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bulletin 44

Part Two

MARCH 1990



NATIONAL SYMPOSIUM ON RESEARCH AND DEVELOPMENT IN MARINE FISHERIES

MANDAPAM CAMP
16-18 September 1987

Papers Presented
Sessions III & IV

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P. B. No. 2704, E. R. G. Road, Cochin-682 031, India

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STUDIES ON THE MATURATION AND SPAWNING OF GREY MULLET OF A RESERVOIR FISHERY IN OKHAMANDAL (GULF OF KUTCH) WITH SPECIAL REFERENCE TO RURAL DEVELOPMENT ALONG THE COAST

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ABSTRACT

Grey mullets formed 57% of the annual marine fish production during 1984-87 from the reservoirs of a solar saltworks along the Okhamandal coast of the Gulf of Kutch. *Mugil cephalus* (23.0%), *Mugil macrolepis* (35.03%), *Mugil parsia* (1.29%), *Mugil tade* (0.629%) and *Mugil carinatus* (40.06%) formed the composition of the catch. Maturing specimens of *Mugil cephalus*, *Mugil macrolepis* and *Mugil parsia* were observed in the catch.

In view of the excellent prospects of aquaculture of this highly esteemed group of fishes, and considering the limited seed resources of 1.64 million per annum from the natural sources, a study of the gonadal development and spawning of the commercially important species was undertaken. Based on the data, experiments to induce the development and spawning were also conducted. Conditioning and prevention of diseases from infection due to injury were major problems. Both *Mugil macrolepis* and *Mugil parsia* responded to pituitary hormone injections, developed ovaries and spawned in 7 days and 37 days respectively.

The prospects of rural development through mullet culture in the coastal areas of Kutch are discussed.

1. INTRODUCTION

The Grey Mulletts constituted 0.22% of the marine landings in India. Their exploitation steadily increased from an annual average 233 t per year during the 1950-'59 to 3,312 t per year during the 1980-'84 period. Gujarat state contributed 47.8% of the mullet production in India during 1984. Mulletts form the mainstay of the littoral fishery of the Gulf of Kutch providing livelihood to the poor traditional fishermen of the coast. Fry and Fingerlings of mullets ascend the backwaters, swamps, creeks and even establish fishery in saltworks reservoirs totally disconnected from sea (Gopalakrishnan *et al.*, 1987, in press). These fishes tolerate wide salinity changes upto 91.34 ppt Luther (1963), Jacob and Krishnamurthy (1942), Devasundaram (1952), John (1958), Sarojini (1958), Jhingran (1958), Shetty *et al.*, (1969), Jhingran and Natarajan (1969), Rangaswamy (1972), and Das (1977, 1978), have studied several

aspects of mullet fisheries. However, no information is available on the fisheries and the biological characteristics of mullets of Gujarat coast. It is well known that the environmental conditions exert a definite impact on the growth, reproduction and survival of the fish population of different regions. The Gulf of Kutch, with widely fluctuating high salinity (35 to 39 ppt), pH (7.7 to 8.5) and temperature conditions (29° to 37°C), is a drought prone arid zone. In the backwaters of the Gulf, these conditions further change (Dave *et al.*, 1982, Gopalakrishnan *et al.*, 1987). In the present paper, the gonadal maturity, development and the spawning behaviour of three economically important mullets are studied with a view to employing hypophysation technique to induce the fish to produce adequate quality seed in hatchery conditions. The data is discussed in relation to practising aquaculture for rural development in the region.

Table 1. Data of mullets in the reservoir fishery during 1984-87

Species	1984-85			1985-86			1986-87			Annual average	
	Production (kg)	% in total catch	% in total mullets	Production (kg)	% in total catch	% in total mullets	Production (kg)	% in total catch	% in total mullets	% in total fishery	% in total mullets
<i>Mugil cephalus</i>	889	7.18	32.87	3031	6.32	10.36	14459	18.09	30.16	13.10	23.0
<i>Mugil macrolepis</i>	1210	9.78	44.73	6173	12.87	21.00	20613	29.70	43.00	19.96	35.03
<i>Mugil parsia</i>	463	3.74	17.11	239	0.49	0.82	326	0.40	0.68	0.73	1.29
<i>Mugil tade</i>	143	1.16	5.29	250	0.52	0.86	104	0.13	0.22	0.35	0.62
<i>Mugil carinatus</i>	—	—	—	19577	40.83	66.88	12437	15.56	25.94	22.82	40.06
Total	1615	21.86	100.00	29270	61.03	99.91	47939	59.88	100.00	56.96	100.00

Table 2. Gonadial condition of mullets

Maturity Stage	Female (ovary)	Ova diameter (mm)			Male (testes)	Corresponding ICES scale (Wood, 1930)
		<i>M. cephalus</i>	<i>M. macrolepis</i>	<i>M. parsia</i>		
I (Immature)	Occupying 1/3 of body cavity, ova transparent	0.070	0.070	0.070	Thread like, occupying less than 1/2 body cavity, dull white (immature)	I-II
II (Maturing I)	Occupying 1/2-2/3 body cavity, ova partially yolk laden	0.140	0.140	0.140	Occupying 1/2 body cavity, dull white (maturing)	III-IV
III (Mature II)	Occupying 1/2-2/3 body cavity ova fully yolk laden	0.175	0.175	0.175	Occupying more than 1/2 to 1/3 body cavity, creamy white colour (mature)	V
IV (Mature)	Occupying 1/2-2/3 body cavity sometimes 3/4 to full, yolk vacuolated, perivitelline space seen yellowish colour	0.350	0.350	0.350	Occupying more than 2/3 body cavity, oozing on applying gentle pressure, creamy white colour (oozing)	VI
V (Mature-Oozing)	Occupying entire body cavity, deep yellowish colour	0.630	0.735	0.630		
VI (Spent Regressing) recovering	Occupying not more than 1/2 body cavity, degenerating ova seen, reddish, flaccid	0.105 to 0.525	0.105 to 0.630	0.105 to 0.525		

MATERIAL AND METHODS

The fishery data from 1984-'87 was analysed to study the production trend of important species. The gonads of three species viz. *Mugil cephalus*, *Mugil macrolepis* and *Mugil parsia* were examined and analysed for maturity, ova diameter progression through maturity stages, the gonado-somatic index (G.S.I. = gonad weight/body weight x 100), fecundity, sex ratio and spawning season. The value of ocular division was calculated at 0.035 mm for studying the ova diameter.

FISHERY

The data on the composition of mullets in the reservoir fishery during 1984-'85 to 1986-87 (Table-1) showed that on an average 58.9% of the catch comprised of mullets represented by *M. cephalus* (23.0%), *M. macrolepis* (35.03%), *M. parsia* (1.29%), *M. tade* (0.629%) and *M. carinatus* (40.06%). The market value of mullets ranged from Rs. 0.18 to 3.22 lakhs during the period.

MATURATION AND SPAWNING

Six maturity stages were recognised in females and four maturity stages were recognised in males (Table-2).

Mugil cephalus

Length at first maturity: It was observed that at 340 mm, 71% of the females and at 380 mm, all the females were maturing. At 400 mm 12.5% of the females were in spent or spent-recovering stage, suggesting that the first maturity in females was around 340 mm. The males showed first maturity at 360 mm when 50% were mature and at 380 mm, 50% males were seen in oozing stage while 66% of them were in spent or spent-recovering stage at 400 mm. However, as males in maturity stage I were not available in the catch, it was possible that first maturity in males might be earlier than 340 mm.

Rangaswamy (1975) estimated the size at first maturity at 376 mm and 425 mm in the Pulicat Lake mullets, and Das (1978) recorded

280 mm and 320 mm in the Goa waters for males and females respectively.

Gonado somatic index: In *M. cephalus*, the advent and advancement of maturity and the monthly fluctuations of the G.S.I. showed a primary peak in November-February and a secondary peak in June-September. This coincided with fully matured gonads in oozing and also spent-recovering stages.

Spawning frequency: The progression of the development of ova diameter indicated the spawning season. In the species, from September to February, one group of maturing ova was seen (Fig. 1 & 2). There was a suggestion of a second group of ova maturing from March-July before degenerating. This was accompanied by the G. S. I. trend and also occurrence of females in the oozing (stage V) and spent (stage VI) conditions. Perhaps, a prolonged spawning season is suggested by this as observed by other authors. Only one spawning frequency has been noted for the species by Jhingran

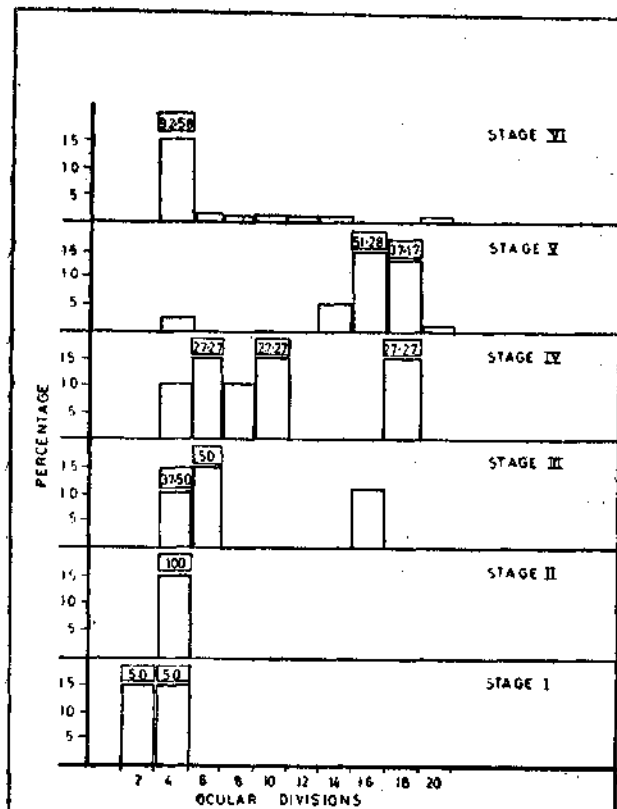


Fig. 1 Development of ova in different maturity stages of *Mugil cephalus*

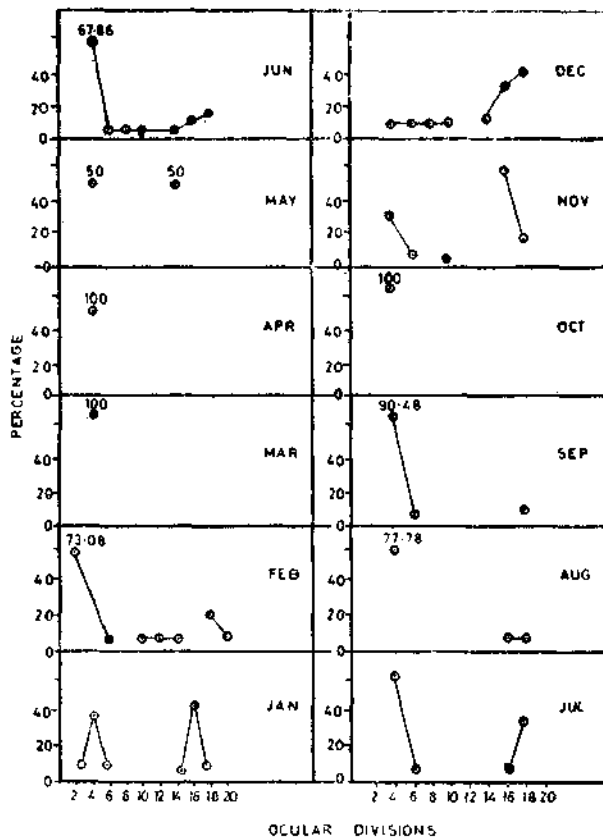


Fig. 2 Size progression of ova during different months in *Mugil cephalus*

(1958, cited by Das, 1978) where the fishes had access to sea for spawning migration. In the present study the lake had no contact with the sea and therefore the second progression of ova may be due to regeneration after regressed conditions.

Spawning season : The monthly distribution indicated that matured and oozing females were available during November to January and July to August. Spent or recovering females were also seen immediately following these months. Fries and fingerlings of the species occurred in the reservoir, but it could not be established that they were spawned by the fishes in the reservoir.

Fecundity : In *M. cephalus* it ranged from 35 to 66.9 lakhs in the size range of 540 mm to 630 mm (total length). The ovaries examined were of 250 grams to 550 grams weight and the egg diameter had size of 0.525 mm to 0.595 mm. The earlier reports of fecundity

were 12.75 to 27.81 lakhs in Australian mullet by Kesteven (1942) and 13.2 lakhs by Jacob and Krishnamurthy (1948, cited by Rangaswamy, 1975), 27.2 lakhs to 49.54 lakhs by Patnaik (1962, cited by Rangaswamy, 1975) and 4.34 to 47.17 lakhs by Rangaswamy (1975) in the Indian mullets from different regions.

Sex ratio : A preponderance of females throughout the period except the peak spawning month of December was observed (Table-3). Both males and females tend to congregate during the final stages of maturity. The sex ratio in various size groups showed that the males were present up to 500 mm only. The tendency of differential maturation reported by other workers was observed in this case also.

Table 3. Sex ratio of *M. cephalus* during different months

Month	%		Ratio of males to 100 Females
	Male	Female	
January	23.0	76.00	30.00
February	25.50	76.50	30.77
March	14.80	85.20	17.40
April	30.00	70.00	42.86
May	—	100.00	—
June	3.40	96.60	3.57
July	—	100.00	—
August	10.00	90.00	11.11
September	19.20	80.80	23.80
October	28.60	71.40	40.00
November	11.00	89.00	12.5
December	41.30	58.70	70.37

Mugil macrolepis

Length at first maturity : *M. macrolepis* had been reported to achieve first maturity at 170 mm and 160 mm in respect of females and males by Luther (1963). In our study the size was observed at 160 mm for females and at 140 mm for males.

Gonado-somatic index : The data showed that the females above 180 mm size group had a high G.S.I. throughout the year with a peak in 220-260 mm size group. In males also similar trend was observed. No mature males were observed beyond 280 mm. The monthwise G.S.I. showed two distinct peaks during February to March and June to September. Gonads in oozing stage were observed during this period.

Spawning frequency : The data (Fig. 3 & 4) indicated a single group of ova maturing through a prolonged spawning season.

Spawning season : The monthly distribution of maturity stages (Fig. 5) showed that a large percentage of Stages IV and V females during January to March and June to August were present. Spent and recovering females also were frequent in the catch during the period. Luther (1963) had also reported June to February as the spawning period for Palk Bay mullets.

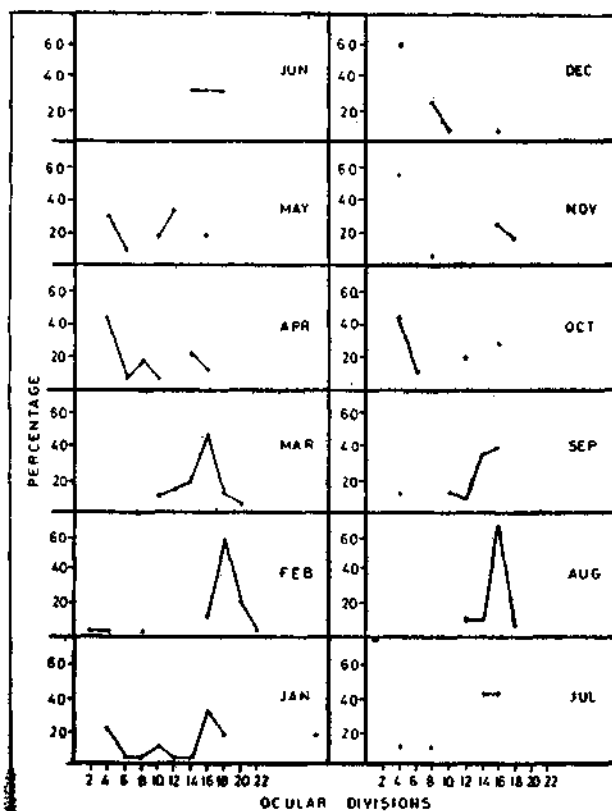


Fig. 4 Size progression of ova during different months in *Mugil macrolepis*

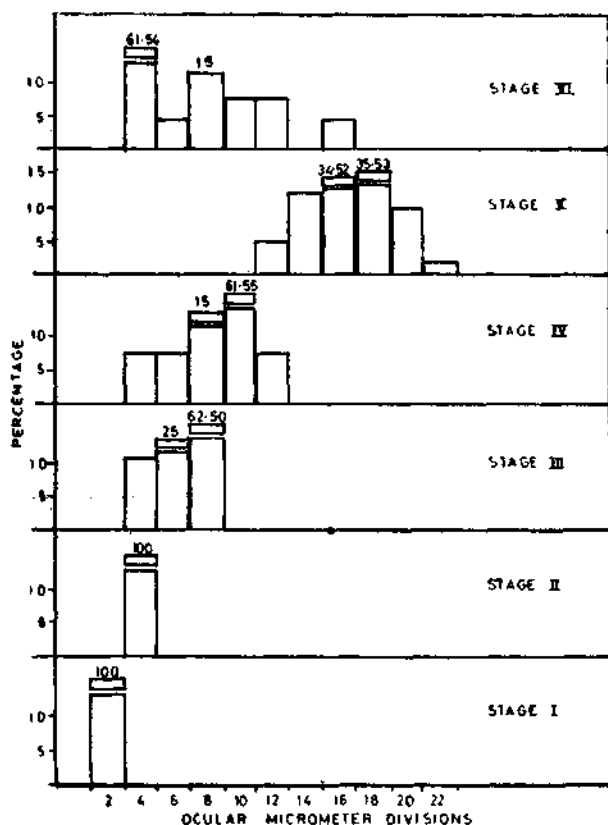


Fig. 3 Development of ova in different maturity stages in *Mugil macrolepis*

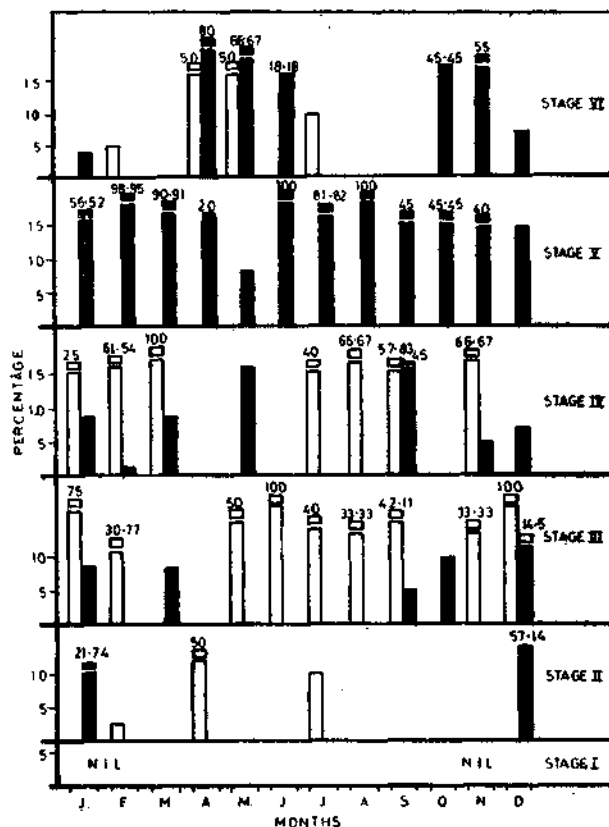


Fig. 5 Percentage of occurrence of various maturity stages in *Mugil macrolepis*

Fecundity : In females measuring 330 mm weighing 300 gms, fecundity of 2.5 to 3.0 lakhs eggs was observed. Luther (1963) reported 1,51,920 to 6,72,600 eggs in fish measuring 230 to 299 mm whereas Alikunhi *et al* (1971) estimated 1.25 to 4.0 lakhs eggs in fishes of 130 to 230 mm length and 40 to 130 grams weight.

Sex ratio : Only during July to September the males were represented in the population in more or less equal numbers, while during the remaining period the males were scarce (Table-4). The data on the sex ratio during different maturity stages showed differential maturation in both sexes, males maturing faster and earlier. The male to female ratio was 1.8 : 1.0 while immediately thereafter, the males declined in strength disappeared. Luther (1963) also recorded 1.2 : 1 ratio during spawning season. Upto 180 to 250 mm groups of the population, males dominated and thereafter slowly declined, totally disappearing after 280 mm.

Table 4. Sex ratio of *M. macrolepis* during different months

Month	Male	% Female	Ratio of males to 100 females
January	14.80	85.20	17.30
February	29.10	70.90	41.00
March	26.60	73.40	36.40
April	9.10	91.90	9.80
May	14.30	85.70	16.70
June	10.00	90.00	11.00
July	47.60	52.40	90.80
August	20.00	80.00	25.00
September	48.70	51.30	95.00
October	—	100.00	—
November	13.00	87.08	15.00
December	6.60	93.40	7.10

Mugil persia

Length at first maturity : Maturing females were seen in 220 mm group. Spent or regressing or recovering specimens were observed in the same group. The maturity increased from 220 mm group and at 280 mm group the spent or recovering fishes were very high. It appeared that the first maturity was around 220 mm. Sarojini (1957) reported mature females in the 105-115 mm size group. Only fully matured males were seen in the fishery. Spent or recovering fishes were also seen at the size of 161-180 mm. The males similar to females appeared to mature much earlier. Sarojini (1957) also had recorded mature males in the 95-105 mm size group.

Gonado-somatic index : A prolonged period of high G. S. I. in the females of 300-320 mm to 400-420 mm size groups was noticed in the fishery. In males also a similar situation from 220-320 mm size group was observed. The monthly distribution of G. S. I. for different size groups indicated maximum ovarian

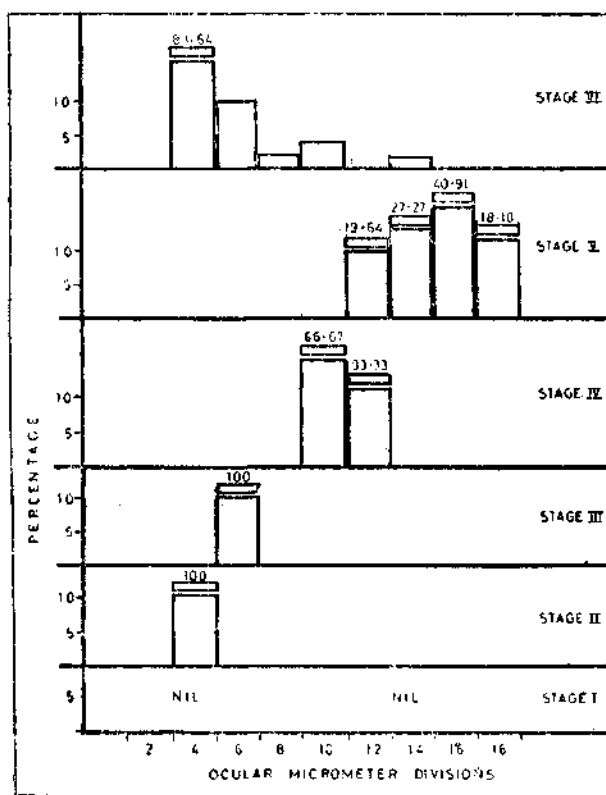


Fig. 6 Development of ova in different maturity stages in *Mugil persia*

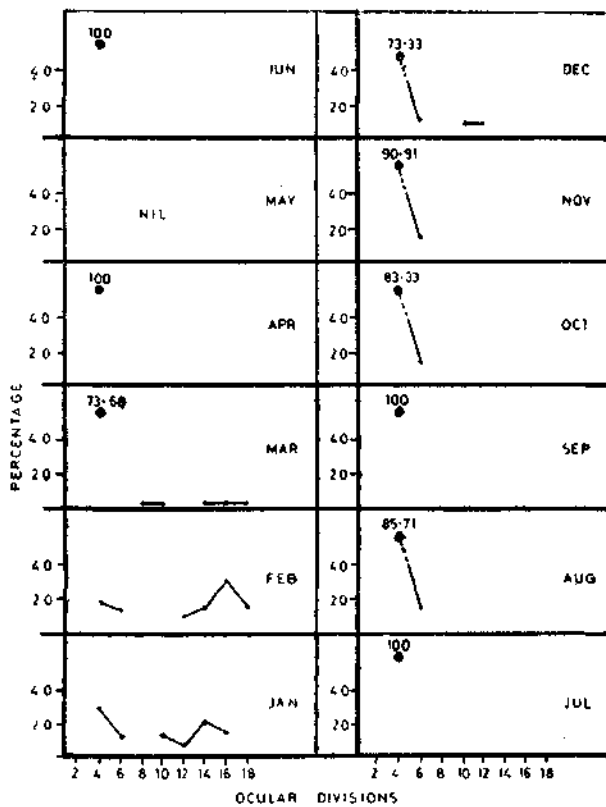


Fig. 7 Size progression of ova during different months in *Mugil parsia*

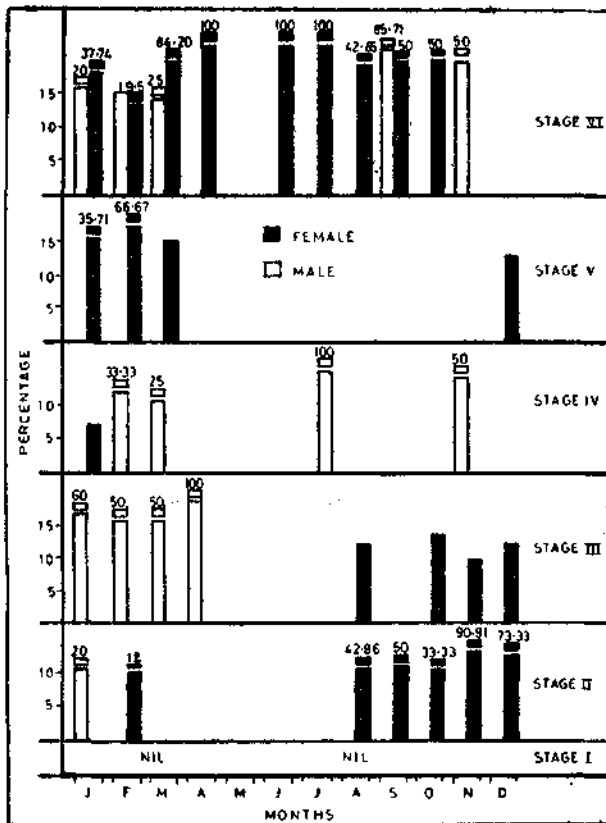


Fig. 8 Percentage occurrence of various stages of maturity in *Mugil parsia*

maturity from December to March with a peak in February. In males, this peak occurred in January.

Spawning frequency : Progression of ova diameter in maturity stages and in monthly distribution (Fig. 6 & 7) suggested a single ova group developing throughout the year.

Spawning season : The monthly distribution of different maturity stages (Fig. 8) showed a maturity peak during December to March in females and November to March in males. The presence of large number of spent or recovering specimens during June to October also, suggested a very long spawning period.

Fecundity : Sarojini (1957 & 1958) reported from West Bengal fecundity rates of 2 to 6 lakhs eggs. In the present study 2.45 lakhs eggs were seen in a 330 mm fish weighing 350 grams.

Sex ratio : Preponderance of females was seen throughout the year. The male to female ratio of 0.5 : 1.0 during the spawning peaks and 0.37 : 1.0 during the remaining months suggested the scarcity of males in the fishery (Table-5). The sex ratio

Table 5. Sex ratio of *M. parsia* during different months

Month	Male	% Female	Ratio of male to 100 females
January	26.00	74.00	35.71
February	47.00	53.00	88.60
March	28.00	72.00	38.80
April	11.00	89.00	12.36
May	—	—	—
June	—	100.00	—
July	30.00	70.00	42.86
August	—	100.00	—
September	50.00	50.00	100.00
October	—	100.00	—
November	26.00	74.00	—
December	—	100.09	—

Table 6. *Details of maturation and spawning*

Fish	Wt (gm)		Dose of hormone injections							
	of fish		1		2		3		4	
			Dt.	mg/kg	Dt.	mg/kg	Dt.	mg/kg	Dt.	mg/kg
1	2	3	4	6	6	7	8	9	10	
3	250	27/6/86	5.0 HCG+PE (50%)	30/6	10.0 HCG+PE (50%)	7/7	10.0 HCG+PE (50%)	7/8	10.0 HCG+PE (50%)	
8	300	20/8/86	16.00 HCG+PE (80%+20%)	26/8	40.00 HCG+PE (50%)	10/9	20.0 (PE)	24/9	40.00 HCG+PE (50%)	
9	250	20/8	16.00 HCG+PE (80%+20%)	26/8	40.00 HCG+PE (50%)	10/9	20.00 (PE)	24/9	40.00 HCG+PE (50%)	
10	250	..	..	..	..	..	..	..	..
11	250	20/8	16.00 HCG+PF (50%)	26/8	40.00	10/9	20.00 PE	22/9	40.00	
12	300	12/12	20.00 HCG+PE (50%)	15/12	50.0 HCG+PE (60%+40%)	22/12	20.00 PE	28/12	20.0 PE	

experiments on *M. macrolepis*

5		6		observations	Remarks
Dt.	mg/kg	Dt.	Mg/kg		
11	12	13	14	15	16
20/8	16.0 HCG+PE (80%+20%)	26/8	40.00 HCG+PE (80%+20%)	Ovary regressed after 4th dose; survived 81 days receiving totally 9 doses of hormones	PE: pituitary hormone extract of mullet pituitary
1/10	40.00 HCG+PF (50%)	17/10	40.00 HCG+PE (80%+20%)	Egg diameter progression 20/8 : 0.490 mm 26/8 : 0.525 mm 10/9 regressed survived. 60 days	HCG: crude human chorionic gonadotropin manufactured by INFAR (India) Ltd, Calcutta 700024.
1/10	40.00 HCG+PE (50%)	17/10	40.00 HCG+PE (80%+20%)	Egg diameter progression: 20/8 : 0.385-0.420 mm 26/8 : 0.455-0.525 mm 10/9 regressed survived 71 days	
"	"	"	"	Egg diameter progression: 20/8 : 0.175-0.210 mm 26/8 : 0.175-0.210 mm 10/9 regressed survived for 80 days	
29/9	40.00 HCG+PE (50%)	17/10	40.00 HCG+PE (80%+20%)	Egg diameter progression: 20/8 : 0.455 mm 26/8 : 0.455 mm 10/9 : 0.490 mm 22/9 : 0.105-0.175 regressed in 30 days survived for 76 days	Kept under regulated photoperiod of 6L/18D for 41 days from 17/9. But no response
9/1/ 87	20.0 (HCG+PE) (80%+20%)	16/1/ 87	20.00 HCG	Egg diameter progression: 12/12 : 0.455-0.490 mm 15/12 : 0.455-0.525 mm 22/12 : 0.525 mm 28/12 : 0.455-0.525 mm 9/1 : 0.350-0.525 mm 30/1 : 0.105 mm regressed fully survived for 65 days.	

1	2	3	4	5	6	7	8	9	10
13	250	9/1/87	40.00 HCG	13/1/ 87	40.0 HCG+PE (80%+20%)	—	—	—	—
14	250	22/1	30-40 HCG+PE (60%+40%)	24/1	32.00 PE	30/1	30.40 HCG+PE (60%+40%)	7/2	30.0 HCG+PE (60%+40%)
15	350	24/1	20-25	30/1	20.25 HCG+PE (60%+40%)	7/2	20.0 HCG+PE (60%+40%)	—	— HCG+PE
16	250	13/2/	10-15 PE	14/2	10-15 PE	17/2	—	—	—
17	300	13/2	10-15 PE	14/2	10-15 PE	17/2	10-15 PE	20/2	10-15 PE
18	300	13/2	10-15 PE	14/2	10-15 PE	17/2	10-15 PE	20/2	10-15 PE
19	300	..	..	..	..	..	..	..	..
21	275	..	..	..	..	..	..	..	..

11	12	13	14	15	16
—	—	—	—	Egg diameter progression : 9/1 : 0.525-0.530 mm 13/1 : 0.560-0.630 mm 15/1 : 0.595-0.700 mm progressing well but died due to laboratory problems.	---
—	—	—	—	Egg diameter progression: 22/1 : 0.525-0.560 mm 30/1 : 0.595-0.630 mm 7/2 : 0.245-0.335 mm regressed fully after initial developmental symptoms. survived for 26 days	
—	—	—	—	Egg diameter progression: 24/1 : 0.525-0.570 mm 30/1 : 0.525 mm 7/2 : 0.245-0.335 mm regressed fully.	
—	—	—	—	Egg diameter progression: 13/2 : 0.455-0.525 mm 17/2 : 0.700-0.805 mm 18/2 <i>Partial spawning occurred</i> 19/2 <i>Repeated partial spawning</i> 20/2 <i>Stripped</i> spawned in 5 days	Spawned
21/2	10-15 PE	25/2	10-15 PE	Egg diameter progression: 13/2 : 0.455-0.525 mm 17/2 : 0.490-0.560 mm 20/2 : 0.595 mm 25/2 : 0.595 mm spawned in 17 days	Spawned
21/2	10-15 PE	25/2	10-15 PE	Egg diameter progression: 13/2 : 0.455-0.525 mm 17/2 : 0.630 mm 20/2 : 0.665 mm 28/3 spawned in 16 days	Spawned
"	"	—	—	Egg diameter progression: 13/2 : 0.455-0.525 mm 17/2 : 0.455-0.525 mm 21/2 Regressed	Regressed
"	"	25/2	10-15 PE	Egg diameter progression: 13/2 : 0.455-0.525 mm 17/2 : 0.525-0.595 mm 20/2 : 0.595 mm 28/2 died due to infection	---

distribution in different maturity stages and size groups showed fully matured males in less numbers and upto 280 mm males were more.

INDUCED MATURATION & SPAWNING

The uncertainty and difficulties for collection of mullet seeds from natural sources, not only affect the development of fish culture but also entail extravagant expenditure in transport and sorting out quality seed. The alternative to natural collection being, production in hatchery, many successful experiments had been conducted by scientists in Hawaii, Taiwan, Israel and in India. In India, only wild spawners from the sea had been bred and their larvae raised (Alikunhi *et al.*, 1971, Mohanty, 1971, Chaudhuri *et al.*, 1977). Yet, no standardised technique for spawning and larval raising in mullet is available. In the present study, shortage of fully ripe spawner females with the proper stage of oocyte development was a serious problem. The percentage of males seen in the fishery also, as reported earlier, was very poor. To overcome the problem, maturation of females with mullet pituitary hormone and crude extract of human chorionic gonadotropin (H.C.G.) was attempted.

Mugil cephalus : The major problem encountered in this fish was mortality in transport and while treatment of injuries afterwards. Improved packing with oxygen in individual plastic bags for transport and treatment with oxytetracycline injections at a dose of 20-30 mg/kg body weight, smearing of the oxytetracycline ointment in the injured parts and treating with potassium permanganate solution of 0.5 to 1.0 mg/litre concentration, the survival could be extended upto 48 hours only. Despite swollenness of the abdomen and the extrusion of 'tissue plug' through the cloaca, none of the specimens responded. The scarified specimens with gonads extending more than three-fourth of the body cavity showed an ova diameter of 0.515 mm to 0.630 mm only against the critical 0.650 to 0.700 mm egg diameter suggested by Sheadeh and Kuo (1972) prior to initiating maturation inducement. Unlike

the spawners collected from the sea-source, the mullets from the reservoir fishery were not in mature condition and therefore failed on inducement. The aggravated injuries leading to bacterial infection tended to delay the process further. Low pituitary hormone dose of 2 mullet pituitaries and 40 RU Synahorin, 2.5 to 3.0 mullet pituitaries and 10 to 35 RU Synahorin spawned 2 out of 4 migratory breeders of the species (Tang, 1964, Lia, 1969, cited by Sheadeh and Ellis, 1972). In the present experiments a dose of 3 to 16 mg/kg mullets pituitaries and 0.48 to 1.2 I.U./gm (16 to 40 mg/kg) H.C.G. did not produce results in 34 females during July and November to January. It therefore, appeared that complete recovery from injuries and a prolonged course of inducement with mullet pituitary glands combined with high dose H.C.G. in specimens with egg diameter of 0.650 mm and above might be able to produce results.

Mugil macrolepis : Altogether 267 females of the species were used in 22 maturation experiments. As seen the case of *M. cephalus*, the injury and mortality due to stress and strain during conditioning was a serious problem due to lack of ready to spawn fishes on which the threshold hormone injections could be used to induce the spawning. Treatment with potassium permanganate, with daily replenishment of 80% sea water in the conditioning tank healed the wounds within 12 to 15 days. Alikunhi *et al.* (1971) had spawned and reared larvae from wild spawners. In our study fully matured spawners were not available. Maturation experiments were conducted using mullet pituitary hormone extract and crude H.C.G. (Table-6).

Successful maturation leading to spawning showed that in one case two consecutive doses of pituitary hormone at 24 hours interval at the rate of 10 to 15 mg/kg body weight were adequate to mature the eggs having 0.455-0.525 mm to 0.700 -0.805 mm dia. in 6 days period, resulting in partial ovulation on the 5th and the 6th day and also stripping on the 7th day. The eggs were fully hydrated, each with single oil globule. After

every partial spawning, the abdomen enlarged again. In the second successful experiment, the maturation was complete in sixteen days, the ova of 0.455-0.525 mm dia, maturing to 0.595 dia. The spawning was natural. six doses of mullet pituitaries at the rate of 10 to 15 mg/kg body weight were administered. In the third successful experiment, spawning occurred on the 15th day in which the ova developed from 0.630 mm dia to 0.665 mm dia. receiving a pituitary dose of 10 to 15 mg/kg body weight six times. The experiments indicated that an initial ova diameter of 0.445-0.525 mm could be stimulated to attain full maturity and spawn naturally by using mullet pituitary glands. However, out of seven specimens having identical morphological and ova diameter characters, physically fit and free from injury, only three responded to pituitary hormone injections. All others, after showing initial signs of egg diameter improvement, regressed quickly, though, the experiments were conducted during the normal spawning season of the species. In other experiments, conducted out of season, no response was noticed even when the H.C.G. was administered with pituitary extract.

Mugil persia : The authors are not aware of any research or experiments to mature and spawn either wild or captive *M. Persia*. Thus the present account is the first report.

The species was found to attain ovarian maturity during December to March. However, no specimen collected had the ovary with oocytes in fully developed stage. Injuries and infections were serious problems encountered. Out of 108 fishes collected and conditioned, only 16 survived (Table 7). Three experiments were conducted with long surviving specimens of 330 mm size group having a weight range of 300-350 grams. In one of the experiments, during February to March, the ova diameter increased from 0.455 -0.525 mm to 0.805-0.875 mm in 37 days and 2.45 lakhs ova hydrated with single yolk globule were released spontaneously. In another experiment, during December to January, the ova diameter increased from 0.105 -0.175 mm to 0.140-

0.210 mm within 28 days but regressed thereafter even though the fish survived for 77 days. In the former experiment, mullet pituitary extract at the rate of 12 to 18 mg/kg body weight was administered at 48 hours interval, followed by one dose at the rate of 24 mg/kg body weight after 30 days, on observation of improvement in the egg diameter. Quick development of ova diameter was noticed following the third dose. However, in the second experiment, different higher doses of pituitary and H.C.G. combinations and pituitary alone, were tried with no substantial result. It is possible that the oocytes in the fish during the second experiment were not responding due to low dose of injected hormones. Kuo and Nash (1975) reported use of 50 to 77.6 I.U./gm body weight of H.C.G. whereas in our experiments, the doze was 0.432 I.U./gm only. Nevertheless, the experiments indicated the prospects of induced maturation and spawning of the fish in proper condition with pituitary hormone extract during the spawning season.

RURAL DEVELOPMENT

The coastal area of the Gulf of Kutch is inhabited by poor fishermen who do not have means to procure modern craft and tackle for fishing. In order to generate employment, to produce food and raise their nutritional level, and over and above to raise their living standards, coastal aquaculture can be considered as a profession for them. By suitably modifying and using the engineering skill, farms can be bunded up in the area. Adequate pumping arrangement for ensuring water supply and seed supply is necessary. But mullet culture alone might not be adequate to sustain the coast of the farm, because these fishes are only moderately priced so that the market value will not be adequate to generate income like many other fish varieties. However, of all the cultivable fishes, mullets are the most suitable fish available in this area. The quick growing fishes like *M. cephalus* are limited in supply. The seed potential of mullets in the Gulf of Kutch is not well-known except for an account

Table 7. Details of maturation and

Fish No.	Wt. of fish (gm)	Dose of injections							
		1		2		3		4	
		Dt.	mg/kg	Dt.	mg/kg	Dt.	mg/kg	Dt.	mg/kg
1	350	2/2/85	12-18	4/2	12-18	4/3	24.0 PE	—	—
2	350	2/2	..	..	..	..	..	—	—
5	300	12/12/ 86	24.0 HCG+PE (50%)	15/12/ 86	56.00 HCG+PE (70%+30%)	22/12	18.00 PE	28/12	18.00 PE

Table 8. Feasibility data on composite fish and prawn farming

Experience Data				Per Hectare				
Operation Area	Area (Hectare)	Harvest (kg)		Value (Rs)		Yield (kg)		
Prawn	Fish	Prawn	Fish	Prawn	Fish	Prawn	Fish	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
1060	1620	20000	80000	57980	21400	18.29	49.39	
Capital Expr. (Rs)				Recurring Expenditure (Rs)				
Farm	Pumps	Land	Loan Repay-ment + Interest	Land Rental	Farm mainte-nance + Insurance	Fishing Nets	Watch & Ward	Total
17	18	19	20	21	22	23	24	25
Nil (free of cost)	22000	Nil (Lease)	18500	100	5000	5000	3600	32200

spawning experiments on *M. parsia*

5		6		Observations	Remarks
Dt.	mg/kg	mg/kg	mg/kg		
—	—	—	—	Egg diameter progression; 2/2/85 : 0.455-0.525 mm 15/2/85 : 0.455-0.560 mm 4/3/85 : 0.560-0.630 mm 8/3/85 : 0.805-0.875 mm spawned spontaneously (survived 55 days)	Spawned PE : pituitary hormone extract of mullet pituitary
—	—	—	—	Egg diameter progression: 2/2 : 0.455-0.525 mm 15/2 regressed fully (survived 157 days)	HCG: crude human chorionic gonadotro- pin manufactured by INFAR (India) Ltd, Calcutta 700024
9/1	18.0 HCG+PE (80% +20%)	16/1	15.00 HCG	Egg diameter progression: 12/12 : 0.105-0.175 mm 15/12 : 0.105-0.175 mm 22/12 : 0.105-0.175 mm 28/12 : 0.105-0.175 mm 9/1 : 0.140-0.210 mm regressed thereafter (survived for 77 days)	HC by one mg= 30 I. U.

in the coastal area of Gulf of Kutch.

Per Hectare			Projected yield & value for 100 Hectare unit				
Revenue (Rs)		Total	Yield (kg)		Value (Rs)		Total value
Prawn	Fish		Prawn	Fish	Prawn	Fish	
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
547	132	679	1829	4930	54700	13200	67900
Net Revenue (Rs)		Individual earning per annum	Pre suppositions				
(cls. no 16-25)			(Rs)	<ol style="list-style-type: none"> (1) The land will be provided by the Govt. to a group of 4 Fishermen or Co-op. Society on nominal rent on long term basis. (2) Farm Construction cost will be fully born by the Govt. as a scarcity or drought relief expenditure under adequate technical and Engineering guidance. (3) 60-80 HP Vertical Lifting Pumps either on power or diesel operated will be installed by Govt. agencies and cost subsidised by 50% and remaining recovered with low interest of 6% per annum. (4) The harvested catch protected and farm insured against natural calamities or robberies. (5) Marketing of catch to be done through a non profit organisation like FFDA if desired by the Fishermen or decided by Govt. as policy towards loan recovery. 			
26		27					
35700		8925					

of seed availability in the Jodia village (Dave *et al.*, 1980) and in the Okhamandal taluka (Gopalakrishnan *et al.*, 1987). The percentage of the quick growing *M. cephalus* formed only 11.6% and other mullets 62.7%. Maturation and spawning by hypophysation technique presented in this paper indicated the state of the art, needing much to be done. Therefore, mixed farming appears to be a more viable proposition. With generous aid from the Government, by way of land leased on nominal rent, soft loans for capital cost, attractive subsidy, necessary technical and engineering assistance in pond construction, considering aquaculture as an essential crash programme related to drought relief, the fisherman of the area can be involved in aquaculture. Mixed farming of mullets and the local prawn species *Metapenaeus kutchensis* in large impounded farms provided with pumps for water supply, needing no inputs like manuring and feeding, can raise a low productive subsistence economy for the well being of the Kutch fishermen. The data presented in Table-8 is minisculed from our experience on such an effort with large reservoir areas of a salt works.

An annual revenue of Rs 68,000.00 can be generated from a 100 acre farm by a group of four fishermen. After paying for the loan repayment, interest on capital and watch and ward etc, adequate income could be found for all the members. It may be noted that though prawn constituted only 25% of the annual production, in terms of value, the contribution was 80.6%, which lends solid support for the economic feasibility of mixed farming. The high cost of pond construction due to the high tidal range and the inadequate availability of the quick growing fish seed are factors necessitating composite culture to raise the per hectare total production to economic level.

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