari	Maharashtra	215.0	12.3	67.1	20.6
1966	Majhawali	Yamina	Haryana	784.0	18.60	80.84	0.56
	Mant	Yamina	Uttar Pradesh	17.3	26.30	72.6	1.1
	Ghagraghat	Ghagra	Uttar Pradesh	228.4	7.4	92.6	–
	Khagaria	Burhi Gandak	Bihar	–	–	65.28	34.72
	Babuaghat	Kosi Khanua Dhar	Bihar	664.0	35.10	46.6	18.3
	Mehdi Jhajha	Badua	Bihar	–	26.1	73.9	–
	Wazir Bhullar	Beas	Punjab	–	–	98.4	1.6
	Loduwal	Sutlej	Punjab	5 560.0	2.6	93.2	4.2
1967	Kulithalai	Gauvery	Tamil Nadu	125.0	50.6	28.3	21.1
	Dharmapuri	Godavari	Andhra Pradesh	Negligible	–	–	–
	Nethla	Yamuna	Uttar Pradesh	6 006.1	7.0	86.4	6.6
	Salempur	Gomati	Uttar Pradesh	1 373.6	26.4	73.6	0.0
	Tonk (Sopari)	Banas	Rajasthan	1 801.0	81.5	17.7	0.8
	Dingrahaghat	Mahananda	Bihar	251.0	94.0	4.0	2.0
1968	Negria	Banas	Rajasthan	1 531.5	59.4	40.4	0.2
	Nanamau	Ganga	Uttar Pradesh	807.6	76.3	23.1	0.6
	Deolan	Yamuna	Uttar Pradesh	239.0	83.7	15.2	1.1
	Mahewapatti	Yamuna	Uttar Pradesh	601.0	18.2	78.0	3.8
1969	Baretha Barrier	Uttangan	Rajasthan	Negligible	–	100.0	–
	Mahewapatti	Yamuna	Uttar Pradesh	1 098.0	52.2	47.4	0.4
	Bahiara	Son	Bihar	252.0	88.50	11.5	–
	Tilauthu	Son	Bihar	–	80.0	–	–
	Dighwara	Ganga	Bihar	–	–	–	–
	North Gauhati	Brahmaputra	Assam	–	8.53	–	
	Nirathanallur	Coleroon	Tamil Nadu	197.85	16.21		
	Sosale	Cauvery	Mysore	–			
1970	Hamidabad	Brahmaputra	Assam	970.0	43.98		
	Ahirauli	Ganga	Bihar	552.0	85.49		
	Pairachali	Kangasabati	West Bengal				
	Mahewapatti	Yamuna	Uttar Pradesh	92.3	17.3		

Figure 9 A simple carp hatchery

water of the receptacle aerated. The entire hatchery is housed in a controlled-temperature laboratory. During 1972, a total of 10 lakhs of spawn was produced out of 19.8 lakhs eggs released in the hatchery (Central Inland Fisheries Research Institute, Barrackpore, Annual Report, 1972).

7.3 Spawning (artificial, induced, natural)

Techniques of spawning rohu are similar to those of *Catla catla* (refer to Jhingran, 1968). Spawning in both wet and dry bundhs usually occurs after continuous heavy showers for days, when large quantity of rain water rushes into the bundhs. In dry bundhs, a selected number of rohu spawners in the ratio of one female to two males (1:1 by weight) are introduced. At first, small-sized mature fish get stimulated to breed and, in order to spawn, migrate either to the shallow area of the bundh itself or to those adjoining it. Bigger fishes spawn next in the same bundh. Spawning occurs over hard or sandy or muddy soil and even on rocky embankments. When spawning is over, a thick blanket of fertilizer eggs is left over the spawning site. The spent fish in bundhs move to the deeper areas in bundhs. Soon after the spawning is over, the eggs are collected from the bundh with the help of nets made of mosquito-netting cloth (gamcha) and released for hatching either in improvised pits or in double-walled hatching hapas or in cement hatcheries.

For induced spawning refer to Section 3.16. As regards selection of breeders, ripe males with freely oozing milt and females with soft bulging rounded abdomen and with reddish vent are chosen. A male rohu can easily be recognized from the female during the breeding season from the roughness of the dorsal surface of its pectoral fins compared to relatively smooth surface of the female. Healthy breeders weighing 1.5-5.0 kg are preferably to be chosen for breeding. To keep breeders in healthy condition, they are often fed with mustard oilcake and rice bran at the rate of 1 percent of their body weight for a few months prior to breeding season, the stocking rate of the brood fish being 1 000-2 000 kg/ha.

For natural spawning refer to Section 3.16 and 7.1.

7.4 Holding of stock

As in *Catla catla* (see Jhingran, 1968). According to Alikunhi (1956), depending upon the density of plankton, the stocking rate varies from 12 lakhs to 20 lakhs per ha. However, much higher stocking densities (7 812 500 spawn per ha as mentioned by Hora and Pillay, 1962) are known to be adopted by fish farmers. At the Pond Culture Substation of the Central Inland Fisheries Research Institute, 10-20 lakhs spawn per ha have been stocked with satisfactory results in well manured nurseries and when artificial feed is to be given. More recently, the survival rate has been raised from 50 percent to as high as 70-75 percent. Stocking of spawn has been increased at Pond Culture Division of the Central Inland Fisheries Research Institute from one million to 3.75 million/ha (Sen, 1972). Thus, from one ha of water, 2.5 m fry can be produced in a single crop of 15 days duration as against 20 000 to 40 000 obtained by conventional methods. Two to three crops can be raised from the same water in a season. The Department of Fisheries, Government of Maharashtra, Bombay, has suggested the stocking density of spawn to be six million per ha. During 1972, when rohu hatchling were stocked at 6.2 million per ha and cobalt chloride (at 0.01 mg/day/fish) given to spawn along with the feed, survival of fry obtained at the end of 14 days was 62 percent as against 45 percent in the control (Central Inland Fisheries Research Institute, Barrackpore, Annual Report 1972). The average growth increment of fry was 21.3 mm/11 246 mg in treated ponds as against 22.7 mm/12 056 mg in the control. For holding of stock in rearing and stocking ponds refer to Section 7.5.

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

Same as in *Catla catla* (see Jhingran, 1968). Pond management practices have recently been reviewed by Huet (1970) and Bardach *et al.* (1972). With a view to finding out a suitable substitute for the fish poison, Derris root powder, a number of indigenous plants have been successfully used to control trash fishes. The powdered seed kernel of *Croton tiglium* (3-5 ppm), powdered root of *Milletia pachycarpa* (2-6 ppm) have also been found quite effective for killing fish (Bhuyan, 1967). The seed powder of *Barringtonia accutangula* was found to kill a wide variety of fish at 20 ppm concentration with its toxic effect lasting for 48 h (Chakrabarty *et al.*, 1972). *Randia dumetorum* (unripe fruit powder at 12 ppm) and *Walsura piscidia* (bark powder at 10 ppm) are reported to be effective in killing tilapia and murrels (Central Inland Fisheries Research Institute, Barrackpore, Annual Reports 1968 and 1969).

Tea-seed cake can be used about a month before bringing the pond into commission; the cake serves not only as a poison for weed fishes and insects, but also as a fertilizer. Mahua oilcake (*Bassia latifolia*) which also serves both as a poison as well as manure in nursery ponds, is effective in killing common predatory and weed fishes at 75 ppm (Central Inland Fisheries Research Institute, Barrackpore, Annual Report 1968). Bhatia (1970) reported that under laboratory conditions the approximate threshold dose of mahua oilcake was found to be 60 ppm to kill fishes, e.g., *Cirrhina mrigala*, *Puntius ticto*, *Cyprinus carpio* var. *communis*, *Colisa fasciata* and *Channa gachua*. At 100 mg/l concentration, all fishes died within 10 h. Waters containing 100, 200, 300, 400 and 500 ppm of mahua oilcake were found to lose their toxicity to fishes after 48, 72, 96, 144 and 192 h respectively. However, for a complete removal of predatory and weed fishes, mahua oilcake at 200-250 ppm has been recommended by the

Central Inland Fisheries Research Institute for application in nursey ponds at least a fortnight before stocking nursery ponds with carp spawn (Central Inland Fisheries Research Institute, Barrackpore, Annual Report 1968). In nursery ponds, endrin has been found to be effective at 0.01 ppm to kill all fishes and pond organisms except molluscs and zooplankters. The toxic effect of the poison lasted for two days at 0.001 ppm, but, at a dose of 0.01 ppm, toxicity continued for about two weeks (Chaudhuri, 1960a). Tafdrin-20, a commercial product of Burmah Shell and Co. containing 20 percent endrin as its active poison, has been suggested by the Central Inland Fisheries Research Institute to be used in nursey ponds at a concentration of 0.01 ppm of endrin. Of all the chemicals such as lime, sodium hydroxide, potassium permanganate, sulphuric acid and cowdung tried to serve as a suitable agent for detoxification of endrin-treated waters, ordinary charcoal at 50 ppm appeared to be relatively more suitable as well as economical. Raw cowdung applied at a rate of 2 000 ppm or 18 000 kg/ha/month has also been found very effective for detoxifying the effects of endrin. The presence of rich organic matter in the soil or a thick algal bloom in the water mass has been observed to accelerate natural detoxification of the pond (Banerjee, 1970) treated with endrin. Other ichthyocides such as thiometon (Konar, 1965), DDVP (Srivastava and Konar, 1965) and phosphamidon (Srivastava and Konar, 1965) have been found successful for killing fish on experimental basis.

Sometimes fairy shrimps appear in nurseries and result in very low survival of spawn, as has been reported in the nurseries at Tungabhadra dam (Chandrasekhar, 1971). Fairy shrimps could be controlled to some extent by treating nurseries with lime (4 000 ppm) or bleaching powder (containing about 33.3 percent chlorine) at 60 ppm or combination of both lime (4 000 ppm) and bleaching powder (12 ppm). But fairy shrimps have been reported to reappear in some treated ponds.

After clearing the nursery ponds of all the predatory and weed fishes by the application of fish poison, they are limed at the following doses, depending upon the quality of the soil, a fortnight before manuring:

pH	Soil type	Lime (kg/ha)
4-5	Highly acidic	2 000
5-6.5	Moderately acidic	1 000
6.5-7.5	Near neutral	500
7.5-8.5	Mildly alkaline	200
8.5-9.5	Highly alkaline	Nil

Generally, lime is applied immediately in nursery ponds after it has been cleared of predatory and weed fishes. In this case, if mahua oilcake is used as a fish poison, lime should be applied earlier than the application of the latter.

The next step in nursey preparation consists of manuring so as to augment the production of zooplankters which form the natural food of carp spawn. Nursery ponds are treated either with organic manures such as cowdung or with inorganic fertilizers (N.P.K.), or with both, one following the other. Pond manuring has also been dealt with under Section 3.4.4. The doses of fertilizers and manures, if used by fish culturists, are mostly determined empirically depending upon the fish poison used for the eradication of unwanted fishes. If the fish poison used in mahua oilcake, which as stated earlier, has a manurial value as well, the pond is manured generally with only 5 000 kg cowdung per ha. But with other poisons, which have no manurial value, cowdung is applied at the rate of 10 000 kg/ha. Spaced manuring with an initial dose of 10 000 kg cowdung per ha, 15 days before the anticipated date of releasing spawn in nurseries at the rate of 5 000 kg/ha seven days after stocking, is said to maintain sustained production of zooplankton. The steps stated above are adopted only when one crop of fry is to be harvested from the nursery pond. If two more crops are to be harvested, nursery ponds may be fertilized with 2 000 kg/ha of cowdung about a week before subsequent stocking. Culture of choice zooplankters for feeding carp spawn has gained importance in recent years. At the Pond Culture Division of the Central Inland Fisheries Institute, crude culture of zooplankton has been obtained the the laboratory and field with mahua oilcake-cowdung-poultry manure in the ratio of 6:3:1 at the rate of 1 000 ppm. A culture of diatoms (Nitzschia and Navicula) has also been obtained in the laboratory and field with urea-bone meal-potassium nitrate in the ratio of 5 : 15 : 3 at the rate of 230 ppm. Bhimachar (1971) conducted experiments to study the conditions under which the optimum production of cladocerans could be raised. For immediate production of a population of cladocerans, organic manures are considered very suitable, since these organisms are known to sustain themselves directly by consuming particulate suspended organic matter. In order to produce a population of Moina micrura in plastic pools, an initial manuring by fresh cowdung + groundnut cake at the rate of 250-350 ppm and 50 ppm respectively, followed by half of the above stated doses at intervals of four days has been recommended. This combination of manures was observed to release about 5.5 ppm of phosphoric acid in the water. It was, however, essential to inoculate the treated water with 2 to 5 ml of any of the pure cladoceran culture to get a dense population of the same. Even if a pure culture of cladocerans is not available for inoculation, mixed zooplankter species may be uniculated provided the inoculum has sufficient quantity of cladocerans. It is said that with the above stated manuring treatment, it is possible to harvest from several plastic pools holding 300 l of water each, every alternate day, in a total of 12 days, about 30 to 70 ml of plankton. In large pools of 8 000 l capacity, plankton volume was found to measure 2.08 ml of sediment per l of water, the production being much higher occasionally.

Moina micrura thus produced can be collected and fed to carp hatchlings. Recently, the Department of Fisheries, Government of Maharashtra, Bombay (Anon., 1969) has evolved the following day-to-day schedule of fertilizing nurseries in order to get an average survival of 45 percent from spawn to fry stage, the stocking density of spawn being six million per ha. The initial dose of fertilization per ha on the day preceding stocking is: superphosphate of lime, 150 kg + triple superphosphate of lime, 50 kg + cowdung or any cattle dung, 700 kg + oilcake, 700 kg. All these four types of manures are mixed together thoroughly by adding water sufficient to make a thick paste and then broadcast throughout the nursery. The nursery is then inoculated initially with 30-50 ml of Daphnia and Moina. On the second day of stocking, oilcake and cattle dung are applied at the rate of 350 kg and 87.5 kg/ha respectively. On the third day of stocking, the dose of oilcake and cattle dung is reduced to half that of the previous day. From the fourth to the ninth day of stocking, oilcake, cattle dung and rice bran are employed at the rate of 87.5 kg, 22 kg and 100 kg per ha respectively. If the spawn to be reared is that of catla, the quantities of manures are to be doubled from the fourth to the ninth day of stocking, catla being a planktophage. With the above stated schedule of fertilization, the spawn grow to fry in 10 days, measuring ca 18-20 mm in length, when they are removed from the nursery ponds. The latter are then prepared afresh for raising second crop of spawn. For obtaining the second crop of spawn, nurseries are initially fertilized one day before stocking with monophosphate of lime and triple phosphate of lime at the rate of 75 kg and 25 kg per ha respectively, the rest of the fertilization schedule remaining the same as in the case of the first crop.

Manuring of nursery ponds with mahua oilcake/cowdung/inorganic fertilizers may sometimes result in the development of phytoplankton blooms, which can be controlled by sprinkling liquid cowdung or some other organic matter or dye, or by covering the surface of the pond with the duck weed Lemna (Alikunhi et al., 1952), all causing the bloom to die within 4-5 days by preventing light penetration.

Nursery ponds are invariably populated with a large number of aquatic insects over greater part of the year and especially during and after the rains. Their destructive role in carp nurseries has been described by Khan and Hussain (1947), Pakrasi (1955), Alikunhi et al. (1955), Alikunhi (1957), Chaudhuri (1960a) and Julka (1965 and 1969). Most of the aquatic insects, either in their larval and/or adult stages, in addition to directly preying upon carp spawn and fry, also compete with the latter for food. Table XLIV shows the common predatory insects which ordinarily abound in nursery ponds in India. The control measure consist of spraying an emulsion of 56 kg mustard or coconut oil and 18 kg washing soap per ha, on the water surface 12-24 h before releasing the fry (Pakrasi, 1955). Chatterjee (1970) has recommended the substitution of soap by Teepol B-300 (a detergent synthesized by Burmah Shell) in the emulsion. The recommended dose of Teepol is 560 ml to be emulsified with 56 kg of mustard oil. Experiments have shown that oil of Alexandrian laurel (Calophyllum inophyllum, a common plant in Malabar and Orissa) and water-dispersible gammexane, commonly known as Hertex W.P., are effective to kill insects and prawns (mostly Palaemon lamerri). These chemicals are economical to use and do not affect the fish spawn and zooplankton (Alikunhi, 1956). Khanna (1957) reported that aquatic insects were killed by gammexane within $\frac{1}{2}$ to 11 h depending on the concentration of the chemical which may vary from 0-6 to 1 ppm. Pure gamma isomer of benzene hexachloride, soluble in ethyl alcohol, is highly toxic to insects killing them in about 6 h at a dose of 0.01 ppm. Carp spawn can tolerate the chemical up to a dose of 0.05 ppm. A treatment recently developed by the Fisheries Department, Government of Maharashtra, Bombay, requires spraying an emulsion prepared by mixing high speed diesel oil (1 l), the emulsifier Hyoxid 0.011 (0.75 ml) and water (40 ml in the ratio of 1 040.75 ml of the emulsion for every 200 m^2 of water surface (Shrigur and Kewalramani, 1967). Bali and Thawait (1972) mentioned the emulsification of high speed diesel-boiler oil in combination with commonly available detergents to control aquatic insects in nursery ponds.

Soon after being stocked in manured nursery ponds containing rich zooplankton, carp spawn start feeding voraciously on natural food. At this time, the feeding requirements of spawn are so large that within 2-3 days of stocking, the food available in the nursery becomes very low. Thereafter artificial feed along with the natural food enhances the growth and survival of spawn considerably. The commonly administered feeds for Indian and exotic carps are rice bran and oilcakes of groundnut, coconut, mustard, etc. Artificial feed are always given in finely powdered form. The feeding schedule for 15 days' rearing of carp spawn is given in Table XLV.

Das (1958b) reported that when carp spawn was reared in manured nurseries and given various artificial feeds with different combinations of protein, fat, carbohydrate, roughage, vitamins, etc., the maximum growth of spawn was obtained with the feed having a combination of hydrolyzed proteins and carbohydrates (50 : 30). Complex proteins and pure carbohydrates gave poor results. Mitra and Das (1965) observed that till oilcake, rice powder and black gram gave higher survival and yields of carp spawn than rice bran. Silkworm pupae and fish meal gave better conversion ratio. Recently a new artificial feed (called NPC mixture) was developed at the Cuttack Pond Culture Division of the CIFRI, which comprised a mixture of dried, finely powdered and sieved aquatic insects (back swimmers), small prawns and shrimps and cheap pulses (Coropea) in the ratio of 5 : 3 : 2. This feed has been found to give better results in enhancing the survival

TABLE XLIV

Some important aquatic insects commonly met in nursery ponds

Aquatic insects		
Order Coleoptera	Order Hemiptera	Order Odonata
FAMILY DYTISCIDAE *Cybister confusus* Sharp. *C. tripunctatus asiaticus* Sharp. *Eretes sticticus* (Linnaeus) *Hydaticus vittatus* (Fabr.) *Sandracottus dejeani* Aube *Canthydrus laetabilis* (Walk) *Laccophilus parvulus* var. *orientalis* Aube *Agabus* sp. *Hypophorous* sp. *Bidessus* sp. *Neposternus* sp. FAMILY GYRINIDAE *Dineutus indicus* Aube *Gyrinus* spp. FAMILY HYDROPHILIDAE *Hydrous indicus* (Bedel) *Hydrous* sp. *Sterrnolophus rufipes* Fabr. *Berosus* spp. *Enochrus* spp. *Laccobius* spp.	FAMILY NOTONECTIDAE *Anisops bouvieri* Kirkaldy *A. breddini* Kirkaldy *A. waltairensis* Brooks *A. barbata* Brooks *A. sardea* (Herrick-Schaffer) *Nychia marshalli* (Scott) FAMILY PLEIDAE *Plea frontalis* (Fieber) *Plea* sp. FAMILY NEPIDAE *Ranatra filiformis* (Fabricius) *R. elongata* Fabricius *R. digitata* Hafiz and Pradhan *R. varipes* Stal *Laccotrephes griseus* (Guer) FAMILY BELOSTOMITIDAE *Diplonychus rusticum* (Fabricius) *Sphaerodema annulatum* Fab. *Belostoma indicum* Lap. and Serv. FAMILY CORIXIDAE *Micronecta scutellaris* (Stal) *M. quadristrigata* Breddin *M. thyesta* Distant *M. albiforns* (Motseh.) *M. halipoides* Horvath *Corixa distorta* Distant *Agraptocorixa* sp.	(i) Suborder Anisoptera FAMILY GOMPHIDAE FAMILY AESCHNIDAE *Anax* spp. FAMILY LIBELLULIDAE *Macromia* sp. *Libellula* sp. *Bradinopygia geminata* (ii) Suborder Zygoptera FAMILY AGRIONIDAE FAMILY COENAGRIONIDAE

TABLE XLV

Feed schedule of spawn for 15 days of rearing

Period	Feed per day in terms of weight (g) spawn at the time of stocking	
	Recommended by Alikunhi (1957)	Recommended by Hora and Pillay (1962)
First 5 days after stocking	Double	Equal
6th to 10th day after stocking	Three times	Double
11th to 15th day after stocking	Four times	Three times

and growth of spawn of catla, rohu, mrigal and silver carp than the cake-rice bran mixture (Lackshmanan et al., 1967). Poultry pellets - a product manufactured by M/s. Nazam Sugar Factory Ltd., Hyderabad (consisting of crude protein 16 percent, ether extract 11 percent, ash 3.5 percent, acid-insoluble ash 2 percent, phosphate 0.8 percent, moisture 10 percent and with added vitamins A, B_2 and D_3) have been found to be quite satisfactory in spawn rearing (Reddi et al., 1971). According to Chakrabarty et al. (1973), survival and growth of rohu hatchlings was best with zooplankton, followed by silkworm pupae, mustard oilcake + rice bran and groundnut oilcake + wheat bran in the order indicated. Prawn waste powder gave the poorest result in rohu. Survival of hatchlings has been mentioned under Section 3.17.

Normally, spawn stocked in nursery ponds attain a length of 20-25 mm in 15 days with artificial feeding, giving a survival of more than 50 percent. Then the fry are netted out and released in rearing ponds, which are to be prepared more or less on the same lines as the nursery ponds (Alikunhi, 1956). In recent years, experiments have been conducted at the Pond Culture Division of the CIFRI on rearing of carp fry to fingerling stage in various combinations of Indian and exotic species. Table XLVI shows the results of three-month rearing of carp fry during 1965-67. In these experiments, ponds were initially cleared of predatory and weed fishes, manured with cowdung at 11 230 kg per ha 10 days before stocking and ammonium sulphate + single superphosphate + calcium ammonium nitrate (11-5-1) at 690 kg/ha, two months after stocking. Fry (size range 23.6-314 mm and average weight of 0.15-0.3 g) were stocked at three densities of 62 500, 93 750 and 125 000 per ha with species ratios of catla 3 : rohu 4 : mrigal 1 : common carp 2. Fingerlings were fed with mustard oilcake and rice bran (1 : 1 by ratio) during the first month equivalent to initial total weight of fry stocked daily; during second and third months twice the initial weight of fry stocked. Silkworm pupae containing ca 59.72 percent protein have been reported to be superior as artificial feed in rearing fry to fingerlings than mustard oilcake and rice bran (Chakrabarty et al., 1971). In the course of three months, the average survival rate of 72-80 percent was obtained. Rohu fingerlings attained 148-150 mm in length, 34.5-41.7 g and a survival rate of 95.6-99 percent. The yield from these experiments was about 1 900-3 500 kg/ha/three months.

In experiments conducted during 1967-68 using combination of fry of one Indian and three exotic carps (in the ratios of silver carp 3 : rohu 3 : grass carp 1.5 : common carp 2.5) and stocking densities of 7 500 to 250 000/ha, overall survival percentages of 74 to 97 in 6 months have been attained at the Cuttack Substation of the CIFRI. During 1972, experiments of 3-month duration were conducted at Cuttack in two 0.08-ha ponds for raising fingerlings from fry of the Indian major carps in combination with the fry of grass carp and the aggregate percentages of survival obtained were 95 and 89.2 respectively. The stocking density and ratio were 2.07 lakhs/ha and catla 3.6 : rohu 3.6 : mrigal 1.6 :

TABLE XLVI

Results of three-month rearing of carp fry during 1965-67 in 12 ponds (each of 0.08 ha) at the Pond Culture Division of the CIFRI
(Lakshmanan et al., 1968; Anon., 1969 and Singh et al., 1972)

Sl. No.	Year	Rate of stocking/ ha (No.)	Species composition and ratio	Number harvested/ ha	Survival %	Gross production/ha/3 months (kg)
1	1965	62 500	C 3:R 4:M 1:Cc 2[a/]	53 650	85.84	20 550
2	"	"	"	52 875	84.60	214 612
3	1966	"	"	50 637	81.02	211 605
4	"	"	"	33 425	53.48	188 952
5	1965	93 750	"	75 800	80.85	251 175
6	"	"	"	56 200	59.94	238 787
7	1966	93 750	"	72 275	77.09	228 025
8	"	"	"	53 362	56.89	193 238
9	1965	125 000	"	95 900	76.72	348 612
10	"	"	"	92 062	73.65	276 937
11	1966	"	"	92 775	74.22	290 821
12	"	"	"	95 437	76.35	203 087

a/ C = catla
R = rohu
M = mrigal
Cc = common carp

grass carp 1.2 respectively. The average survival/growth were : catla 50 percent/8 g, rohu 92 percent/23.5 g, mrigal 77 percent/31.5 g and grass carp 81 percent/19.5 g in one pond and catla 62.51 percent/6.0 g, rohu 98.9 percent/19.5 g, mrigal 95.5 percent/34.3 g and grass carp 100 percent/14.6 g in the other. The weights of fingerlings produced in three months worked out to 3 108 kg and 3 163 kg/ha in two ponds respectively (Central Inland Fisheries Research Institute, Barrackpore, Annual Report 1972).

Stocking pond management aims at obtaining maximum production of marketable fish per unit water area in the shortest possible time. The first step to prepare stocking pond is to initially clear them of weeds and remove predatory and weed fishes, the methods for which are the same as those used in respect of nursery and rearing ponds. Old tanks and ponds with excess of bottom silt should be desilted before stocking as far as possible. After the eradication of predatory fish and minnows, ponds are limed at a dose depending upon the soil pH. Lime dose will be the same as in the case of nursery ponds. Fertilization schedule of pond is to be modified depending on its soil characteristics. If there is very little organic carbon in soil, then 20-30 tons/ha/year of cowdung is used. The first instalment should be 1/6 of total quantity a fortnight before stocking and rest in 10 equal monthly instalments. If the soil has organic carbon reserve, the quantity of cowdung will have to be varied accordingly. If mahua oilcake is used, the first instalment is to be reduced by 25 percent. The use of inorganic fertilizers varies according to available phosphorus and nitrogen in the soil. The high, medium and low criteria of available phosphorus and nitrogen are based on the following:

	Available P_2O_5 (mg/100 mg of soil)	Available N_2 (mg/100 mg of soil)
High	6-12	50-75
Medium	3-6	25-50
Low	0-3	0-25

The standard combination of N : P : K as 18 : 8 : 4 is generally recommended but the ratio of N and P will have to be modified according to the availability of N and P as stated above. After determining the total quantity of inorganic fertilizer required, the same may be applied in 10 equal monthly instalments alternating with organic manure. The period during which algal blooms develop the use of fertilizer should be stopped temporarily.

The next important step is to stock the ponds with fingerlings in optimum density and with proper species combination, because economic utilization of pond complex alone can give an optimum production. In India, mixed fish farming is an age-old practice. In Bengal, a combination of catla 30 percent, rohu 30 percent and mrigal 40 percent is reported to be commonly adopted (Alikunhi, 1957). The stocking combination of Indian major carps, as recommended by Hora and Pillay (1962), is shown in Table XLVII. However, in recent years, experiments have been conducted at the Pond Culture Division of the CIFRI to find out the optimum stocking density and ratios of the fast-growing compatible species of compatible feeding habits so as to utilize all the ecological food niches available in a pond in order to obtain high production per ha of water body. This system of pond management is called mixed farming or composite fish culture or polyculture. Alikunhi et al. (1971) conducted several preliminary composite culture experiments of Indian and exotic carps of variable durations during 1962-63. They reported that a maximum production of about 28 kg/0.04 ha was obtained in 52 days when grass carp, silver carp, catla, rohu, scale carp and mirror carp were stocked in the ratio of 2.5 : 1.5 : 1.5 : 2.4: 1 respectively at a stocking density of 135 per 0.04 ha. In these experiments, ponds were manured with cowdung at the rate of 5 000 kg/ha and grass carp was fed with Hydrilla at the rate of 250 g/pond/alternate day. Alikunhi et al. (1971) concluded that stocking density of 3 000-3 500 fingerlings having a total weight of 300-350 kg/ha is necessary to give a production of 3 000-3 500 kg/ha/year under regular manuring and/or artificial feeding.

During the years 1965-68, year-long culture experiments combining seven Indian and exotic species of fishes with some variations in the stocking ratio have been conducted at the Pond Culture Division of the CIFRI by Lakshmanan et al. (1971).

Seventeen experiments were conducted on production of table fish through composite farming under two broad combinations, involving rohu as one of the major species, viz., (i) culture of Indian major carps alone and (ii) culture of Indian and exotic carps. Table XLVIII shows production of fish in various experiments on composite fish culture. The gross production in 9 experiments with catla, rohu and mrigal ranged from 1 439-2 975 kg/ha/year (average 2 088 kg/ha/year) and in 8 experiments with Indian and exotic species 2 239 to 4 210 kg/ha/year (average 3 085 kg/ha/year).

Average size attained by fish in these experiments was 0.67 kg in one year. The details of experiments conducted during 1965-68 showing various combinations, stocking density, fertilizers and supplementary feeds used, etc., are given in Tables XLIX and L. An All-India Coordinated Research Project on Composite Culture of Indian and Exotic Fishes was initiated in 1971 by Indian Council of Agricultural Research with its headquarters at the CIFRI, with a view to trying intensive fish culture in different parts of the country. At one of the centres of this Project, viz., Gujartal Fish Farm, in two ponds gross and net fish yields corresponded to 2 962-3 210 kg/ha/6 months and 2 569-3 087 kg/ha/6 months respectively. At the other centre of the Project, i.e., Kulia Fish Farm gross and net yields of fish harvested from one pond amounted to 3 232 kg and 2 917 kg/ha/6 months respectively (Sinha, 1972). In another pond of 0.13 ha gross and net productions of 6 521 kg and 6 286 kg/ha/year respectively have been obtained (Sinha and Gupta, 1974).

TABLE XLVII

Stocking combinations of Indian major carps
(Hora and Pillay, 1962)

Species	Percentage of stock recommended		Stock of fingerlings (8-13 cm long) per ha	
	I	II	I	II
Catla	30	30	1 875	1 875
Rohu	60	50	3 750	3 125
Mrigal	10	10	625	625
Kalbasu	-	10	-	625
TOTAL			6 250	6 250

TABLE XLVIII

Production of fish in various composite culture experiments

Sl. No.	Year of experimentation	Area of the pond (ha)	Gross production (kg/ha/year)
I.	Composite culture of Indian major carps alone		
1	1965-66	0.122	1 439
2	"	0.12	1 521
3	"	0.08	2 535
4	"	0.06	2 975
5	1966-67	0.06	1 647
6	"	0.12	2 193
7	"	0.06	2 571
8	1967-68	0.08	1 821
II.	Composite culture of Indian and exotic carps		
9	1963-64	0.4	3 064
10	1965-66	0.133	2 234
11	"	0.4	2 745
12	"	0.133	3 500
13	"	0.133	4 210
14	1966-67	0.4	3 575
15	1967-68	0.14	2 575
16	"	0.16	2 830
17	"	0.16	3 041

TABLE XLIX

Composite culture of Indian major carps alone for one year (Anon., 1969 and Lakshmanan *et al.*, 1971)

Sl. No.	Experimental details	Pond No. 1	Pond No. 2	Pond No. 3	Pond No. 4
1	2	3	4	5	6
1	Year of experimentation	1965-66	1967-68	1966-67	1965-66
2	Pond size (ha)	0.08	0.08	0.12	0.06
	Depth (m)	1.5-2.0	1.5-2.0	2.5-3.5	1.0-1.5
	Location	Killa Fish Farm Cuttack	Killa Fish Farm Cuttack	Dolmundi Cuttack	Killa Fish Farm Cuttack
3	Condition of ponds	Rain-fed, perennial, free from weeds, well exposed and protected from floods. No regular inlets and outlets			
4	Initial preparation of ponds	Netted thoroughly and poisoned with Tafdrin-20 at 0.01 ppm about 6 weeks ahead of stocking to remove all existing fishes			
5	Species combination	Catla 4, rohu 3, mrigal 3	Catla 3, rohu 6, mrigal 1	Catla 3, rohu 4, mrigal 1	
6	Stocking density - No. of fingerlings/ha/pond	3 750/300	3 750/300	3 750/450	15 000/900
7	Source of fingerlings	Induced-bred spawn reared up to fingerling stage			
	Size (a) Length (mm)	102-225	109-177	101-124	31-40
	(b) Weight (g)	46-62	23-116	12-18	0.3-0.6
8	Initial total weight (kg) of fingerlings stocked per pond/ha	15.3/191	18.6/233	6.6/54.6	0.4/6.6
9	Fertilization				
	(a) Kind	Ammonium sulphate + single superphosphate + calcium ammonium nitrate (11 : 5 : 1) and cowdung			
	(b) Rate/ha/yr (kg)				
	(i) Inorganic	1 000	1 750	1 816	3 113
	(ii) Organic (cowdung)	45 000	3 750	15 000	19 000
	(c) Frequency				
	(i) Inorganic	Half yearly	Alternate month	Monthly	At irregular intervals
	(ii) Organic	Once in 4 months	Only once	At irregular intervals	"
10	Artificial feed	Mustard oilcake and rice bran (1 : 1 by weight)			
	Rate/ha/yr (kg)	Nil	Nil	1 500	2 650
	Frequency (kg/ha/day)			ca 4	ca 9

Continued

Table XLIX concluded

1	2	3	4	5	6
11	Fortnightly observations on water quality and plankton (range and average)				
	pH	6.0-9.4/8.0	7.6-8.8/8.2	7.8-8.8/8.2	8.0-9.9/8.3
	Total alkalinity (ppm)	25.9-78.2/52.3	25.6-69.6/68.2	19.4-60.9/37.5	36.4-97.8/58.3
	Nitrates (ppm)	0.08-0.16/0.11	0.04-0.18/0.12	0.06-0.16/0.10	0.06-0.18/0.12
	Phosphate (ppm)	0.12-1.8/0.55	0.04-0.28/0.17	0.03-0.10/0.07	0.36-4.1/0.36
	Maximum plankton density (ml/45 l)	1.5	3.2	1.5	1.8
12	Mode of harvesting	By repeated netting and finally poisoning with Tafdrin-20			
13	Data on fish production				
	(i) Gross weight (kg of fish harvested/pond/ha	202.8/2 535	161.3/1 821	263/2 193	178.5/2 974.2
	(ii) Survival (%) - Range/Average	85.0-97.7/91.0	75.0-96.6/83.55	92.0-100/97.6	80.0-89.7/85.7
	(iii) Average length (mm) and weight (g) of individual species and their percentage contribution at the end of the experiment:				
	Catla	334-428/734 (37.06)	335-434/747.5 (34.37)	382.6/780.6 (44.00)	243.6/171.3 (24.8)
	Rohu	387-484/789 (34.42)	326-421/588 (55.84)	328/490 (35.00)	292.3/281.8 (13.2)
	Mrigal	374-430/655 (28.52)	406-424/788 (11.79)	340.5/400 (21.00)	295.8/240.4 (32.0)
14	Economics[1/] (Calculated per ha/yr)	I.Rs.	I.Rs.	I.Rs.	I.Rs.
	(i) Income	9 506.25 (A)	6 828.75 (A)	8 772.00 (A) at I.Rs. 4.00/kg (Rate at which sold by owner)	5 950.00 (A) at I.Rs. 2.00/kg (due to small size)
	(ii) Expenditure				
	(a) Pond preparation	100.00	100.00	100.00	100.00
	(b) Fingerlings	375.00	375.00	375.00	150.00
	(c) Fertilizers	873.00	802.00	855.24	1 276.75
	(d) Artificial feed	-	-	612.50	1 047.50
	(e) Labour	375.00	375.00	375.00	375.00
	(f) Nets (depreciation charges only)	500.00	500.00	500.00	500.00
	TOTAL:	2 223.00 (B)	2 152.00 (B)	2 817.74 (B)	3 448.25 (B)
	(iii) Net profit:	7 283.25 (A-B)	4 676.75 (A-B)	5 954.26 (A-B)	2 500.75 (A-B)

1/ Exclusive of establishment salaries

TABLE L

Composite culture of indigenous and exotic carps for one year (Anon., 1969 and Lakshmanan et al., 1971)

Sl. No.	Experimental details	Pond 1	Pond 2	Pond 3	Pond 4
1	Year of experimentation	1965-66	1967-68	1966-67	1965-66
2	Pond size (ha) Depth (m) Location	0.133 1-2 Killa Fish Farm Cuttack	0.16 1-2 Killa Fish Farm Cuttack	0.4 1-2 Killa Fish Farm Cuttack	0.133 1-2 Killa Fish Farm Cuttack
3	Condition of ponds	Rain-fed, perennial, free from weeds, well exposed and protected from floods. No regular inlets and outlets			
4	Initial preparation of ponds	Netted thoroughly and poisoned with Tafdrin-20 at 0.01 ppm about 6 weeks ahead of stocking to remove all existing fishes			
5	Species combination	Catla 1, rohu 5, mrigal 1, silver carp 4, grass carp 3, common carp 3, gourami 0.3	Catla 3, rohu 4, mrigal 2.5, silver carp 6, grass carp 1.5, common carp 2.5, kalbasu 0.5	Catla 2.5, rohu 5, mrigal 2.5, silver carp 5, grass carp 2, common carp 2.5 kalbasu 0.5	Catla 2, rohu 6, mrigal 2.5, silver carp 5, grass carp 2, common carp 2.5, gourami 0.3
6	Stocking density				
	No. of fingerlings/ha/pond	4 450/605	6 250/1 000	5 000/2 000	5 075/666
7	Source of fingerlings	Induced-bred spawn (except that of common carp and gourami) reared up to fingerling stage			
	Size (initial): (a) Length (mm) (b) Weight (g)	100-200 20-78	100-200 20-72	40-70 1.2-5.8	115-200 18-70
8	Initial total weight (kg) of fingerlings stocked per pond/ha	27.2/204.3	45/282	4.5/11.3	32.1/240.5
9	Fertilization				
	(a) Kind	N-P-K mixture (6-8-4) ammonium sulphate + single superphosphate + calcium ammonium nitrate (11:5:1) and cowdung			
	(b) Rate/ha/yr (kg)				
	(i) Inorganic (ii) Organic (cowdung)	113 25 000	1 380 21 500	975 21 560	1 725 25 000
	(c) Frequency				
	(i) Inorganic (ii) Organic (cowdung)	Quarterly Monthly	Monthly Monthly	Once in 2 months Monthly	Once in 2 months Monthly
10	Artificial feed	Mustard oilcake and rice bran (1:1 by weight)			
	Rate/ha/yr (kg) Frequency (kg/ha/day)	Nil	3 000 ca 9	3 010 ca 9	2 320 ca 9

Continued

Table L (Continued)

Sl. No.	Experimental details	Pond 1	Pond 2	Pond 3	Pond 4
10 (Cont.)	Kind	(b) Aquatic weeds (for grass carp)			
		Hydrilla, Najas, Ceratophyllum and Azolla	Hydrilla, Ceratophyllum and Azolla	Spirodella	Lemna
	Rate/ha/yr (kg)	14 400	11 700	14 660	13 875
	Frequency (kg/ha/yr)	Suitably spaced once in 7, 10, 15 or 20 days according to availability			
11	Fortnightly observations on water quality and plankton (range and average)				
	pH	7.8-8.4/8.3	7.8-9.0/8.3	7.8-9.4/8.5	8.0-9.4/8.7
	Total alkalinity (ppm)	44.4-112.8/65.8	58.9-90.7/70.05	25.6-60.4/40.7	32.32-88.0/32.5
	Nitrates (ppm)	0.6-0.18/0.13	0.06-0.14/0.12	0.08-0.16/0.12	0.08-0.16/0.12
	Phosphates (ppm)	0.45-4.0/1.14	0.04-0.18/0.12	0.10-0.48/0.21	0.12-4.20/1.04
	Maximum plankton density (ml/45 l)	1.4	0.3	2.9	1.9
12	Mode of harvesting	By repeated netting and finally poisoning with Tafdrin-20			
13	Data on fish production				
	(i) Gross weight (kg) of fish harvested/pond/ha	297.20/2 234.00	486.63/3 041.40	1 430/3 575	561.20/4 210.00
	(ii) Survival (percent) range/average	46-100/72.56	36.0-98.4/86.70	85.0-99.2/95.40	40.0-95.78/86.93
	(iii) Average length (mm) and weight (g) of individual species and their percentage contribution at the end of the experiment				
	Catla	402/899 (15.12)	285/279 (7.01)	400/826 (14.28)	392/816 (9.30)
	Rohu	326/404 (14.12)	361/508 (20.02)	356/504 (17.03)	380/622 (20.72)
	Mrigal	466/750 (8.59)	411/628 (15.87)	400/660 (10.77)	470/1 245 (15.74)
	Silver carp	426/856 (38.62)	402/648 (38.50)	480/990 (33.21)	475/1 231 (34.87)
	Grass carp	365/577 (8.93)	438/913 (5.07)	401/708 (8.41)	436/924 (5.34)
	Common carp	306/489 (10.86)	278/362 (7.66)	333/586 (10.16)	350/707 (7.68)
	Gourami/Kalbasu	322/625 (1.05)	353/467 (1.05)	279/275 (0.89)	334/688 (0.49)
	Common carp Young (ones)	2.71%	4.82%	5.25%	5.77%

Continued

Table L concluded

Sl. No.	Experimental details	Pond 1	Pond 2	Pond 3	Pond 4
14	Economics[1/] (calculated per ha/yr) at I.Rs. 3.75/kg of fish harvested	I.Rs.	I.Rs.	I.Rs.	I.Rs.
	(i) Income	8 377.50(A)	11 503.75(A)	13 406.25(A)	15 787.50(A)
	(ii) Expenditure				
	(a) Pond preparation	100.00	100.00	100.00	100.00
	(b) Fingerlings	450.00	600.00	250.00	500.00
	(c) Fertilizers	310.00	680.00	625.00	918.75
	(d) Artificial feed	-	1 193.75	625.00	625.00
	(e) Labour	625.00	625.00	1 175.00	980.00
	(f) Nets (depreciation charges only)	500.00	500.00	500.00	500.00
	Total:	1 985.00(B)	3 698.75(B)	3 275.00(B)	3 623.75(B)
	(iii) Net profit :	6 392.50(A-B)	7 805.00(A-B)	10 131.25(A-B)	12 163.75(A-B)
	Approximately :	6 390.00	7 800.00	10 130.00	12 160.00

1/ Exclusive of establishment salaries

In experiments conducted during 1968-71 using both Indian and exotic species, gross production ranging from 1 134 to 3 212 (average 2 291) kg/ha was obtained in eight experiments of one-year duration and from 1 323 to 2 340 (average 1 685) kg/ha in eleven experiments of six months duration. Average size attained in both the sets was about 0.66 kg. During 1972, in an experiment of one-year duration, gross and net productions to the extent of 5 096 kg and 4 874 kg/ha/year were obtained when stocking density was 5 000/ha and the species combination tried was silver carp 2 : catla 1 : rohu 3 : mrigal 1.5 : common carp 1.5 : grass carp 1 and miscellaneous fish. The average survival percentage and growth recorded were : catla 100/1.79 kg, silver carp 95.5/1.56 kg, grass carp 100/1.34 kg, mrigal 100/0.55 kg, rohu 99/0.72 kg, common carp 98/1.04 kg, hybrid (catla x kalbasu) 40/0.43 kg, reba 40/0.13 kg and mullet (Mugil cephalus) 38/0.47 kg. In another experiment on composite fish culture with periodic harvesting and replenishment gross and net productions per ha in one year were recorded to be 5 604 kg and 5 440 kg respectively (Central Inland Fisheries Research Institute, Barrackpore, Annual Report 1972). In another experiment, catla, rohu, mrigal, silver carp, grass carp and common carp were stocked at the rate of 10 540 fingerlings per ha in two adjacent ponds each of 0.25 ha in the ratio of 1 : 3, 1 : 2, 1 : 2 respectively. To this was added 544/ha of miscellaneous fish in one pond and in the other 568/ha. Species comprising miscellaneous fishes included Notopterus chitala, Ompok bimaculatus, Mystus seenghala and Pangasius pangasius. In one year, in both the tanks, catla weighed, on an average, 1 179-1 197 g, silver carp 1 032-1 152 g, grass carp 1 106-1 542 g, mrigal 654-766 g, common carp 977-1 772 g, O. bimaculatus 79-102 g, N. chitala 163-238 g, M. seenghala 330-398 g, and P. pangasius 733-742 g, respectively. The quantum of inorganic fertilizers (a mixture of urea and triple superphosphate) used was 1 530 kg/ha/year in one pond and 1 140 kg/ha/year in the other. Each of the ponds received cattle dung at 14 400/kg/ha/year. Artificial feed (a mixture of groundnut oilcake and rice bran) was given 12 852 kg/ha/year in one pond and 13 340 kg/ha/year in the other. Intensive feeding and fertilization resulted in gross and net productions/ha/year of 7 500 kg and 7 343 kg respectively in one pond and 5 734 kg and 5 652 kg respectively in the other pond. In terms of fish flesh, the highest contribution (2 638.6 kg in one pond and 2 261.6 kg in the other) was made by the most prized among the Indian major carps, rohu, which formed 35.14-39.42 percent of the total production recorded in both the ponds. The miscellaneous fishes which were added to both the ponds, themselves contributed 1.16-1.23 percent in terms of fish flesh directly but their presence in the pond enhanced the production of the main carp species since they kept a check on insects, minnows, molluscs, etc. (Chaudhuri et al., 1974).

Record gross and net productions/ha/year of 9 395.5 kg and 9 094 kg respectively have been obtained from one experimental pond, at Cuttack. The pond was stocked at 7 500/ha with fingerlings of catla, rohu, silver carp, grass carp, common carp and mrigal in the ratio of 1.0 : 2.5 : 2.5 : 1.0 : 1.0 : 2.0. To this was added small numbers of Notopterus chitala and grey mullet. This is an All India Record and can be rightly called "aquaplosion". In another pond at Cuttack, gross and net productions of 8 846 and 8 623 kg/ha/9½ months was obtained in 1973. The pond was stocked at 7 500/ha with fingerlings of catla, rohu, silver carp, grass carp, common carp and mrigal in the ratio of 1 : 2.5 : 2.5 : 1 : 2 : 1. To this was added a small number of N. chitala, hybrids of catla x rohu and grey mullet for observing the performance of these in ponds. Average weights attained by the different species were - silver carp 1.5 kg, catla 1.34 kg, rohu 1.0 kg, mrigal 1.3 kg, common carp 1.0 kg and grass carp 1.75 kg (Chaudhuri, et al., unpublished). In other experiments at Cuttack gross and net yields of fish under composite culture have been obtained in the order of 8 584.8 kg and 8 251 kg/ha/year respectively in one pond and 7 409.9 kg and 7 186.9 kg/ha in 287 days in the other.

The Central Inland Fisheries Research Institute undertook a fish production scheme in three ponds, measuring 2.15, 1.48 and 1.93 ha under the Operational Research Programme on composite fish culture at Krishnanagar Fish Farm, District Nadia, West Bengal in order to achieve high fish production from larger water bodies. The Pond 1 was stocked in May and June 1973 with catla, rohu, mrigal and common carp in the ratio of 2.4 : 1.5 : 2.5 : 3.6 respectively at a stocking density of 6 000/ha. Fish production obtained from this pond was 5 708.7 kg/year, which worked out to gross and net productions/ha/year of 2 654 kg and 2 514 kg respectively. The Pond 2 which was stocked in May 1973 with catla, rohu, mrigal and common carp in the combination of 3 : 1 : 3 : 3 respectively at a stocking density of 5 600/ha yielded 6 348.03 kg/1.48 ha/year, which amounted to a gross and net production/ha/year of 4 290 kg and 4 134 kg respectively. The average weights attained by catla, rohu, mrigal and common carp were 583.5 g, 1 065 g, 2 145 g and 571 g respectively. Large fish were harvested periodically and their number was replenished. Pond 3 was stocked with catla, rohu, mrigal, silver carp, grass carp and common carp with a ratio of 2.25 : 1.5 : 2.5: 0.25 : 0.5 : 3 respectively at a stocking density of 6 000/ha. The gross and net productions obtained from this pond/ha/13 months worked out to 4 184 kg and 4 062 kg respectively and the total production from this pond was 8 175.5 kg/1.93 ha/13 months. The species-wise percentage of contribution by weight in the total production was catla 21.69, rohu 18.81, mrigal 24.15, silver carp 17.63, grass carp 5.84, common carp 11.38 and miscellaneous 0.5 (Sinha and Sharma, 1974).

In other countries, e.g., Bangladesh and Burma, Indian major carps: catla, rohu, mrigal and kalbasu are also stocked and grown together in the same pond. In Bangladesh (former East Pakistan), Ahmad (1952) reported the various stocking combinations of catla, rohu, mrigal and kalbasu, taking into consideration ecological conditions of the water. A maximum production of 1 656 kg/ha/year was reported from these ponds which had greenish water with permanent plankton bloom. In these ponds, stocking ratio was catla 5 : rohu 3 : mrigal/kalbasu 2 at a stocking density of 1 000/ha.

In Burma, composite culture of catla, rohu, mrigal in combination with exotic species such as common carp and gourami is of very recent origin. In one 0.12 ha pond, catla, rohu, mrigal, common carp and miscellaneous fishes (e.g., Labeo nandina, L. calbasu, L. stoliczkae, L. pangusia, L. boga, Osteobrama belangeri and Osphronemus goramy) were stocked in the ratio of 1 : 3 : 1.2 : 1 : 0.3 at a stocking density of 7 500/ha. With proper fertilization of ponds and daily feeding fishes with a mixture of rice bran and peanut oilcake and chopped pieces of aquatic and semi-aquatic vegetation, fish yield of about 4 372.5 kg/ha/9 months was obtained.

In another 0.2 ha pond a production of 10 390 kg/ha/year was obtained by stocking fingerlings (50-68 mm long) of catla, rohu, mrigal, catla-rohu hybrid, rohu-catla hybrid and gourami in the ratio of 37 : 11.5 : 52.5 : 3 : 3 : 0.9 respectively at a stocking density of 10 570/ha. In addition, 320 kg/ha of small prawns were harvested from the pond during this period. In this experiment on composite fish culture, the pond was limed and fertilized two months before being stocked with fingerlings. Cowdung (5 000 kg/ha) or poultry droppings (2 500 kg/ha) were used for manuring ponds. In addition, triple superphosphate at 100 kg/ha was applied in five to six doses every alternate month. Supplementary feed given to fish was a mixture of rice bran and peanut oilcake (in the ratio 1:1) and was given daily at 1-5 percent body weight of the stocked fish besides green leaves and other wastes from the adjoining vegetable garden (FAO, 1970).

Stocking ponds which when left uncared often get chocked with luxuriant growth of aquatic weeds pose a serious problem to pisciculturist. The methods adopted for the control of aquatic weeds have been reviewed by Jhingran (1968 and 1973), Philipose (1967), Ramachandran (1969), Gupta (1973), etc. The methods for controlling aquatic weeds fall under three categories: (1) physical removal by manual or mechanical means; (2) destruction and integration by chemical treatment, and (3) biological control by fishes. Of these, physical removal of aquatics is suitable only for smaller water bodies, where the traditional methods of hand-picking, uprooting emergent and marginal weeds and cutting them with scythes are considered suitable. Physical removal will lead to quicker regrowth and, if repeated too often, may result in serious deficiency of essential mineral elements. Large-scale control of all the common major aquatic weeds is possible with weedicides. In recent years a wide variety of chemical weedicides have come into use for the control of aquatic weeds. The chief considerations in the use of herbicides in fishery waters are that they should be (i) effective in killing weeds at reasonably low rates of application, not exceeding 10 ppm for those applied in water and about 10 kg/ha for those sprayed on a surface area basis; (ii) cheap and easily available; (iii) non-toxic to warm blooded animals so that they could be used freely without any hazard to humans and stock animals; (iv) should not pollute the treated water or leave any residual harmful effects which will adversely affect the fertility of the water and soil; (v) should not involve special costly equipment and constant supervision by technical personnel; and (vi) should not have any corroding action to metal containers and sprayers. Of all the floating weeds, the water hyacinth (Eichhornia crasipes) is the most noxious and for its successful control the chemical 2, 4-dichlorophenoxy acetic acid (2, 4-D) has been used. In order to determine the effective dose for total destruction of water hyacinth which occurs in widely varying densities, the field infestations of this plant based on the weight and condition of the weed, were categorized into three: small (13 kg/m^2), medium (23 kg/m^2) and big (35 kg/m^2) and the effective doses of the active ingredients of 2, 4-D (sodium salt) were found to be 15 mg, 30 mg/kg respectively for these three infestations (Ramachandran, 1969). The other weedicide Taficide-80 (2, 4-D sodium salt 80 percent) at the rate of about 4-6 kg/ha in an aqueous solution (concentration 1-1.5 percent) in combination with the detergent "Surf" at 0.25 percent concentration has been found to completely kill this weed (Ramachandran and Rama Prabhu, 1968). The weedicide action of Taficide-80 during summer months shows itself within a week without any adverse effect on the fingerlings and adults of major carps. The cost of clearance works out to be I.Rs. 11 200 per ha. Simazine (2-chloro-4, 6-bisethylamino-1, 3, 5-triazine), at the rate of 5 kg active ingredient per ha, sprayed as an aqueous emulsion has also been found to kill and clear water hyacinth. Simazine and Taficide-80 both at a dose of 5 kg/ha have been used for an effective kill of Pistia stratiotes in the field (Ramachandran and Rama Prabhu, 1968). Gramaxone (with 20 percent paraquat as active ingredient) has been found effective to control Pistia, Salvinia and Spirodella infestations when applied at the rate of 0.1-0.2 kg, 1 kg and 0.2 kg of active ingredient per ha respectively (Central Inland Fisheries Research Institute, Barrackpore, Annual Reports 1970 and 1972). In field trials, spray of 1-1.5 percent aqueous solution of ammonia with 0.25 percent detergent was able to kill the floating infestation of Pistia sp. and Salvinia sp. within a few days (Central Inland Fisheries Research Institute, Barrackpore, 1970).

Marginal weeds like Cyperus were totally killed with 1 percent aqueous solutions of both Taficide-80 and Tafapon (2, 2-dichloropropionic acid sodium salt 85 percent) at the rate of 28 kg per ha in yards trials. Eleocharis plantaginea was controlled with 2.5 percent aqueous solution of 2, 4-D with detergent at 0.25 percent concentration. Colocassia antiguorum, when sprayed with an aqueous solution of Taficide-80 at a concentration of 1.5 percent with detergent "Surf" was badly affected with its leaves getting curled, elongated and finally dropping off the leaf stalks (Ramachandran and Ramaprabhu, 1968). In field trials conducted at the Pond Culture Division of the CIFRI, about 3.7 percent of sodium salt with 0.25 percent detergent has been found to be highly effective against Colocasia sp. and Ipomoea carnea. Yard and field experiments indicated that 2, 2-dichloropropionic acid is highly effective against Panicum sp. at 10.15 kg active ingredient per ha, but regeneration took place within 2-3 months after treatment (Central Inland Fisheries Research Institute, Barrackpore, Annual Report 1970). 2, 4-D is very effective at 12 kg/ha against the Cyperus spp. provided the weedicide is sprayed before the plants have flowered. Ipomoea carnea, Typha latifolia, Jussiaea repens have been effectively killed with 2, 4-D at the rate of 2 kg, 5 kg 8 kg of active ingredient per ha respectively in field trials (Central Inland Fisheries Institute, Barrackpore, Annual Report 1972). Lantana sp. was found to be susceptible to 2, 4, 5-7 (20 percent amine salt) formulation at the rate of 5 kg active ingredient per ha.

Ramachandran and Ramaprabhu (1968) have reported that lily plants got uprooted with just one application of 2, 4-D (sodium salt 80 percent) at ca 1.5 percent concentration with the detergent "Surf" (0.25 percent - 1.0 percent). Taficide-80, at a concentration of 2.5 percent in aqueous solution with a detergent, defoliated Nymphoides cristatum and N. indicum completely. A certain measure of success has been achieved at the Central Inland Fisheries Research Institute in controlling Nymphoides cristatum, Nymphaea rubra, and a few other rooted aquatics including Vallisneria spiralis, Hydrilla verticillata, Potamogeton pectinatus and Ottelia alismoides by spreading copper sulphate pelleted with mud on the bottom soil in 4-5 intermittent doses totalling ca 175 kg/ha without killing fish (Central Inland Fisheries Research Institute, Barrackpore, Annual Report 1969 and Mitra and Banerjee, 1970).

Submerged weed like Hydrilla, Nechamandra, Ottelia, etc., can be effectively controlled by the application of copper sulphate mud pellets at the rate of 35 kg/ha. Two to four applications of these pellets are necessary (Mitra and Banerjee, 1970). Other weedicides such as Simazine, at about 3-5 ppm active ingredient, and Aquathol (199 technical Endothal, i.e., Disodium 3, 6 endoxodexa hydrophthalate) were found effective against Hydrilla verticillata. Sulphur dioxide, at about 50 ppm, in the form of bisulphite in acid medium has also been found to be able to achieve effective kill of Hydrilla verticillata in cement cisterns Ramachandran and Ramaprabhu, 1968).

Algal blooms may be controlled either by spraying 0.5 percent copper sulphate on the water surface or by treating the water surface with simazine to give about 0.5-1.0 ppm concentration of the active ingredient. Simazine is not toxic to fish or zooplankton at the above stated dose (Ramachandran and Ramaprabhu, 1968). Tafazine-50 at 0.3-05 ppm of active ingredient was found to control Microcystis bloom in ponds effectively (Central Inland Fisheries Reseach Institute, Barrackpore, Annual Report 1972).

Jhingran (1968) reported the role played by grass carp, Ctenopharyngodon idella, in controlling weeds like Hydrilla, Lagorosiphon, Najas, Lemna, Azolla, etc. Experiments on the efficiency of grass carp in controlling floating aquatic weeds indicated that advanced fry and fingerlings (27-42 mm) of the fish accepted Wolffia and, as they grew in size, they could take bigger duckweeds (Lemna, and Spirodella), but still showed preference for zooplankton as food. Advanced fingerlings, juveniles and adults of grass carp relish and effectively control Azolla and Salvinia. Thick infestations of the submerged weeds, Hydrilla, Najas and Ceratophyllum can be controlled by grass carp whereas the fish has also been observed to clear infestations of Ottelia, Vallisneria, Nechamandra, Utricularia, Trapa, Myriophyllum, Limnophila, etc. Other weeds, such as Potamogeton pectinatus, Halophila ovata, Nitella, Spirogyra and Pithophora are also utilized but the fish does not appear to feed actively on Eichhornia, Pistia, Nymphoides and Nymphaea (Singh et al., 1968). Observations on preliminary screening of feeds at Cuttack for grass carp showed that advanced fingerlings of the species feed on cut leaves of potatoes, cauliflower, raddish and cabbage. Emaciated grass carp when fed with oilcake alone or a mixture of oilcake and rice bran showed slight improvement but when fed with rice bran alone, the fish recorded an increase in weight. Grass carps when fed with guinea grass, leaves of cauliflower, cabbage and Ipomoea carnea at a feeding rate of 100 g/day gained an average weight in one month 28.5 g, 25.0 g, 14.0 g, 5.6 g respectively, the control being (-) 1.9 g. Grass carp has also been observed to clear off Spirogyra from ponds.

7.6 Foods and feeding

In intensive fish culture, where the aim is to produce a large and payable crop of harvestable-sized fish, artificial feeding is necessary as it allows to maintain a higher density of fish than the natural fertility of the pond could support and stimulate the fish to a better utilization of the natural food. In small ponds, which are unsuitable for conventional fish culture, artificial feeding can double or triple the production. Artificial feeding is also beneficial in ponds whose soil and/or waters are too poor to raise any but a small crop of natural fish.

The criteria of a successful fish feed are: (i) ready acceptability, (ii) easy digestibility, (iii) high conversion value, (iv) easy transportability, (v) abundant availability, (vi) high keeping quality and (vii) low costs. However, the main consideration in artificial feeding is the economic one - the feed given should be cheap and best utilized. A complete artificial feed in its nutritive value should be as far as possible similar to natural food. When compared to the natural food, the artificial feeds in general have relatively low protein content. The ratio between protein and other nutrients in the natural food is said to be around 1:1 but varying up to 1:1.8, while in artificial feed considerably low ratios are encountered. To compensate this disproportion, the artificial feed should supplement natural food in fish culture operation in ponds and tanks.

Artificial feeds given to fish are: of vegetable origin such as leaves, grass, tubers and roots, starches, oilcakes, grain fodders, etc. Dried yeast is a rich food containing digestible protein and B group vitamins. Feeds of animal origin are: silkworm pupae, fresh and marine fish, dried fish, fish meal, shrimp, crab, etc. The use of dry concentrate as food is relatively recent in fish culture. Fishes may feed directly on dung applied as manure in ponds.

In pisciculture it is essential to know the weight increase of the cultivated fish as related to the amount of feed, or in other words, the food conversion rate. The conversion rate which expresses a ratio between food consumed for increase per unit weight gained by the body discounting the food requirement by the fish for its maintenance and energy requirement (sustenance) is:

$$\text{Conversion rate} = \frac{\text{Quantity of feed}}{\text{Weight increase (flesh)}}$$

The food conversion rate has been variously termed as food quotient, food coefficient, growth coefficient or nutritive ratio. The total amount of feed to be given is calculated by multiplying the artificial growth expected (kg/ha by the conversion rate, according to the following formula:

$$\text{Amount of feed to be distributed per ha} = \text{Growth per ha due to artificial feeding} \times \text{Food conversion rate}$$

For artificial feeding in nursery and rearing ponds refer to Section 7.5. In India, artificial feeding in stocking ponds is recently introduced. Oilcakes such as mustard/groundnut and rice bran are given in equal ratio, depending on the size of the fish desired, their relative size during the months of growth and the distribution period. Artificial feeding is to be stopped during winter or when there is sufficient algal bloom in the pond or oxygen depletion occurs. Otherwise fish are fed daily. Feeding should be preferably done in the morning hours since the process of digestion requires more oxygen for increased metabolic activity of the fish. The increased requirement of oxygen can be met during day when the oxygen content of the pond is always higher at night. Care should be taken not to change the feeds suddenly because fish may refuse the new feed given to them.

Oilcake is best given soaked and placed on flat baskets which can be conveniently lowered or lifted out of the pond. Grain fodders should preferably be soaked for several hours before being given to fishes because the soaked grains will sink to the bottom and will be readily consumed by the fish. Feeds may also be prepared as thick pastes and put in wide-mouth containers which may be kept near the pond margin. Ordinarily feeds may be broadcast into ponds at different marked spots. The spots selected for distribution should be clear, firm and devoid of vegetation. The feeding spots should be periodically inspected and changed so that no sustained putrefaction occurs at the spot of feeding.

7.7 Disease and parasite control

See Table LI.

7.8 Harvest

Same as in *Catla catla* (see Jhingran, 1968). Rohu is generally cultured in combination with other carps. During 1965-68, Lakshmanan *et al.* (1971) conducted eight experiments on the composite culture of Indian and exotic fishes. In all these experiments the total gross production ranged from 2 229 kg to 4 210 kg, with an average 3 062 kg and rohu ranked second in order from production view point and contributed to the gross production to the extent of 14.12-26.89 percent. In all these experiments the production percentage contributions to the gross production of various species are: silver carp 33.21-39.43; mrigal 5.54-18.44; catla 6.30-15.12; common carp 6.86-10.86; grass carp 5.03-9.13; kalbasu 0.79-1.94; gourami 0.33-1.05 and young ones of common carp about 4.25. For details refer to Section 7.5.

7.9 Transport

Before transporting, fish seed are conditioned in order to rid them of excreta and to inure them to subsist in a restricted area to which they are inevitably subjected during transport. Conditioning of rohu fry and fingerlings is the same as that in case of *Catla catla* (refer to Jhingran, 1968). The transport of fry and fingerlings of rohu is the same as in *Catla catla* (see Jhingran, 1968). Table LII shows packing density of Indian major carp seed for 12-hour journey in standard plastic bags of 16-18-l capacity. For transport of fingerlings and brood fish, two successful models of closed system live fish carrier tanks have been designed in the country. Mammen (1962) designed a "splashless tank". The latest splashless tank is of a petrol tanker design of 1 150-l capacity with an autoclave-type lid. It has a built-in aeration system for supplying compressed air, which works on a belt driven by the engine of the transporting vehicle. An oxygen cylinder is carried only as a standby for emergency. The inside of the tank is lined with U foam which prevents physical injury to live fish during transport. A total weight of 250 kg of live fish can be transported at a time in the splashless tank. Adult catla weighing up to 60 kg have been successfully transported in this tank as also 90 000 carp fingerlings. The load ratio of fish to water in this type of carrier comes to about 1 kg of fish/4.5 l of water.

TABLE LI

Diseases and their control measures

Disease	Control measures
Fungal (Saprolegnia) infection	Dip treatment in 3 percent common salt solution or in 1 : 2 000 solution of copper sulphate or in 1 : 1 000 solution of $KMno_4$ for 5-10 min or until fish shows distress (Hora and Pillay, 1962); or 1 min dip treatment in 1 : 3 000 $CuSo_4$ solution once daily for 3-4 days or under laboratory conditions dip treatment for 3 sec in 1 : 10 000 solution of malachite green (Gopalakrishnan, 1963, 1964 and 1968). Small ponds may be treated with 1 g of malachite green for 5-10 m^3 of water (Huet, 1970).
Gill rot or branchiomycosis	Prevention of pollution, ceasing artificial feeding, letting fresh water into the pond, addition of quick lime (50-100 kg/ha), etc. In case of limited infections, 5-10 min bath in 3-5 percent salt solution or in 5 ppm $KMno_4$ solution (Alikunhi, 1957); or 1 h bath in benzalkonium chloride containing 1 to 4 ppm of active ingredient (Huet, 1970). Application of $CuSo_4$ at 8 kg/ha in waters having an average depth of 0.5 m or at 12 kg/ha when average depth of 1 m, subdivided into 4 doses (Schäperclaus, 1933).
Fin and tail rot	Bath for 1-2 min in 1 : 2 000 solution of $CuSo_4$ till the fish shows distress (Hora and Pillay, 1962). One min dip in 1 : 3 000 solution of $CuSo_4$ (Gopalakrishnan, 1963); 1 : 20 000 solution of $CuSo_4$ for 10-15 min treatment of infected portions (Khan, 1933); painting of infected organs of the fish with a saturated solution of $CuSo_4$ (Pal, 1972).
Ulcer	In early stage of infection, dip treatment of 1 min in 1 : 2 000 $CuSo_4$ solution for 3-4 days. Badly infected ones be destroyed and pond water disinfected with a 0.5 ppm solution of $KMno_4$ (Gopalakrishnan, 1968).
Dropsy	Through disinfection with 1 ppm $KMno_4$ solution or dip treatment in 5 ppm of the same chemical for 2 min (Gopalakrishnan, 1963). Treatment with chloromycetin at a concentration of 60 mg in 4.5 l water. No food to be given during treatment (van Duijin, 1956). Treatment with 1 ppm of $CuSo_4$.
Ichthyophthiriasis	Dip for hourly durations in 1 : 5 000 formalin solution for 7-10 days or in 2 percent common salt solution for more than 7 days or in 1 : 50 000 quinine solution for 3-10 days (Gopalakrishnan, 1963 and 1964) or in trypoflavine (1 g for 100 l of water) or chloramine at 1 g for 100 l of water, or PMA (Pyridyl mercuric acetate) at 1 : 500 000 during 1 h (Huet, 1970). Affected ponds to be disinfected with salt or quicklime (Hora and Pillay, 1962) or malachite green at 0.15 g/m^3 (Huet, 1970).
Trichodininasis and Scyphidiasis	5-10 min dip in 2-3 percent common salt solution, 1 : 1 000 acetic acid solution and 1 : 5 000-1 : 6 000 formalin solution (Tripathi, 1954). In early stages of Cyclochaeta infections, a bath in 1 percent salt solution for 5-10 min and in advanced cases in 3 percent salt solution, 1 : 500 glacial acetic acid or 1 : 2 500 formalin solution (Hora and Pillay, 1962).
Costiasis and Bodomonasis	Bath of 5-10 min duration in 2-3 percent common salt solution (Tripathi, 1954) or in 1:2 500 formalin solution or 1 : 500 glacial acetic acid solution (Hora and Pillay, 1962).

Continued

Table LI concluded

Disease	Control measures
Myxosporidiasis	No therapeutic measure. Heavily infected to be killed and less infected ones to be transferred to other ponds.
Gyrodactylosis	Alternate bath in 1 : 2 000 acetic acid and sodium chloride solution, dip treatment of 5-min duration in 1 : 5 000 formalin solution (Gopalakrishnan, 1964).
Ligulosis	Partly controlled biologically by the destruction of permanent host.
Leech infection (Hirudinea and Hemiclepsis marginata)	Dip treatment in 1 : 1 000 solution of glacial acetic acid and disinfection of pond with 1 : 10 000 $KMno_4$ (Khan, 1944); a single treatment with 5 ppm gammexane (Saha and Sen, 1955); dip in 2.5 percent common salt solution for about 30 min (Gopalakrishnan, 1963), or in 1 : 5 000 lysol for 5-15 sec (Huet, 1970).
Argulosis	Application of lime in the pond at 0.1-0.2 g/l after all fish are removed and pond bottom exposed to sun for at least 24 h before application of lime (Hora and Pillay, 1962). Pond treatment with gammexane at a concentration of 0.2 ppm repeated twice or thrice at weekly intervals (Saha and Sen, 1955; Gopalakrishnan, 1964). Bath in 1 : 1 000 glacial acetic acid for 5 min followed by 1 percent salt solution for 1 h (Khan, 1944), 1 : 5 000 lysol for 5-15 sec or 1 : 1 000 $KMno_4$ for 40 sec (Huet, 1970). Application of lindane at 8 ml/10 000 l (Hickling, 1971).
Learnea infection	In case of a few fishes being affected, mechanical removal of parasites by pulling them out from their anchorage, preferably followed by a bath in weak permanganate solution for 2-3 min (Alikunhi, 1957). For heavy infection, dip treatment over short duration in a 5 ppm solution of $KMno_4$ (Gopalakrishnan, 1963); or application of gammexane at 1 ppm concentration (Saha et al., 1959).

TABLE LII

Packing density of fry/fingerlings of Indian major carps for 12-h journey in standard plastic bags of 16-18-l capacity (Mammen, 1962)

Fry or fingerlings to be packed		
Size (cm)	Number per plastic bag	
	Range	Average
1	1 000-10 000	5 500
2	500- 5 000	2 200
3	200- 1 000	600
4	200-500	330
5	75-300	225
6	50-200	80
7	25-100	70
8	25-50	40

The other live fish carrier designed in India is by Patro (1968). Patro's carrier is of laboratory gas supply design type and comprises an outer chamber of 120 cm diameter open from top and a slightly smaller inner one closed from top, the latter, during transport, fitting inside the former. The top of the inner chamber is provided with an air vent and an oxygen valve. The outer chamber serves as a storage tank and is initially filled with water along with fishes to be transported. The inner chamber, which is slipped from the upper open end of the outer, serves as an oxygen holding chamber at its top and is lined throughout with U foam to prevent fish from sustaining injury during transport. This "double barrel type" carrier, as named by Patro, can transport a total weight of 100 kg of live fish at a time. Once filled, the oxygen supply of the carrier lasts up to 5 h and thereafter refilling with oxygen becomes necessary.

In recent years, chemicals have been used in the transporting medium. Kewalramani and Gogate (1968) used three drugs, namely novocaine, amobarbital sodium and barbital sodium for narcotizing major carps for transport. They first dissolved these drugs in distilled water to prepare requisite concentrations and then injected the fluid intramuscularly near the base of the dorsal fin of the fish before transporting them. During 1965, three experimental consignments of brood fish comprising 65 specimens of L. rohita and Cirrhina mrigala were transported by road under novocaine over a distance of 72 km in about 2½ h. Doses of about 50 mg of novocaine per kg of fish were administered for anaesthetizing fishes that weighed 1-3 kg each. In case of catla, each weighing between 2-5 kg, 30 mg of novocaine per kg of fish was administered and fishes transported to a distance covered in 1½ h. Novocaine is regularly used for sedating major carps in transport by the Department of Fisheries, Government of Maharashtra, Bombay since 1966. Barbital sodium was found to be effective at a dose of 50 mg per kg of fish. Amobarbital sodium was observed to bring partial loss of equilibrium in fish at a dose of 8 mg/kg of fish.

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SYNOPSIS OF FISHERIES BIOLOGICAL DATA

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

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