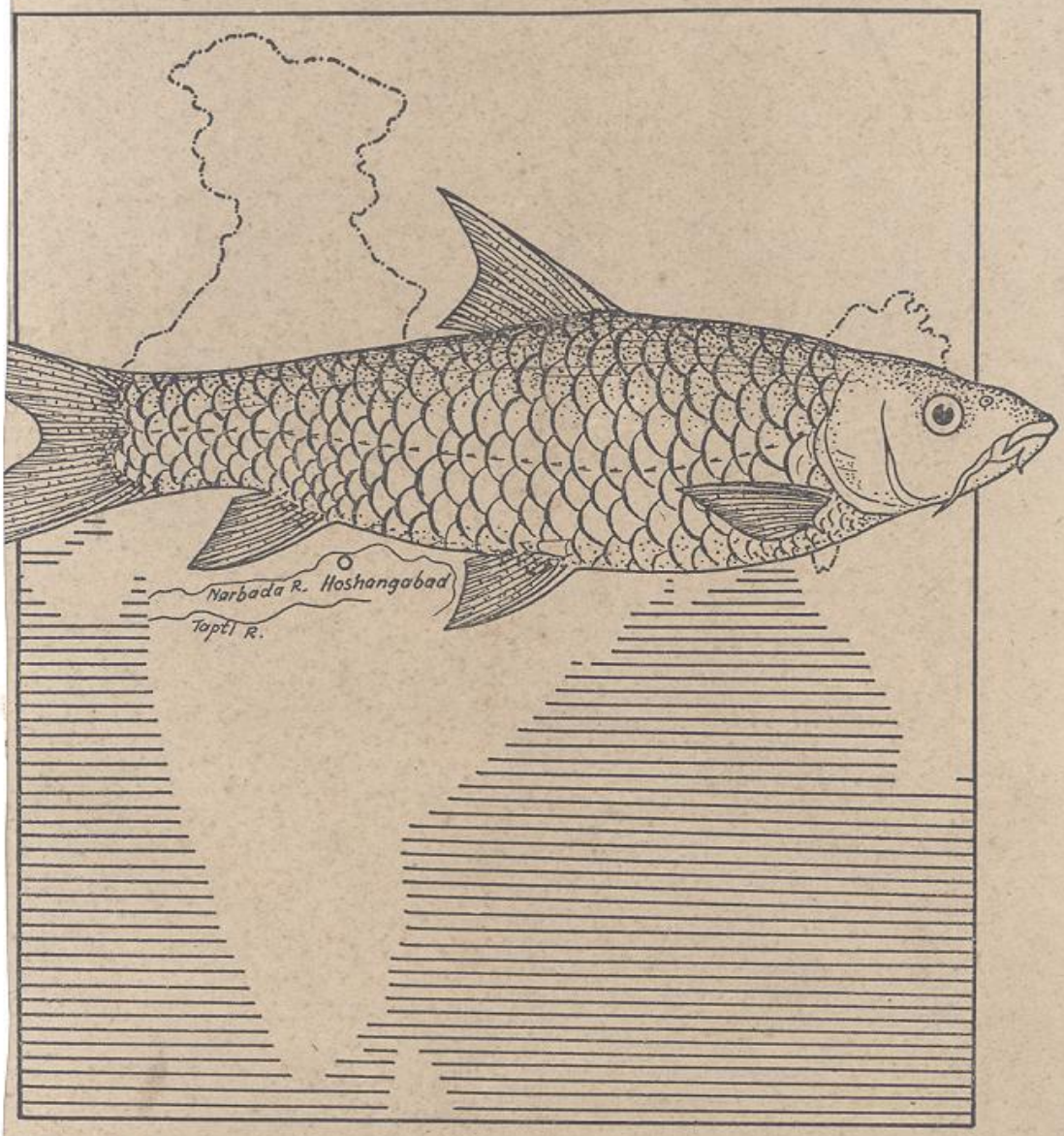
BIOLOGICAL INVESTIGATIONS ON THE FISH & FISHERIES OF NARBADA RIVER
(1958 - 1966)



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CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
BARRACKPORE, WEST BENGAL,
INDIA.

BIOLOGICAL INVESTIGATIONS ON THE FISH AND FISHERIES OF NARBADA RIVER

(1958-1966)

By

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III. DESCRIPTION OF NARBADA RIVER

Narbada river, one of the two important westerly flowing rivers of Peninsular India, is about 1,280 km long (see Map I). The river originates in the Amarkantak hills at an elevation of 1,057 meters above sea level in the Bilaspur district (Madhya Pradesh) and after widening into an estuary below Broach (Gujarat State) drains into the Gulf of Cambay. The river, which is entirely fed by seasonal rain, drains a long and relatively narrow area of about 94,235 sq km in Madhya Pradesh and Gujarat State falling within Vindhya and Satpura hill ranges. The last 160 km of the river flow through the Gujarat State. Narbada river has eighteen principal tributaries, their catchment area ranging from 1,350 to 6,330 sq km. Of these tributaries, sixteen are in Madhya Pradesh and two in the Gujarat State.

41 Tributaries – 500 Km² area each
22 South Bank (21 in MP + 1 Guj.)
21 North Bank.

IV. FISH FAUNA OF NARBADA DRAINAGE

A classified list of fishes of Narbada drainage is given in the Appendix. Of 77 listed species of fishes belonging to 19 families, 11 marked with asterisk (*) are from an earlier record of Hora and Nair (1941) who collected 40 species from the hill-streams arising from Satpura range in the Hoshangabad district and flowing in Narbada river. The rest of the species represent the collections made by small drag nets from the shallow regions of Narbada river near Hoshangabad during pre- and post-monsoon periods of 1959 to 1961 and from spawn-collection nets operated in various stretches of Narbada river between Indravarna and Jhanor (Gujarat State) during monsoon seasons of 1959 to 1964.

V. CATCH STATISTICS AND DISPOSITION OF FISHERIES IN A SECTION OF NARBADA RIVER NEAR HOSHANGABAD

The catch statistics were collected from a 48 km stretch of Narbada river by covering fish landings of two important fish assembly centres at Hoshangabad and Shahganj. The sampling of fish assembly centres was made on about 21 days at Hoshangabad and about 9 days at Shahganj in each month. As the observations on the fish landings at Shahganj were

I. INTRODUCTION

Practically no scientific account on the status of fisheries of Narbada and Tapti, the two westerly flowing rivers of Peninsular India, is on record. Whatever little information is available mainly pertains to Hilsa fishery of Narbada river. Kulkarni (1950, 1951 and 1954) reported on the monsoon fishery, upstream migration, location of spawning grounds within tidal limits, breeding habits and early life history of Narbada Hilsa. Karamchandani (1961) located spawning grounds of Hilsa in the freshwater regions of Narbada river. The other contributions relate to the fish collections from small hill-streams, flowing in Narbada river (Hora and Nair, 1941) and the location of spawning grounds of carps in "Boori" Narbada, a defunct stretch of Narbada river, in Madhya Pradesh (Rajan and Kaushik, 1958).

Investigations leading to the evaluation of capture fisheries of Narbada and Tapti rivers were initiated at the Central Inland Fisheries Research Institute, Narbada-Tapti Unit, Hoshangabad (Madhya Pradesh), in August 1958. The present report embodies a brief account of the investigations undertaken in Narbada river from 1958 to 1966. The information gathered in regard to Tapti river is being reported separately elsewhere.

II. AIMS AND OBJECTS

The main objectives of the investigations conducted in Narbada river are outlined below :

i) To study the present status of fisheries by estimating the total fish production of the river as far as practicable, together with an inventory of fish fauna of the river,

ii) to conduct detailed biological investigations on the commercially important fishes of the river,

iii) to evaluate new carp seed resources in certain sections of the river and locate spawning grounds of the commercially important species, and

iv) to conduct inventory survey of fishing villages of Narbada river for collecting statistics of fisherman population, active fishermen, fishing craft and gear, etc.

discontinued in July 1964, the catch statistics from this month onwards relate to the Hoshangabad fish assembly centre only. The information collected included species composition of commercial catches with total weight of each fishery and size/age composition of species encountered in the commercial catches. The data collected on these aspects have helped in estimating the magnitudes of fish landings and in determining the monthly fluctuations of various fisheries and age/size composition of important fisheries in the commercial catches.

During the period of eight years from 1958-59 to 1965-66, the annual landings ranged between 32.3 and 57.2 tonnes, the average being 41.5 tonnes. The annual landings and the average monthly catches for these years are given in Table I.

TABLE I

Year (Sept. to August)	Fish landings in tonnes	
	Annual weight	Average monthly weight
1958-59	34.7	2.9
1959-60	39.4	3.3
1960-61	35.0	2.9
1961-62	43.4	3.6
1962-63	57.2	4.8
1963-64	56.8	4.7
* 1964-65	32.3	2.7
* 1965-66	32.8	2.7

Av. 41.45

The average monthly fish landings ranged between 2.2 tonnes (in August) and 4.0 tonnes (in November). The fish catches in the four quarters were 7.9 tonnes (18.8%) in July-September, 11.8 tonnes (28.1%) in October-December, 11.2 tonnes (26.7%) in January-March and 11.1 tonnes (26.4%) in April-June.

The fishery was at the lowest level in monsoon months (July to September) which is attributable to suspension of cast

* The figures are exclusive of catches from Shahganj assembly centre.

net and gill net operations during high floods. However, the fishery was abruptly revived by increased fishing effort in the post monsoon period when the floods in the river subsided. The fish landings attained maximum level in post monsoon period and summer, except in the months of December and May when the catches were comparatively low.

The commercial catches were represented by about 23 species of fishes, 10 belonging to carp group, 8 to catfish group, 2 to murrel group, 2 to spiny eels and 1 to feather-backs. The average annual catches (in tonnes) of various species and their percentage composition in the annual landings of eight years from 1958-59 to 1965-66 are presented in Table II.

TABLE II

Species	Annual landings : 1958-59 to 1965-66	
	Average weight in tonnes	Percentage composition
Tor tor	7.60	28.0
Labeo fimbriatus	5.35	19.7
Labeo calbasu	1.11	4.1
Cirrhinus mrigala	0.69	2.5
Labeo bata	0.45	1.7
Labeo dyocheilus	0.42	1.6
Puntius sarana	0.38	1.4
Catla catla	0.15	0.6
Cirrhinus reba	0.14	0.5
Labeo gonius	0.07	0.3
CARP GROUP		60.4
Rita pavimentata	2.78	10.2
Mystus seenghala	2.45	9.0
Mystus aor	1.29	4.7
Wallago attu	2.08	7.7
Clupisoma garua	0.48	1.8
Ompok bimaculatus	0.12	0.4
Mystus cavasius	0.07	0.3
CATFISH GROUP		34.1
Channa spp	1.00	3.7
Mastocembelus spp	0.35	1.3
Notopterus notopterus	0.14	0.5
MISCELLANEOUS FISHES		5.5

The status of various fisheries in the commercial catches is given below :

The major carps, comprising Tor tor, Cirrhinus mrigala and Catla catla, contributed 27.9%, 30.3%, 29.2%, 30.8%, 27.3%, 31.6%, 32.1% and 29.1% in the annual landings of 1958-59 to 1965-66. The former species formed the bulk fishery (28.0%) and the latter two species were poorly represented (2.5% and 0.6% respectively) in the commercial catches.

Tor tor, locally known as 'badas', was the most dominant, the annual yield being 8.2, 7.9, 6.4, 7.7, 8.6, 9.6, 5.7 and 6.5 tonnes in the years 1958-59 to 1965-66. This species constituted important fishery throughout the year except in monsoon months (July to September). The dominant size groups 216-420 mm and 421-625 mm formed 47.0% and 31.9% by weight from 1958-59 to 1961-62 and dominant age groups IV-V (401-505 mm) and II-III (281-400 mm) made up 36.3% and 33.0% from 1962-63 to 1965-66.

The medium-sized carps comprising Labeo fimbriatus Labeo calbasu, Labeo dyocheilus and Labeo gonius, made up 23.1% 21.8%, 25.9%, 23.9%, 28.5%, 30.1%, 23.0% and 25.8% in the annual landings of the years 1958-59 to 1965-66. The former two species together contributed to the bulk of this fishery, while the latter two species were seasonal and sporadic in occurrence in the total catches.

Labeo fimbriatus, locally known as 'rohu'* constituted an important fishery (19.7%) in the commercial catches next only to Tor tor. 5.1, 4,5, 4.5, 4.9, 7.1, 8.2, 3.4 and 4.8 tonnes of this species were annually landed during the years 1958-59 to 1965-66. The species contributed to the bulk of commercial catches in the winter (November and December) and summer months (March to June). The dominant size group 321-470 mm made up 50.8% by weight from 1958-59 to 1961-62 and dominant age group IV-V (310-411 mm) formed 40.1% by weight from 1962-63 to 1965-66.

Labeo calbasu, locally known as 'kalont', is the next important species (4.1%) in medium-sized carp group. 1.1, 1.0, 0.8, 1.1, 1.5, 1.4, 0.9 and 1.1 tonnes of this species were annually landed during the years 1958-59 to 1965-66. This species

* It is known as 'Katrohu' in other parts of Madhya Pradesh.

formed fairly important fishery during the winter and summer months. Size group 321-470 mm was the most dominant and contributed 67.3% by weight.

The minor carp fishery, comprising Labeo bata, Puntius sarana and Cirrhinus reba, contributed 3.1, 3.9, 4.8, 4.0, 3.7, 3.0, 4.0 and 4.1% in the annual landings of the years 1958-59 to 1965-66. In this group, Labeo bata was the most dominant (1.6%) and was followed by Puntius sarana (1.4%) and Cirrhinus reba (0.5%).

The fishery of large-sized catfishes, represented by Mystus seenghala, Mystus aor and Wallago attu, accounted for 17.9, 18.5, 19.7, 21.5, 20.4, 20.9, 25.6 and 26.5% in the total landings of the years 1958-59 to 1965-66. Mystus seenghala was the most dominant (9.0%) and was closely followed by Wallago attu (7.7%). Mystus aor made up only 4.7% in the total landings.

Mystus seenghala and Mystus aor, locally called 'seenghar' and 'kohra' respectively, together contributed to the bulk of commercial catches. 3.8, 2.8, 2.5, 3.8, 4.4, 4.4, 3.3 and 4.8 tonnes of the two species were annually landed during the years 1958-59 to 1965-66. The two species formed fairly important fishery throughout the year, with peak in post-monsoon months. Size groups 650 mm and above of Mystus seenghala and 471-650 mm of Mystus aor were most dominant and made up 41.4% and 40.7% respectively.

Wallago attu, locally known as 'parheen' contributed 1.5, 2.1, 1.8, 2.3, 2.7, 2.7, 1.8 and 1.6 tonnes in the annual landings of the years 1958-59 to 1965-66. It contributed to the bulk of fish landings during the monsoon and post-monsoon months (July to October). Size group 650 mm and above made up the bulk (43.5%) in its fishery.

The fishery of medium-sized catfishes, comprising Rita pavimentata, Clupisoma garua and Ompok bimaculatus, accounted for 15.9, 17.1, 14.3, 15.5, 11.7, 9.8, 8.7 and 6.2% in the total landings during the year 1958-59 to 1965-66. While the former species made up the bulk fishery, the latter two species were comparatively poorly represented in the catches.

Rita pavimentata, locally known as 'gegra' constituted an important fishery (10.2%) next only to Tor tor and Labeo fimbriatus. The estimated annual yields of this species in the total landings of years 1958-59 to 1965-66 were 3.6, 3.5, 2.7, 3.7, 3.3, 2.7, 1.2 and 1.2 tonnes. It formed the bulk of total landings during the monsoon and post-monsoon months (July to October). The size group 116-215 mm made up the bulk (64.5%) of this species from 1958-59 to 1961-62 and dominant age group IV and above (204 mm and above) from 1962-63 to 1965-66 (48.6%).

The small-sized catfish group, represented by Mystus cavasius and Mystus vittatus, contributed a negligible fishery (0.3%) in the commercial catches during the years 1958-59 to 1965-66.

The miscellaneous fish group comprised two species of Channa, two species of Mastocembelus and Notopterus notopterus.

Channa marulius and C. punctatus, locally known as 'samal' contributed 3.7% in the total catches. 1.1, 0.9, 0.6, 0.9, 1.2, 1.1, 0.8 and 1.4 tonnes of these two species were annually landed during the years 1958-59 to 1965-66. The two species of Channa together formed an important fishery during the post-monsoon months (September to November) and early summer (April and May). The size group measuring 511 mm and above was the most dominant (58.2%) in the fishery.

The two species of Mastocembelus and Notopterus notopterus formed minor fishery in the commercial catches (1.3% and 0.5% respectively).

Catch-per-unit-effort: With a view to determine the fluctuations in the abundance of fish in the 48 km stretch of Narbada river near Hoshangabad, observations on the catch-per-unit-effort, mainly in respect of long line, cast net and gill net operations, were made at Shahganj from 1958-59 to 1963-64 and at Bhilpura and Dongarwara (Hoshangabad) from 1961-62 to 1965-66. The data for various years are presented in Table III.

TABLE III

Year	Catch-per-unit-of effort (in kg)			
	Long line	Cast net	Gill net	Combined
1958-59	0.078	0.017	-	0.048
1959-60	0.208	0.353	-	0.281
1960-61	0.173	0.355	-	0.264
1961-62	0.194	0.370	0.249	0.271
1962-63	0.342	0.451	0.358	0.384
1963-64	0.231	0.581	0.638	0.483
1964-65	0.241	0.540	0.480	0.420
1965-66	0.170	0.509	0.519	0.399

It is noteworthy that the fluctuations in catch-per-unit-effort from 1958-59 to 1965-66 followed a trend similar to that of annual landings recorded during the corresponding years.

The percentage composition of catches from long line, cast net and gill net operations are given in Table IV.

TABLE IV

Species	Percentage composition (by weight)		
	Long line	Cast net	Gill net
1	2	3	4
Tor tor	10.0	30.2	34.2
Labeo fimbriatus	3.4	31.3	32.6
Labeo calbasu	1.0	7.6	6.8
Cirrhinus mrigala	0.6	2.6	3.5
Catla catla	0.2	0.5	2.3
Labeo gonius	*	0.4	*
Labeo dyocheilus	*	0.9	1.2
Labeo bata	0.1	3.6	1.2
Cirrhinus reba	0.1	1.7	0.1
Puntius sarana	1.3	2.7	1.1
CARP GROUP	16.7	81.5	83.0

* Negligible

contd...

contd...

1	2	3	4
Mystus seenghala	2.4	4.2	9.0
Mystus aor	6.1	3.2	1.4
Wallago attu	6.1	7.2	5.4
Rita pavimentata	52.9	0.4	0.3
Clupisoma garua	7.0	0.1	*
Ompok bimaculatus	1.4	*	*
Mystus cavasius	1.7	*	*
CATFISH GROUP	77.6	15.1	16.1
Channa spp.	1.0	2.4	0.8
Notopterus notopterus	0.6	0.3	0.1
Mastocembelus armatus	4.1	0.1	-
Small fish	-	0.6	-
MISCELLANEOUS	5.7	3.4	0.9

VI. ESTIMATION OF FISH CATCHES OF THE NARBADA RIVER IN MADHYA PRADESH

In order to estimate the total fish production of Narbada river in Madhya Pradesh, the important fish markets were covered in the 720 km stretch of Narbada river on weekly market days and other days. The details of estimated monthly fish production from three fishery zones - Central, Eastern and Western zones - each covering a 240 km river stretch (see Map I), are summarised below :

(i) Central zone : Estimation of fish production was undertaken from Udhiapura to Harsud from November 1960 to March 1961. 16 to 18 fish markets (including Hoshangabad and Shahganj) were covered in this river stretch. Over 52,500 kg of fish, valued at Rs.75,250/-, was estimated to have been landed in this stretch during the five month period.

(ii) Eastern zone : Fish catches were estimated of the river stretch from Mandla to Gadarwara in December 1960, January and March 1961. 11 to 14 fish markets were covered to record fish production from this river stretch. Over 36,900 kg of fish, valued at Rs.60,200/-, was estimated to have been landed during three months.

* Negligible

(iii) Western zone : Fish production was estimated from Khandwa to Barwani from December 1960 to March 1961. 12 to 13 fish markets were covered for determining monthly fish catches from this zone. Over 33,850 kg of fish, valued at Rs.56,620/-, was estimated to have been landed during the period of four months.

The details of fish production from the three zones are given in Table V.

TABLE V

Months	Estimated fish production (in kg)		
	Central zone	Eastern zone	Western zone
November 1960	19,460	-	-
December 1960	11,260	23,430	6,560
January 1961	8,500	5,910	9,320
February 1961	6,310	-	9,340
March 1961	6,990	7,600	8,630

The species composition of fish catches from the three zones are presented in Table VI.

TABLE VI

Species	Central zone	Eastern zone	Western zone
CARPS :			
Tor tor	30.1	25.3	28.1
Labeo fimbriatus	24.4	21.5	22.1
Labeo calbasu	-	3.7	5.0
Labeo gonius	-	1.1	-
Labeo dyocheilus	-	-	1.2
Cirrhinus mrigala	1.8	1.2	2.7
Catla catla	-	0.6	0.4
Labeo bata	2.9	1.4	1.3
Puntius sarana	3.5	3.6	4.6

contd....

Species	Central zone	Eastern zone	Western zone
CATFISHES :			
Mystus seenghala	10.3	8.2	5.6
Mystus aor	9.1	6.5	6.8
Wallago attu	4.4	10.5	3.9
Rita pavimentata	3.0	6.4	4.7
Clupisoma garua	0.8	-	-
Ompok bimaculatus	-	-	0.8
MISCELLANEOUS FISH :			
Channa spp.	2.0	4.2	2.6
Mastocembelus armatus	-	1.9	3.1

VII. BIOLOGICAL INVESTIGATIONS ON THE COMMERCIALLY IMPORTANT FISHES

(1) Tor tor (Ham.) or 'Badas'

(i) Fishery : Badas grows to a maximum size of 865 mm in total length in Narbada river and forms the most predominant fishery in the commercial catches. The annual catches and the status of this fishery in th commercial landings are given in Table VII.

TABLE VII

Year (September-August)	Landings (in kg)	Percentage composition	
		in carp group	in total catches
1958-59	8,161	49.9	29.4
1959-60	7,845	50.7	29.62
1960-61	6,432	46.07	28.69
1961-62	7,858	48.77	27.37
1962-63	8,712	40.99	25.45
1963-64	9,576	43.91	28.39
* 1964-65	5,718	48.23	28.5
* 1965-66	6,494	44.26	26.13

* Exclusive of landings from Shahganj assembly centre

This species forms the major fishery of cast net gill net operations but comparatively insignificant fishery long line. It constitutes the most outstanding fishery in commercial landings throughout the year, except in the monso period when the operation of cast net and gill net is suspe due to high floods in the river.

(ii) Catch-per-unit-effort : The observations on catch-per-unit-effort of this species from cast net and gill net operations for various years are presented in Table VII

TABLE VIII

Year	Catch-per-net-per-hour (kg)		Percentage in fishery o	
	Cast net	Gill net	Cast net	Gill net
1958-59	0.068	-	27.54	-
1959-60	0.091	-	29.58	-
1960-61	0.091	-	32.23	-
1961-62	0.104	0.108	30.32	52.44
1962-63	0.122	0.181	29.93	43.74
1963-64	0.194	0.132	32.54	38.28
1964-65	0.109	0.171	25.87	31.64
1965-66	0.131	0.112	31.35	28.61

(iii) Food and feeding habits : For studying the feeding intensity of this fish, 945 specimens were examined from 1960-61 to 1962-63. The feeding intensity was determine by gastrosomatic index (GSI) and 'condition' of gut. Feeding was found to be poor from July to October (average GSI : 1.8) and this period coincided with its peak breeding season. The feeding activities increased progressively from November to June (average GSI : 5.1).

The gut contents of 945 specimens of adult fish collected from April 1960 to March 1963 and 57 specimens of juveniles (95-200 mm in total length) collected from Septembe to December 1963 were analysed. The food composition of adul and juvenile fishes is shown in Table IX.

TABLE IX

Main food items	Adult	Juveniles
Macro-vegetation	41.7%	4.7%
Molluscs	10.6%	21.9%
Filamentous algae	12.3%	2.8%
Insects	8.0%	53.8%

The macrovegetation comprised higher aquatic plants like Vallisneria, Ceratophyllum, Naias, Hydrilla, Chara, unidentified grasses and plant debris. Among filamentous algae, Spirogyra, Pithophora, Mougeotia, Zygnema were the most common. The insect diet consisted of caddis-fly larvae, diptera larvae (mostly Chironomous), dragon-fly nymphs and water bugs.

The above observations show that juveniles and adults subsist on almost the same food organisms but in varying degrees. The insects, which form the main food of juveniles, are comparatively less important in the diet of adult fish. Similarly, the macro-vegetation which comprises the main food of adult fish is less important in the diet of juveniles. This shows that the fish is insectivorous in juvenile stage, but it grows to be herbivorous in the adult stage.

The diet composition of adult fish has indicated that it is mainly herbivorous, feeding on higher aquatic plants and filamentous algae. It is also carnivorous to some extent, feeding on molluscs and insects. The protrusible and suctorial mouth of the fish and presence of large quantities of sand, mud and debris in the guts are suggestive of its bottom feeding habits.

Since the fish feeds extensively on underwater rooted vegetation and algae in its natural habitat, it appears to be promising for biological control of submerged weeds.

(iv) Body length and intestine length relationship : The length of intestine in relation to length of fish depends upon the nature of food of the fish. For determining the relationship between the body length (X) and intestine length (Y), the formula has been calculated, which is expressed below :

$$Y = 4.0448\ X - 503.0643$$

The coefficient of correlation (r) was found to be 0.8.

From the above formula, the ratio between the fish length and the intestine length was calculated to be 1: 2.68 (Range 1: 1.53 to 1: 3.82).

(v) Age and growth : The scales of Tor tor collected from 903 specimens from April 1960 to March 1963 were studied and the lengths of various age groups were determined. The length frequency data of 6,057 specimens collected from October 1961 to May 1963 were also analysed. The lengths of various age groups up to seventh year, as determined from the analysis of scales and length frequency data are given in Table X.

TABLE X

Age group	Length from analysis of L/F distribution (mm)	Length from analysis of scales (mm)
I	235	249
II	299	320
III	362	380
IV	424	440
V	482	490
VI	532	533
VII	570	580

The relationship of scale length (S) with fish length (L) shows a high degree of correlation, the value of coefficient of correlation being 0.92. This relationship is expressed in the following formula :

$$S = 0.0306\ L + 1.2412$$

(vi) Length-weight relationship : The formulae correlating total length (L) with weight (W) of males and females of Tor tor were calculated. These relationships show high degree of correlation in males (r = 0.96) and females (r = 0.99). The formulae expressing these relationships are given below :

Male : $\log W = 2.9851 \log L - 4.9647$
Female : $\log W = 3.0522 \log L - 5.1263$

(vii) Body lengths relationship : The relationships between total length (X) and various other body measurements (Y) viz. fork length, height of body, length of head, width of head, and eye diameter were determined. The values of co-efficient of correlation (r) and the formulae for various relationships are given in Table XI.

TABLE XI

Variable (Y)	Coefficient of correlation	Formula
Forklength	0.91	Y = 0.8949 X - 7.08
Height of body	0.96	Y = 0.2426 X - 6.8885
Length of head	0.97	Y = 0.2176 X - 7.5476
Width of head	0.95	Y = 0.1231 X - 5.6301
Eye diameter	0.93	Y = 0.0191 X + 5.3069

(viii) Maturity and spawning : The maturity of this species was studied by gonadosomatic index and ova diameter measurements of specimens measuring over 280 mm. The first maturity of this species is attained in size range of 270-290 mm (age group II). The average monthly values of gonadosomatic index and ova diameter measurements for the years 1960-61, 1961-62 and 1962-63 are shown in Table XII.

TABLE XII

Month	Gonadosomatic index	Ova diameter measurement(mm)
April	3.82	0.519
May	5.68	0.664
June	12.13	0.808
July	22.99	0.942
August	30.10	1.211
September	25.44	1.253
October	6.56	0.646
November	5.69	0.633
December	4.02	0.456
January	4.79	0.598
February	4.17	0.563
March	2.85	0.435

The maturity was also studied by gross examination of the gonads. The ovaries were mostly in maturing stages in April-June, maturing and ripe stages in July-September, spent and resting stages in October-December and resting stages in January-March.

The above observations have indicated that this species has a prolonged breeding season. The breeding season commences in July-August and continues upto December with peak breeding from July to September. The availability of a large number of post-larvae of size range 9-12 mm from August to February fully supports these observations. The breeding season was also studied by length frequency study of 12,243 post-larvae and juveniles (size range : 6-60 mm) of the species, collected from November 1959 to March 1962.

The detailed observations on ova diameter of this species have indicated that the younger fish breeds earlier than the older fish. The presence of four groups of ova, including a group of immature ova, in a fully ripe ovary indicates that the individual fish breeds in three acts of spawning probably with an interval of 2-3 weeks in between two acts. It was further observed that as soon as the last batch of mature ova is laid, the ovary starts maturing and gets ready for spawning in the next season. The fish belonging to various size groups breed in succession during different periods, exhibiting prolonged spawning season. Since the younger fish, which are far more in number than the older fish, are early breeders, the peak breeding is exhibited during the first half of the breeding season.

(ix) Fecundity : The relationships of fecundity with total length, weight of fish and weight of ovary were determined which are as follows :

Total length of fish (L) and Fecundity (F) :

$$\text{Log } F = 1.9749 \text{ Log } L - 1.0384$$

Weight of fish (W) and Fecundity (F) :

$$F = 14.29 W + 1297$$

Weight of ovary (Wo) and Fecundity (F) :

$$F = 198.52 Wo + 277$$

The calculated fecundity in relation to total length of fish is presented in Table XIII.

TABLE XIII

Total length (mm)	Calculated Fecundity
290	6,677
330	8,616
375	11,090
425	14,200
475	17,690
525	21,560
575	25,800
625	30,420
675	35,410
725	40,780
750	43,610

(2) Labeo fimbriatus (Bloch) or 'Rohu'

(i) Fishery : 'Rohu' forms a sizeable fishery, next only to Tor tor. It has been found to attain a maximum size of 645 mm (over 2 feet) in Narbada river. The estimates of annual catches of this species and its status in the commercial catches are given in Table XIV.

TABLE XIV

Year September-August	Landings (in kg)	Percentage composition in carp group	Percentage composition in total catches
1958-59	5,088	31.10	18.33
1959-60	4,543	29.36	17.15
1960-61	4,507	32.29	20.10
1961-62	4,972	30.86	17.32
1962-63	7,257	34.14	21.20
1963-64	8,209	37.64	24.33
* 1964-65	3,364	28.37	16.76
* 1965-66	4,844	33.01	19.49

* Exclusive of landings from Shahganj assembly centre

Like Tor tor, this species constitutes the major fishery in the catches of cast net and gill net. It forms an important fishery in the winter (November and December) and summer months (March and April). The monsoon period marks lean season for this species due to suspension of cast net and gill net operations during high floods in the river.

(ii) Catch-per-unit-effort : The observations on catch-per-unit-of-fishing-effort of this species from cast net and gill net operations are given in Table XV.

TABLE XV

Year	Catch-per-net-per-hour (kg)		Percentage in fishery o	
	Cast net	Gill net	Cast net	Gill net
1958-59	0.062	-	23.43	-
1959-60	0.082	-	29.48	-
1960-61	0.098	-	29.46	-
1961-62	0.087	0.050	33.28	16.68
1962-63	0.127	0.207	34.59	30.90
1963-64	0.135	0.116	31.39	27.79
1964-65	0.069	0.14[illegible]	28.28	30.10
1965-66	0.127	0.13[illegible]	32.30	37.63

(iii) Food and feeding h bits : 1,109 specimens, measuring 96-645 mm in total lengt , were examined for studying the feeding activities of this fis from 1963-64 to 1965-66. The feeding intensity which was studied by gastrosomatic index (GSI) and the 'condition' of gut (percentage of full and 3/4th full guts) showed a similar trend during the three years' observations.

The feeding intensity of this species was at the lowest level from July to September (monsoon season) which coincided with the peak breeding period. Soon after the breeding was over, the feeding activities increased progressively from October till January and thereafter as soon as the gonads started maturing, it decreased from February till the breeding was over in September.

The gut contents of 553 specimens of adult fish collected from July 1963 to October 1965 were analysed by volumetric and occurrence methods. The food composition of this fish is given in Table XVI.

TABLE XVI

Gut contents	Percentage composition			Grading
	By volume (X)	By occurrence (Y)	Mean $\frac{(X+Y)}{2}$	
1. Bacillariaceae	22.51	49.00	35.75	I
2. Chlorophyceae	9.92	11.88	10.90	IV
3. Myxophyceae	1.71	6.27	3.99	V
4. Miscellaenous	0.39	2.55	1.48	VI
5. Decayed Organic matter	14.80	15.15	14.97	III
6. Sand and Mud	50.67	15.15	32.91	II

The preponderance of gut contents was determined by the method suggested by Natarajan and Jhingran (1961) and by calculating the mean of percentages of the gut contents by volume and occurrence. The grading by two methods was found to be quite comparable.

Of the 16 genera of Bacillariaceae (Diatoms), Nitzschia, Synedra, Navicula, Diatoma, Fragillaria and Amphora were the most dominant by volume and occurrence in the guts. Chlorophyceae (green algae and desmids) was represented by 5 genera, of which Spirogyra, Eremosphaera and Pediastrum were the most abundant and more commonly encountered in the diet of the fish. Myxophyceae comprised two genera viz. Merismopedia and Oscillatoria, which occurred moderately in the guts.

The data on food composition of fish were analysed for various size groups. The analysis showed that there is no marked variation in the food habits of various size groups, except that the larger fish subsists more frequently on large-sized organisms like Spirogyra, Nitzschia and Synedra.

Due to non-availability of 0- group fish from riverine habitat, 50 fry (15-32 mm), reared in natural nursery pit, were examined to determine the food habits of this size group. The analysis of the gut contents showed that the fry mainly subsiste on bottom mud and decayed organic matter mixed with stray diatom

The presence of large quantities of decayed organic matter, sand and mud mixed with diatoms and algal forms in the guts showed that the fish is a bottom feeder and browses on twigs and sandy bottom.

(iv) Body length and gut length relationship : The ratio of gut length to body length showed that the gut length increases as the fish grows and the relationship between the two variables was found to be curvilinear.

(v) Maturity and spawning : The maturity of this species was studied by gonadosomatic index and ova diameter measurements. The details of maturity in terms of gonadosomatic index (male and female) and size of large ova are given in Table XVII.

TABLE XVII

Month	Gonadosomatic index		Average diameter of large ova (mm)
	Male	Female	
April 1963	1.327	9.14[illegible]	0.563
May	2.990	19.180	0.736
June	5.407	25.930	0.463
July	30.390	128.970	1.111
August	12.558	67.635	0.607
September	0.470	7.460	0.302
October	0.530	3.340	0.222
November	0.266	4.260	0.241
December	0.337	3.910	0.211
January 1964	0.470	4.540	0.209
February	1.090	4.390	0.330
March	0.730	4.740	0.225

The ovaries were mostly in maturing and ripe stages in April-June, ripe and spent stages in July-September, spent and resting stages in October-December and resting and maturing

stages in January and March. The above observations show that the breeding season of the fish extends from July to September, with peak breeding in August.

The gonadosomatic index bears inverse relationship with gastrosomatic index, indicating that the feeding intensity declines considerably during breeding season.

(vi) Condition factor : The condition factor was correlated with gastrosomatic and gonadosomatic indices in the two sexes. The condition factor of males was found to be greater than that of females before breeding season but lower during the breeding season. This shows that the strain of spawning is greater in males. To make up this deficiency, the males show greater feeding activities, as compared to females, after the breeding season. The females, on the other hand, show greater feeding activities, as compared to males, before the commencement of breeding. The condition factor and the gastrosomatic index follow almost similar trend, whereas the condition factor is inversely related to gonadosomatic index.

(vii) Length-weight relationship : The length-weight relationship of this species was calculated to be

Male : $\log W = 3.2089 \log L - 5.4949$

Female : $\log W = 2.7321 \log L - 4.2556$

Where W = Weight of fish in grams, and
L = Total length of fish in mm

(viii) Fecundity : The relationships of fecundity with total length, weight of fish and weight of ovary were determined and are presented below :

Total length of fish (L) and Fecundity (F) :

$$\log F = 3.7917 \log L - 4.8898$$

Weight of fish (W) and Fecundity (F) :

$$F = 150.61 W + 3539.46$$

Weight of ovary (Wo) and Fecundity (F):

$$F = 656.326 Wo + 61549.796$$

The calculated fecundity in relation to total length of fish is presented in Table XVIII.

TABLE XVIII

Total length (mm)	Calculated Fecundity
430	124,700
460	161,000
490	204,500
520	256,100
550	316,900
580	387,400
610	469,000

(3) Rita pavimentata Gunther or 'Gegra'

(i) Fishery : Gegra attains a maximum size of 415 mm in Narbada river and constitutes an important seasonal fishery during monsoon months near Hoshangabad. The annual landings of this species and its status in commercial catches are presented in Table XIX.

TABLE XIX

Year (September-August)	Landings (in kg)	Percentage composition	
		in catfish group	in total catches
1958-59	3,676	37.60	13.24
1959-60	3,565	37.53	13.46
1960-61	2,775	36.73	12.37
1961-62	3,753	35.40	13.07
1962-63	3,380	30.20	9.87
1963-64	2,727	26.10	8.08
* 1964-65	1,236	17.82	6.16
* 1965-66	1,146	13.98	.61

* Exclusive of landings from Shahganj assembly centre

While the fishery of this species is the most predominant in the commercial catches during the monsoon months (July to September), a lean season is noticed in the winter months (December to February). It constitutes the main bulk in the long line catches. Heavy catches of this fish in the monsoon landings are ascribed to the flooded condition of the river, when long lines are actively operated and the operation of all other gears like cast net and gill net is suspended. Moreover, it feeds actively during the monsoon period and is effectively caught on baited lines in the turbid waters. This results in predominance of this species in the total landings of the monsoon period. In winter months, however, the fish is inactive in feeding habits due to cold and does not take bait, which accounts for the extremely poor fishery from long line operations in these months.

(ii) Catch-per-unit-effort : The observations on catch per 500 hooks per hour of this species for various years are given in Table XX.

TABLE XX

Year (September-August)	Catch per 500 hooks per hour (kg)		Percentage in long-line fishery	
	Hoshangabad	Shahganj	Hoshangabad	Shahganj
1958-59	-	0.115	-	71.70
1959-60	-	0.155	-	66.18
1960-61	-	0.122	-	63.42
1961-62	0.040	0.104	19.28	69.25
1962-63	0.054	0.143	15.14	64.18
1963-64	0.067	0.112	27.32	60.35
1964-65	0.060	-	28.95	-
1965-66	0.053	-	12.88	-

(iii) Food and feeding habits : 1031 specimens of this species collected from August 1958 to July 1960 were examined for stomach-content study. The feeding intensity was determined by average feed (in cc), gastro-somatic index (GSI) and condition of feed (percentage of gorged and full stomachs).

The observations have shown that the fish feeds actively in monsoon months and poorly in winter months. The condition factor, which fluctuated between 1.335 and 1.435, was found to be correlated with the feeding intensity of the fish.

Stomachs of 1031 specimens of adult fish collected from August 1958 to July 1960 and 190 specimens of juveniles (below 125 mm in total length) collected from July 1960 to October 1960 were examined for food analysis. The feeding intensity of juveniles was intensive in July-August 1960 (Av. feed = 0.05 cc; GSI = 1.81), but declined in September-October 1960 (Av.feed = 0.04 cc; GSI = 1.21). The main food items of adults and juveniles are shown in Table XXI.

TABLE XXI

Food items	Percentage by volume	
	Adults	Juveniles
Molluscs	38.0	-
Prawns	6.6	22.7
Macrovegetation	5.5	4.8
Insects	4.5	14.4
Teleosts	3.4	1.8
Microvegetation	0.2	-
Miscellaneous	1.0	-

The food composition of adults and juveniles shows that the molluscs which formed the main food of adults do not find a place in the diet of juveniles and the percentage of prawn and insects is higher in the diet of the latter.

The insect diet mainly consisted of dragon-fly nymphs water bugs, caddis-fly and its larvae, beetles, dipteran larvae; the teleost diet of Mastocembelus armatus and fish scales; macrovegetation of green seeds; and micro-vegetation of filamentous algae.

From the nature of diet of the adult fish, it appears that the fish is omnivorous and bottom feeder. The presence of spiny eels and prawns in its diet suggests that it also feeds under boulders and stones. The bulk and frequency of occurrenc

of molluscs in the diet of adult fish has suggested that it is the principal food of the fish. Its preference for prawns is noticed during the peak feeding period in July, when they are available in greater abundance.

(iv) Age and growth : 2,704 specimens were measured for length frequency studies. The mean lengths of various age groups and the growth rate up to fifth year are given in Table XXII.

TABLE XXII

Age (year)	Mean length (mm)	Growth rate
I	153	-
II	213	Between I & II = 60 mm
III	258	" II & III = 45 mm
IV	288	" III & IV = 30 mm
V	301	" IV & V = 22 mm

Cleithrum bones from 357 specimens were studied and the results indicate that the markings are annular.

(v) Length-weight relationship : The length-weight relationships of Rita pavimentata (both male and female) are expressed by the following formulae :

Male : $\log W = 3.0033 \log L - 4.8803$
Female: $\log W = 3.2258 \log L - 5.3827$

The coefficient of correlation (r) was found to be as high as 0.98 and 0.99 in males and females respectively.

(vi) Maturity and spawning : The maturity study of this species was based on gross examination of the ovaries, gonadosomatic index and ova diameter measurements. The first maturity is attained when the fish is in between 213 and 258 mm in total length (age groups II-III). The details in respect of gonadosomatic index and ova diameter are presented in Table XXIII.

TABLE XXIII

Month	Gonado-somatic index	Ova diameter measurement (mm)
October	0.49	0.278
November	0.73	0.279
December	0.44	0.240
January	0.52	0.274
February	0.56	0.271
March	0.53	0.271
April	0.82	0.287
May	1.02	0.963
June	4.13	1.310
July	5.99	1.710
August	9.51	1.647
September	2.61	0.861

The ovaries were mostly in spent and resting stages in October-December, resting stages in January-March, maturing and ripe stages in April-June and ripe and spent stages in July-September.

On the basis of gonadosomatic index, three ovaries were selected from the monthly samples collected from October 1958 to September 1960 and 600 ova from each of these selected ovaries were measured for maturity studies. The analysis of frequency polygon of ova diameters showed that the ovaries from December to March were in the resting stage and contained only one group of ova with mode at 0.12 mm which represented the immature stock. In the months of April and May, a group of maturing ova with mode at 0.25 mm emerged from the immature stock of ova. The ovaries in the months of June, July and August had a group of fully ripe ova with mode at 1.55 mm. From September to November, the ovaries contained few 'left-over' ova having mode at 1.42 mm.

The above observations have indicated that this species has only one spawning season extending from June to September, with peak breeding in July-August.

(vii) Fecundity : The relationship of fecundity (F) with total length of fish (L) was determined, which is as follows :

$$\text{Log } F = 5.8526 \text{ Log } L - 10.4458$$

The fecundity of this species is shown in Table XXIV.

TABLE XXIV

Total length (mm)	Fecundity
240	2,970
262	4,660
282	7,230
300	11,400
323	17,475
345	24,600
350	30,000

VIII. CARP SEED RESOURCES IN A PORTION OF THE NARBADA RIVER IN GUJARAT STATE

With a view to locating new and productive carp seed resources in the Narbada river in Gujarat State, exploratory investigations were undertaken to ascertain the availability of eggs, spawn and fry of commercially important species, particularly major carps, during the monsoon seasons of 1959, 1960, 1961 and 1962. For the purpose, three trial nets were operated for three hours in the morning and three hours in the evening every day during the period of investigations. The location of centres (see Map II) and periods of observations are shown in Table XXV.

TABLE XXV

Monsoon Season	Centre	District	Period of observation
1959	(i) Poicha	Broach	17.6.59 to 10.8.59
	(ii) Indravarna	Broach	17.6.59 to 15.8.59
1960	(i) Malsar	Baroda	30.6.60 to 20.9.60
	(ii) Poicha	Broach	30.6.60 to 13.9.60
	(iii) Mangrol	Broach	30.6.60 to 12.9.60
1961	Moti-Koral	Baroda	11.7.61 to 27.8.61
1962	Jhanor	Broach	14.7.62 to 14.9.62
1964	Sisodra	Broach	1.7 .64 to 5.9.64

1959 Monsoon Season

(i) Poicha Centre : Over 1,80,000 carp spawn were collected by operating 3 trial nets for 36 hours on 7 days during the period of investigations and the number of carp spawn collected per net per hour was estimated to be 1,440. On rest of the days spawn was either not available or the nets could not be operated due to high floods in the river and strong wind. The spawn was available in sufficiently large quantities on 10th, 11th, 12th and 19th July, 1959.

(ii) Indravarna Centre : Over 45,000 carp spawn were collected by operating three nets for 69 hours on 13 days during the period of investigations, while on remaining days the nets could not be operated due to high floods in the river. The number of carp spawn collected per net per hour was estimated to be 236. Spawn was available in fairly good quantities on 18th and 19th July, 1959.

The samples of carp spawn, on rearing in local nursery ponds, were found to consist of 39.9% and 38.9% major carps (catla and mrigal) at Poicha and Indravarna Centres respectively.

At Poicha, a suitable site for the operation of spawn collection nets is located two miles in the downstream, opposite Ganga Nath Village, where the river bed is sandy. When the water level in river exceeds c.6.0 m (20 feet), the centre is rendered unsuitable. The collection site at Indravarna is unsuitable because, due to river being narrow and the river bank steep, it gets flooded during normal floods.

1960 Monsoon Season

(i) Malsar Centre : About 1,30,50,000 carp spawn was collected by operating 2 to 3 spawn collection nets for 202 hours on 37 days and the catch per net per hour during the entire season was estimated to be about 1,400. The peak collection was made on 22nd July 1960, when 15,30,000 carp spawn were collected from one net in one hour.

(ii) Poicha Centre : About 8,00,000 carp spawn was collected by operating 3 nets for 227 hours on 41 days and the catch per net per hour during the entire season was estimated to be about 55. The maximum collection (per day) was made on 22nd July 1960, when 5,800 carp spawn was collected per net per hour.

(iii) Mangrol Centre : About 3,30,000 carp spawn was collected by operating 2 to 3 nets for 156 hours on 26 days. The peak collection was made on 24th July 1960, when 2,000 spawn was collected per net per hour. During the entire season, spawn catch per net per hour was estimated to be 42.

In the samples of carp spawn reared in local nursery ponds, the major carps (catla, mrigal and rohu) made up 94.0%, 78.4% and 84.0% at Malsar, Poicha and Mangrol Centres respectively.

The river bed at Malsar site is shallow and gradually sloping and a stretch of 1 km constitutes an ideal carp seed collection ground for the operation of about 100 nets simultaneously. This collection centre is well connected with Baroda and Broach by rail and road. Like Indravarna, Mangrol Centre is also unsuitable for the same reasons.

1961 Monsoon Season

Moti-Koral Centre : Over 46,00,000 carp spawn was collected by operating mostly 3 nets for 253 hours on 46 days, the average catch per net per hour being 6,000 during the entire season. The carp seed was collected in abundance on 6th, 7th and 8th August, 1961, when over 20,00,000 spawn was collected from three nets in 18 hours.

The samples of carp spawn reared in local nursery ponds, were found to contain 52.0% major carps (catla, mrigal and rohu).

The collection site at this centre is shallow, sandy and gradually sloping and about 75 nets can be operated simultaneously in a stretch of about 1 km. It is conveniently connected with Baroda and Broach by rail throughout the year and also by road during the pre- and post-monsoon months.

1962 Monsoon Season

Jhanor Centre : About 40,00,000 of carp spawn were collected from three nets operated for 368 hours on 63 days and the catch per net per hour was estimated to be about 3,600. Sufficiently large quantities of carp spawn were available on 20th and 21st August 1962, when over 20,00,000 (half of the entire season's catch) of spawn was collected from 3 nets in 12 hours, the catch per net per hour being 55,000.

The major carps (catla and mrigal) in the nursery reared samples of carp spawn made up 88.0% at this centre.

The river bank on Jhanor side is unsuitable due to its being precipitous, but the opposite bank has somewhat gradual slope and about 15 nets can be operated in a row along the bank in about a km stretch.

1964 Monsoon Season

During 1964 monsoon season, the investigations on the availability of fish seed were intensified by operating nets for 24 hours round the clock and additional data were also collected to correlate the concentrations of carp seed in the nets with the fluctuations in flood level, current velocity and turbidity in the river and other related factors.

Sisodra Centre : Investigations on carp seed resources were conducted at Sisodra (District Broach, Gujarat State) in the Narbada river from 1.7.1964 to 5.9.1964. A total of 1,158 ounces of spawn, estimated at over 100 lakh, was collected by operating three Midnapore type nets and one Gujarat type net round the clock for 24 hours during the period of investigations. Of the total collection, 1108.5 oz. of spawn was yielded by major floods on 44 days and only 49.5 oz. by minor floods on 21 days. Most of the spawn was collected during the receding phase of the floods. The maximum collections were made during night hours when the weather was favourable.

Fluctuations in the flood level in the river were studied in relation to the quantity and quality of spawn and effects of current velocity and turbidity on spawn concentration in the nets. The abundance of spawn in the river was found to be generally associated with major floods. High quality spawn was collected in abundance in the early part of the receding phase of the floods. Of the 10 floods registered at this centre, six were of high magnitude, and high yields of spawn were noticed in 5 floods viz. II, V, VI, IX and X. The total spawn yield in these floods was 1134.7 oz. (97.9% of the entire season's catch). Floods II to X contributed 63.0, 0.7, 0.4, 18.2, 62.8, 0.3, 0.7, 2.4 and 8.2% respectively of the total seasonal yield. The optimum current velocity for high concentrations of spawn in the nets was found to range between 0.5 and 1.0 km per hour. The turbidity played an important role in respect of spawn concentrations in the nets depending on current velocity, mesh of the net and position of nets in relation to the river bank. The chemical characters such as pH and dissolved oxygen content of river water did not appear to have any relation to spawn concentrations. Similarly meteorological characters appeared to have no direct relation with the availability of spawn (Anon., 1965).

The spawn, as assessed by an analysis of spawn samples, was found to contain 47.5, 42.9, 63.2, 74.4, 87.0, 53.0, 45.5 and 43.9% major carps in floods II to X. The quality of spawn was also determined by rearing spawn yields from floods V, VI and IX, in a nursery pond, which yielded 70.6% of major carps. The major carp content in spawn samples of corresponding floods made up 67.9%. In nursery reared samples, among major carps, catla overwhelmingly dominated (68.2%), while rohu and mrigal accounted only for 0.1% and 1.6% respectively.

Associates were generally available in relatively greater abundance in the rising phase of the floods than in the receding phase. In the entire season, Puntius ticto, Elops spp. and Chela spp. occurred more frequently and abundantly in the collections. The examination of gut contents showed that the feeding on spawn was more pronounced in Mystus aor, Wallago attu and Ambassis ranga. Among forage fishes Puntius sophore, Puntius ticto, Rohtee cotio and Chela spp. showed predatory leanings on spawn to a marked degree. The advanced carp fry also frequently fed on spawn.

The catching efficiency of Midnapore nets was compared to that of Gujarat nets. The former type nets were more efficient in the order of mesh sizes 1/8", 1/16" and 1/8" + 1/16" During the entire season, Midnapore nets were 8.4 times more efficient than Gujarat nets. It has been estimated that over 6.75 crores of major carp spawn can be collected at Sisodra by operating 50 Midnapore nets round the clock for 24 hours.

Of the spawn collected at Sisodra, 910 oz. (73 lakhs) of spawn was supplied to the Fisheries Department, Gujarat State.

IX. LOCATION OF SPAWNING GROUNDS OF INDIAN SHAD, Hilsa ilisha (Ham.) IN THE NARBADA RIVER IN GUJARAT STATE.

During the course of investigations on the location of spawning grounds of commercially important species of fish in the Narbada river, about 95,000 Hilsa eggs were collected from spawn-collection nets operated at Jhanor, Moti-Koral, Malsar, Rundh, Narkhedi, Poicha, and Mangrol (see Map II) during monsoon seasons of 1959, 1960, 1961, 1962 and 1963.

Three batches of Hilsa eggs, each numbering 700 to 800, were successfully reared in the field laboratory upto 8, 13 and 14 days after hatching. Embryonic and larval development of Hilsa was studied in greater detail and was compared with the earlier work of Kulkarni (1950) from Narbada river, and Jones and Menon (1951) from Hooghly river. The diameters of 300 fertilised eggs of Hilsa were measured and the average diameter of the egg was found to be 2.1 mm (Range: 1.6 to 2.4 mm). The inner membrane of the egg could be seen only in the preserved material.

The availability of fertilised eggs and the occurrence of mature Hilsa in the commercial catches in the river during monsoon seasons of the years 1959 to 1963 have shown that the spawning season of Hilsa in the Narbada river commenced in June-July and continued upto September, the peak of spawning being in the month of August, when the river was flooded to the maximum. The occurrence of Hilsa eggs in abundance, which is concomitant with up stream migration of large shoals was found to have a relation with lunar periodicities. The time of Hilsa fishing and periodicity in occurrence of Hilsa eggs in the Narbada river have shown that large shoals of Hilsa ascend the river with high tides.

The occurrence of a large number of developing eggs of Hilsa in the Narbada river from Jhanor (in lower reaches) to Mangrol (in upper reaches) during the monsoon seasons of 1959-63 have shown that Hilsa breeds all along the river stretch upto Indravarna (about 10 km upstream of Mangrol), while ascending. These observations are of significant importance in view of the construction of proposed dam across the Narbada river near Navagam (Gujarat State), about 5 km upstream of Indravarna. These observations have indicated that the dam to be constructed at Navagam will not act as a barrier to upstream migration of Hilsa to its spawning grounds.

The observations on Hilsa catches in Narbada river during the monsoon season have shown that the sex ratio in ascending males and females caught near Broach is about 3.5 : 1 in the beginning of the spawning season (July) and nearly 1 : 1 during the spawning season (August and September), which indicates that the males ascend to the spawning grounds earlier than the females.

The length frequency data of Hilsa from the tidal and freshwater zones have shown that while all size groups of ripe Hilsa (males 265 - 605 mm; females 295 - 605 mm) occurred in the tidal zone, only older Hilsa (males 315 - 485 mm; females 415 - 555 mm) migrated to the freshwater areas. It is thus noteworthy that younger (two year old) ripe Hilsa (males 265 - 315 mm; females 295 - 415 mm), encountered in abundance in the tidal areas, were totally absent in the freshwater area indicating the long-range upstream migration of only older groups of Hilsa. It appears probable that the younger Hilsa maturing for the first time ascend only upto tidal limit, whereas the older Hilsa migrate higher up in freshwater areas for breeding. The differential spawning behaviour of the two runs of Hilsa in Narbada river, the one spawning near tidal limits and the other spawning higher up in freshwater may be due to either varied nature of physiological changes occurring in the young and the old Hilsa or the presence of two differen races of Hilsa in the Narbada river.

The length frequency data have further shown that as compared to the Gangetic Hilsa, the Narbada Hilsa attains firs maturity at higher length (males 256 mm; females 295 mm) and i also of larger size (males and females both - over 605 mm).

X. INVENTORY SURVEY OF FISHING VILLAGES OF THE NARBADA RIVER

During the year 1958-59 a total stretch of about 945 km of Narbada river was surveyed from Mandla (Madhya Prade in the east to Broach (Gujarat State) in the west. In all 712 villages situated along the banks of the Narbada river in two states were covered to collect information with regard to fisherman population, actively engaged fishermen, statistics o craft and gear, etc. The river stretches of 32 km along north bank in Madhya Pradesh, 24 km along north bank and 56 km along south bank in Gujarat State were not surveyed due to dense forest and rocks in these areas. The data collected in this survey are given in Table XXVI.

The analysis of data on fisherman population has shown that although nearly an equal number of fishing villages (172, 177) were encountered on the two banks of the river, north bank was found to be more densely populated (45,025) than the south bank (24,127).

Out of 69,152 fishermen residing in 349 fishing villages, only 3,082 fishermen were reported to be actively engaged in fishing throughout the year. The rest of the fisherman population is either wholly engaged in cultivation and manual labour or engages in fishing only occasionally during the fishing seasons.

TABLE XXVI

States	Madhya Pradesh (800 km)		Gujarat State (145 km)	
River banks	North	South	North	South
No. of villages surveyed	304	295	55	58
No. of fishing villages	142	143	30	34
Fisherman population	28,017	14,814	17,008	9,313
Actively engaged fishermen	1,709	891	440	42
Total number of boats	2,349	748	410	45
No. of fishing boats	2,045	467	-	-
Fishing gear :				
Drag net	28	5	152	6
Scoop net	1,465	785	1,190	438
Gill net	1,079	156	1,498	225
Cast net	3,121	1,240	157	60
Bag net	-	-	300	-
Long line	2,741	1,154	886	420
Trap	424	71	-	12
Total :	8,858	3,411	4,183	1,161

Long lines (5,201), cast nets (4,578), scoop nets (3,878) and gill nets (2,958) were more commonly encountered in the fishing villages and the occurrence of the remaining fishing gear viz. drag nets, bag nets and traps, was limited to a very few fishing villages.

XI. SUGGESTIONS FOR THE DEVELOPMENT OF FISHERIES AND FUTURE WORK ON THE RIVER NARBADA

(i) Estimation of total fish production :

Fishery in the Narbada river is of diffused nature and there are very few regular fish landing/assembly centres. The disposal of fish catches is effected at a few regular fish markets located in big towns and in many small villages on market days, most of which have one market day in a week. The fishermen from a particular section of the river take their catches to six or seven different places in a week to meet weekly market days (Monday through Sunday) and also to some important regular fish markets in the area every day. Attempts were made by this unit to estimate the total fish production by sampling all the regular fish markets and some of the important weekly markets in the 720 km stretch of Narbada river from Mandla in the east to Barwani in the west, for a limited period from November 1960 to March 1961, but it was not feasible to continue this work. The observations on the catch statistics were, therefore, limited to the 48 km river stretch near Hoshangabad, as was being done earlier. Since the fishery staff of the State Governments is posted in each district, the estimation of total fish production from Narbada river in Madhya Pradesh and Gujarat State may be taken up by the respective State Fishery Departments, as this information collected over a number of years will help the State Fishery Departments in the planning of development, exploitation and conservation of fisheries of Narbada river. The data may be collected from regular fish assembly centres/fish markets and weekly markets on species-composition of catches with total weights of each fishery and size composition of important species of fishes in the commercial catches. The data thus collected may be utilised for determining (a) total fish production, (b) monthly and seasonal fluctuations in the catches of various fisheries, and (c) size composition of each fishery entering the commercial catches.

Besides the estimation of total fish production, information on catch-per-unit-effort for different types of gears may also be collected at selected places along the river where facilities for such observations are available.

(ii) Survey of carp seed resources :

Systematic survey of spawn resources has been completed by this Unit at seven centres in the Narbada river draining Gujarat State, including one centre where detailed investigations on the spawn behaviour, concentration and dispersal were undertaken. Knowledge of spawn behaviour with reference to the hydrodynamics of the river and its availability in time, space, quality and quantity with reference to physico-chemical and meteorological conditions in respect of most of the spawn collection centres in Narbada river is lacking. These investigations on spawn behaviour, concentration and dispersal may, therefore, be taken up in Narbada river in Madhya Pradesh and Gujarat State by State Fishery Departments along with spawn collection work which is already being done by them, with a view to elucidate the factors responsible for fluctuations in abundance of quality fish seed and to be able to predict its availability in time and space.

(iii) Stocking of major carp fingerlings :

The observations on the capture fishery of Narbada river in Madhya Pradesh and the information collected during the inventory survey of fishing villages in the entire stretch of Narbada river in Madhya Pradesh and Gujarat State have indicated that the percentage of the three conventional major carps viz. Catla catla, Cirrhinus mrigala and Labeo rohita is extremely low in the commercial catches of the entire river stretch. Fish seed collected from a portion of the Narbada river draining Gujarat State was found to contain low percentages of Cirrhinus mrigala and Labeo rohita whereas the percentage of Catla catla in the spawn collections was quite high. Almost similar conditions in respect of spawn quality seem to prevail in the lower stretch of Narbada river in Madhya Pradesh in Maheshwar-Barwani areas. In the upper stretch of the Narbada river in Madhya Pradesh, particularly in the Hoshangabad area, the quality of fish seed is reported to be extremely poor. In view

of the above observations, the stocking of the three major carps in Narbada river may be done by the respective State Fishery Departments with a view to increase their abundance in the river and thereby augment the fisheries and enrich carp seed resources of this river.

(iv) Experimental fishing with 'mahajal' and gill nets :

The fishing in the Narbada river near Hoshangabad is mainly done by cast nets and long lines and consequently the catches are very poor. In recent years, occasional fishing with 'mahajal' has increased the fish production. High percentage of Catla catla in 'mahajal' catches and comparatively low catches from cast net fishing has indicated that the cast net is not an effective gear for catching large-sized fish and that probably the fisheries are not properly exploited. Experimental fishing with mahajal and multi-meshed gill nets may be tried by State Fishery Departments, with the help of Fisheries Co-operative Societies, to increase the rate of exploitation in the Narbada river.

(v) Culture of mahaseer (Tor tor) and its use for weed control in confined waters :

The possibilities of culturing mahaseer (Tor tor) in tanks and reservoirs may be explored by the State Fishery Departments. Fry of this species can be obtained in good abundance from the Narbada river from October to January. The food, growth, condition factor, survival rate, etc. may be studied.

The dietary habits of mahaseer from the Narbada river have shown that it feeds voraciously on aquatic plants and algae. Being an indigenous species, the possibilities of using this fish for biological control of pond weeds may be investigated.

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APPENDIX

Classified list of fishes from Narbada river**

Class TELEOSTOMI — Subclass ACTINOPTERYGII

Order CLUPEIFORMES

Suborder CLUPEOIDEI

Family CLUPEIDAE

Subfamily CLUPEINAE

1. Hilsa ilisha (Hamilton)
2. Gonialosa manminna (Hamilton)

Suborder NOTOPTEROIDEI

Family NOTOPTERIDAE

3. Notopterus notopterus (Pallas)

Order CYPRINIFORMES

Division Cyprini

Suborder CYPRINOIDEI

Family CYPRINIDAE

Subfamily ABRAMIDINAE

4. Chela laubuca (Hamilton)
5. Oxygaster clupeoides (Bloch)

Subfamily RASBORINAE

6. Barilius barila (Hamilton)
7. Barilius bendelisis var. chedra (Hamilton)

** The classification adopted here is mainly after L.S. Berg. ("Classification of fishes, both recent and fossil". Trav. Inst. Zool. Acad. Sci., U.S.S.R., 5(2), 1940).

8. Barilius evezardi Day
9. Barilius radiolatus Gunther
10. Danio (Danio) aequipinnatus (McClelland)
11. Danio (Danio) devario (Hamilton)
12. Danio (Brachydanio) rerio (Hamilton)
13. Esomus danrica (Hamilton)
14. Rasbora daniconius (Hamilton)

Subfamily CYPRININAE

15. Amblypharyngodon mola (Hamilton)
* 16. Tor khudree Sykes
17. Tor putitora (Hamilton)
18. Tor tor (Hamilton)
19. Puntius ambassis (Day)
20. Puntius amphibius (Cuvier and Valenciennes)
* 21. Puntius chrysopoma Cuvier
22. Puntius conchonius (Hamilton)
23. Puntius dorsalis (Jerdon)
* 24. Puntius guganio (Hamilton)
* 25. Puntius pinnauratus (Day)
26. Puntius sarana (Hamilton)
27. Puntius sophore (Hamilton)
28. Puntius ticto ticto (Hamilton)
* 29. Puntius titius (Hamilton)
30. Oreichthys cosuatis (Hamilton)
31. Catla catla (Hamilton)
32. Cirrhinus mrigala (Hamilton)
33. Cirrhinus reba (Hamilton)
* 34. Garra gotyla (Gray)

* Recorded by Hora & Nair (1941)

35. Garra lamta (Hamilton)
* 36. Garra mullya (Sykes)
37. Labeo bata (Hamilton)
38. Labeo boggut Sykes
39. Labeo calbasu (Hamilton)
40. Labeo dyocheilus (McClelland)
41. Labeo fimbriatus (Bloch)
42. Labeo gonius (Hamilton)
43. Labeo rohita (Hamilton)
44. Osteobrama cotio cotio (Hamilton)

Subfamily GARRINAE

45. Crossocheilus latius latius (Hamilton)

Family PSILORHYNCHIDAE

* 46. Parapsilorhynchus tentaculatus (Ann.)

Family COBITIDAE

47. Noemacheilus botia (Hamilton)
48. Noemacheilus dayi Hora
* 49. Noemacheilus evezardi Day

Subfamily COBITINAE

50. Lepidocephalichthys guntea (Hamilton)

Division Siluri

Suborder SILUROIDEI

Family SILURIDAE

51. Ompok bimaculatus (Bloch)
52. Wallago attu (Bloch & Schneider)

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* Recorded by Hora & Nair (1941)

Family BAGRIDAE

53. Mystus (Mystus) bleekeri (Day)
54. Mystus (Mystus) cavasius (Hamilton)
55. Mystus (Mystus) vittatus (Bloch)
56. Mystus (Osteobagrus) aor (Hamilton)
57. Mystus (Osteobagrus) seenghala (Sykes)
58. Rita pavimentata Gunther

Family AMBLYCIPITIDAE

* 59. Amblyceps mangois (Hamilton)

Family SISORIDAE

60. Gagata itchkeea (Sykes)
61. Glyptothorax lonah (Sykes)
* 62. Laguvia ribeiroi Hora

Family SCHILBEIDAE

63. Clupisoma garua (Hamilton)

Family HETEROPNEUSTIDAE

64. Heteropneustes fossilis (Bloch)

Family CLARIDAE

65. Clarias batrachus (Linnaeus)

Order ANGUILLIFORMES

Suborder ANGUILLOIDEI

Family ANGUILLIDAE

66. Anguilla bengalensis (Gray & Hardw)

Order BELONIFORMES

Suborder SCOMBERESOCOIDEI

Family BELONIDAE

67. Xenentodon cancila (Hamilton)

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* Recorded by Hora & Nair (1941)

Order OPHIOCEPHALIFORMES

Family CHANNIDAE

68. Channa gachua (Hamilton)
69. Channa marulius (Hamilton)
70. Channa punctatus (Bloch)

Order PERCIFORMES

Suborder PERCOIDEI

Family CENTROPOMIDAE

71. Chanda nama (Hamilton)
72. Chanda ranga (Hamilton)

Family NANDIDAE

73. Badis badis (Hamilton)
74. Nandus nandus (Hamilton)

Suborder GOBIOIDEI

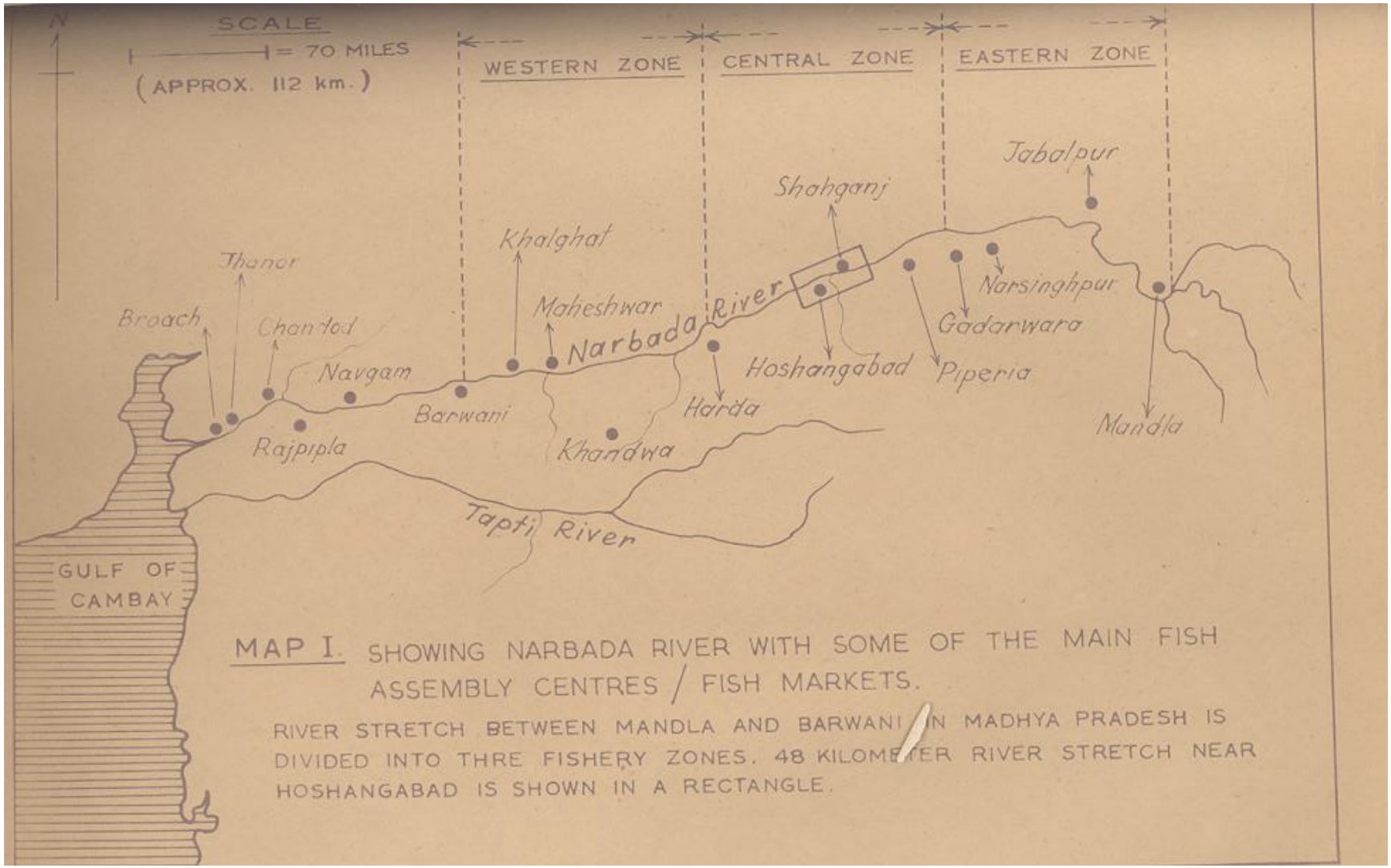
Family GOBIIDAE

75. Glossogobius giuris giuris (Hamilton)

Order MASTOCEMBELIFORMES

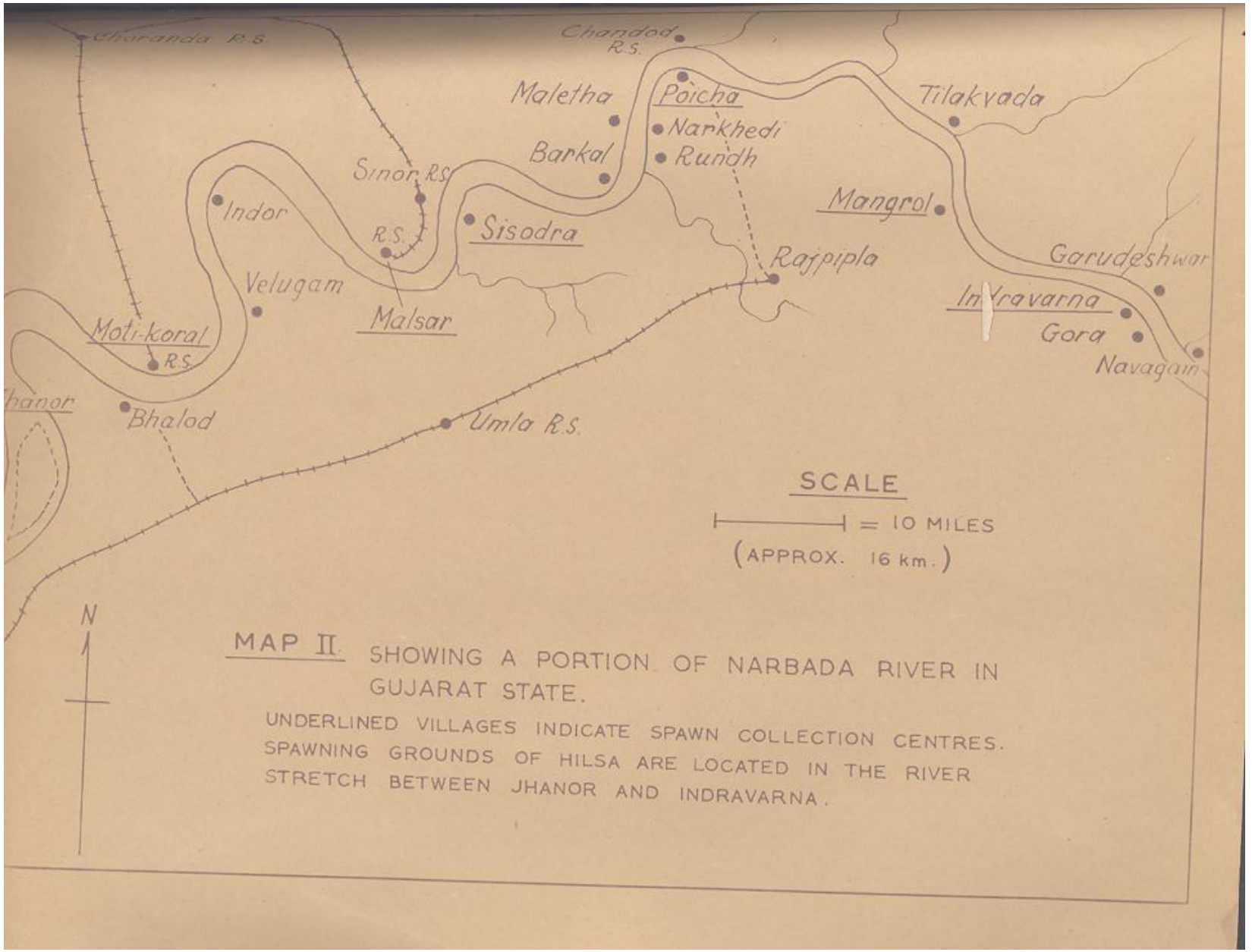
Family MASTOCEMBELIDAE

76. Mastocembelus armatus armatus (Lacepede)
77. Mastocembelus pancalus (Hamilton)



MAP I. SHOWING NARBADA RIVER WITH SOME OF THE MAIN FISH ASSEMBLY CENTRES / FISH MARKETS.

RIVER STRETCH BETWEEN MANDLA AND BARWANI IN MADHYA PRADESH IS DIVIDED INTO THRE FISHERY ZONES. 48 KILOMETER RIVER STRETCH NEAR HOSHANGABAD IS SHOWN IN A RECTANGLE.



MAP II. SHOWING A PORTION OF NARBADA RIVER IN GUJARAT STATE.

UNDERLINED VILLAGES INDICATE SPAWN COLLECTION CENTRES. SPAWNING GROUNDS OF HILSA ARE LOCATED IN THE RIVER STRETCH BETWEEN JHANOR AND INDRAVARNA.