

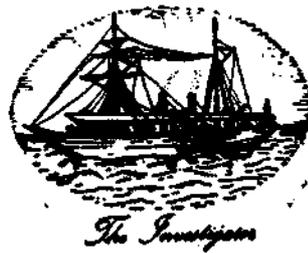
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SPAWNING GROUNDS OF THE MILKFISH AND SEASONAL ABUNDANCE OF THE FRY ALONG THE EAST AND SOUTHWEST COASTS OF INDIA

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ABSTRACT

The fish seed resources surveys conducted along the east and southwest coasts of India have shown the occurrence of fry and fingerlings of *Chanos chanos* in appreciable quantities during different months. An attempt is made to present a quantitative distribution of fry of the milkfish in space and time in the study area. The occurrence of spawners and fry along some stretches of the coast indicate the proximity of spawning grounds of the milkfish and these are delineated. The research programmes on controlled breeding of *Chanos* and its culture aspects underway at the Central Marine Fisheries Research Institute are also discussed.

INTRODUCTION

The milkfish *Chanos chanos* (Forsskal) is important in the economy and nutritional needs of some of the developing countries in the Indo-Pacific. It is the prime finfish species in coastal aquaculture operations in countries such as Philippines, Indonesia and Taiwan. Although it spawns in the sea and spends a good part of its life in the marine environment, it is highly adaptable and can be acclimated and cultured in situations ranging from fresh water to sea water. Interest in milkfish culture in India dates back to a few decades and credit goes to the Fisheries Department of the Govt. of erstwhile Madras State for attempting culture in different habitats including fresh water, in areas far distant from the coast. The early efforts of the Central Marine Fisheries Research Institute, in the late forties and fifties of culturing chanos in saline water ponds at Mandapam yielded useful results, but the work was discontinued. The revival of interest in coastal aquaculture has once again drawn attention to the importance of chanos as a good candidate species for culture in a wide variety of available habitats and under

farm conditions. The moot point has been whether we should go in a large way in developing techniques for induced breeding of chanos by adopting techniques which have been successfully tried in other countries such as Indonesia and Philippines or depend only on wild seed presently available in plenty along some parts of our coast.

The fry and fingerlings of chanos are available in the coastal waters, lagoons, estuaries, creeks and mangrove areas along the east coast of India and sporadically along the west coast in Gujarat, Goa and southwards. Adult chanos are taken in coastal gillnet fisheries in some areas and pertinent earlier references from Indian seas are as follows : Chacko, 1951, 1952 ; Panikkar *et al.*, 1952 ; Chacko *et al.*, 1953 ; Devanesan and Chidambaram, 1953 ; Chacko, 1955 ; Chacko and Mahadevan, 1956 ; Tampi, 1957 and Chacko and Thomas, 1962. Occurrence of milkfish fry have been cited by various authors from different localities (Chacko, 1942 ; Job and Chacko, 1947 ; Ganapati *et al.*, 1950 ; Panikkar *et al.*, 1952 ; Krishnamurthi, 1957 ; Alikunhi, 1957 ; Mahopatra, 1966 ; Evangeline, 1967 ; Saha *et al.*, 1967 ; Rao, 1969,

1970; Tampi, 1973; Rao and Gopalakrishnan, 1975; Basu and Pakrasi, 1976; Pati and Rao, 1978; Rao *et al.*, 1978; Sundararajan *et al.*, 1978; Dhawan and Gopinathan, 1978).

Despite this, there is practically no information on the spawning grounds and the seasonal abundance of the fry along the Indian coasts. In order to understand this problem better, a base line study all along east and south-west coasts of India was made on a time bound programme to understand the regional and seasonal abundance of the milkfish fry in the coastal waters. The survey along the coasts of Karnataka, Kerala and Tamil Nadu have been carried out on a comprehensive basis over a period of one year enabling quantifications for different seasons.

Aquaculture of milkfish is rapidly developing in many countries. At present the only source of the seed for the farmer is from the natural waters. This is often irregular and inadequate. To facilitate steady supply of seed to the farmer, natural and induced breeding of milkfish is necessary (Schmittou, 1975). Induced breeding and artificial propagation of milkfish from the wild and captive stock have been attempted by various scientists in a number of countries (Liao and Chang, 1976; Alikunhi, 1976; Nash and Kuo, 1976; Liao and Chen, 1979; Liao *et al.*, 1979; Vanstone *et al.*, 1976, 1977; Chaudhri *et al.*, 1977; Kuo *et al.*, 1979). The Central Marine Fisheries Research Institute is making an attempt to develop broodstock of milkfish for induced breeding experiments.

Biological data from fifteen adult milkfish from the Gulf of Mannar and Palk Bay area was also collected.

Based upon the availability of spawners and fry recorded in the present investigation and correlating the observations made by various workers from different localities during different

periods, possible spawning grounds along the Indian coasts have been identified.

STUDY AREA AND METHODS

Observations on the availability of milkfish fry were carried out in the coastal waters, bar mouth regions, estuaries, backwaters, lagoons and creeks from Ichapuram in the north east coast to Kasargod in the northern part of Kerala Coast. To facilitate collection and analysis simultaneously at all the centres of investigation, the sampling was carried out on zonal basis. Table 1 gives the area of study, investigation period, number of stations covered and the methods of sampling.

Milkfish spawners were collected from the Gulf of Mannar and Palk Bay area during 1978 and 1979 employing bottom set gill nets and drift nets. The specimens were analysed for biological data such as length, weight, sex, length and weight of gonad, GSI value, ova diameter and maturity stage.

The location of the possible spawning grounds in the Indian waters was attempted based on the availability of spawners and fry in the present investigations as well as observations made by earlier workers.

RESULTS

Occurrence of adult milkfish

In the present study the authors could gather some interesting information on the availability of milkfish spawners along the Palk Bay and Gulf of Mannar areas. Occurrence of adult milkfish is a regular phenomenon in the Theedai and Ariyankundu areas in the Palk Bay and Pudumadam and Appatheevu in the Gulf of Mannar. At Ariyankundu about 100 numbers of milkfish spawners are caught every year, the abundant period being January to April. They are in the size range of 1.0 to

1.5 metres in length and 7.00 to 15.00 kg in weight. The milkfish are caught by bottom set nylon gill nets with mesh size of 17 cm. In this region the sea forms a shallow bay with a stretch of coral sand rocks with a depth of 2 fathoms. A few numbers of milkfish spawners are caught during October-November

seines. During the present observations, on 4th November 1978 one female milkfish weighing 8 kg was obtained. Adult milkfish are caught from Appatheevu area during the month February-March and November-December every year.

TABLE 1

Area of investigation	Period of investigation	No. of stations covered	Method of sampling
<i>Zone I Andhra</i>			
Ichapuram	April-June	4	Velon screen stretched as drag-net usually operated by two men
Bellupude	May-June		
Kusumpuram	1976, 1977 & 1978		
<i>Zone II Madras</i>			
Arambakam in the north to Muthupet lagoon in the south	March 1976-March 1978	31	-do-
<i>Zone III Mandapam</i>			
Sundarapandipatnam in the north to Keelakkarai in the south	January 1976-June 1978	59	-do-
<i>Zone IV Tuticorin</i>			
Mayanikulam in the north to Kanyakumari in the south	January 1976-June 1978	65	-do-
<i>Zone V Vizhinjam</i>			
Kanayakumari in the south to Sakthikulankara in the north	March 1976-June 1978	39	-do-
<i>Zone VI Cochin</i>			
Neendakara in the south to Ponnani in the north	March 1976-June 1978	34	Quantitative estimation by sampling one cubic metre of water
<i>Zone VII Calicut</i>			
Ponnani in the south to Kasargod in the north	March 1976-March 1978	83	Velon screen stretched as drag-net usually operated by two men

every year from Theedai region and we also could collect a gravid female on 15th October 1978 weighing 8 kg. During the months of November and December a few adult milkfish are caught from Pudumadam area in shore

The authors could examine fifteen milkfish, the largest number ever analysed from the wild from any place in India. Fourteen fishes were caught from Ariyankundu and one from Appatheevu (Table 2).

TABLE 2. *Details of the adult milkfish analysed in the Palk Bay and Gulf of Mannar region*

(Gonad weight, GSI and Fecundity of adult milkfish)

Date of catch	Place	Total length (mm)	Body Weight (Kg)	Sex	Gonad weight (gm)	GSI	Ova diameter (mm)	Maturity stage according to P. R. S Thampi (1957)	Fecundity (Total No. of eggs in million)	No. of eggs/Kg body wt of fish in thousand
10-4-1978	Ariyankundu	1161	9.00	Female	909	10.10	0.67	III	—	—
10-4-1978	"	1131	7.00	Male	73	1.04	—	II	—	—
25-1-1979	"	1075	7.00	Male	20	0.29	—	I	—	—
29-1-1979	"	1290	15.00	Female	310	2.07	0.37	II	3.45	230
30-1-1979	"	1270	15.00	"	1257	8.85	0.80	III	5.32	355
7-2-1979	"	1175	9.50	"	147	1.55	0.42	II	1.42	150
14-2-1979	Appa Island (Kilakarai)	1290	14.50	"	355	2.45	0.29	II	3.52	243
17-2-1979	Ariyankundu	1055	7.50	Male	19	0.25	—	I	—	—
18-2-1979	"	1235	14.00	Female	235	1.68	0.32	II	1.78	127
22-2-1979	"	1340	13.50	"	330	2.44	0.37	II	3.42	253
22-2-1979	"	1152	11.40	"	920	8.07	0.71	III	3.57	313
23-2-1979	"	1294	14.00	"	1170	8.36	0.71	III	4.45	318
23-2-1979	"	1042	9.00	Male	275	3.06	—	III	—	—
23-2-1979	"	1145	10.50	Female	965	9.10	0.74	III	3.90	371
26-2-1979	"	1186	12.00	"	1090	9.08	0.76	III	3.09	257

The fishes were obtained during January, February and April. Of the 15, eleven were females measuring from 1145 to 1290 mm in total length and 9 to 15 kg in weight. The ovary length varied from 370.5 mm to 461.5 mm and weighed between 0.147 kg to 1.327 kg. The GSI value for the stage II of maturity fishes was between 1.55 and 2.45 and that of mature fishes (stage III) was between 8.36 and 10.10.

1.04 and 3.06 for the Ist, IInd and IIIrd stages of maturity respectively.

Occurrence of milkfish fry

The place of occurrence during the period of investigation, the total of milkfish fry in numbers and the size range of the fry collected during each month are presented in Table 3 and illustrated Fig. 1.

NO	DATE OF CAPTURE	PLACE OF CAPTURE	LENGTH mm	WEIGHT kg	SEX	GONAD		EGG dia. mm	MATURITY STAGE †
						LENGTH mm	WEIGHT kg		
1	10-4-1978	ARIYANKUNDU	1160.5	9.0	f	410.0	0.909	0.672	III
2	10-4-1978	..	1113.0	7.0	m	489.0	0.073	—	II
3	25-1-1979	..	1075.0	7.0	m	391.5	0.020	—	I
4	29-1-1979	..	1290.0	15.0	f	372.5	0.031	0.37	II
5	30-1-1979	..	1270.0	15.0	f	415.5	1.327	0.79	III
6	9-2-1979	..	1175.0	9.5	f	380.0	0.147	0.42	II
7	17-2-1979	..	1055.0	7.5	m	173.5	0.019	—	I
8	18-2-1979	..	1235.0	14.0	f	370.5	0.235	0.32	II
9	22-2-1979	..	1240.0	13.5	f	458.0	0.330	0.37	II
10	22-2-1979	..	1152.0	11.0	f	407.0	0.920	0.71	III
11	23-2-1979	..	1294.0	14.0	f	461.5	1.170	0.71	III
12	23-2-1979	..	1042.0	9.0	m	326.0	0.275	—	III
13	23-2-1979	..	1145.0	10.5	f	445.0	0.965	—	—
14	26-2-1979	..	1186.0	12.0	f	391.0	1.090	—	—
15	14-2-1979	APPATHEEVU (Near Keelakkurai)	1290.0	14.5	f	390.5	0.355	0.28	II

† After Temple, 1957

Fig. 1

The size of the males ranged from 1042 to 1113 mm in total length and 7 to 9 kg in weight. The length of testes varied from 173 mm to 489 mm and weighed between 0.019 kg to 0.275 kg. The GSI value was 0.25 to 0.29,

ANDHRA ZONE

Every year large quantities of milkfish fry are collected from Ichapuram area during April - June and two persons could easily collect 20,000 fry/day during the peak season.

TABLE 3. Details of milkfish fry collected from the east and southwest coasts of India
(Monthwise numbers and the size length in mm of the fry)

Place of occurrence	Months, Numbers and the size range of <i>Chanos</i> fry caught											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
<i>Andhra Zone</i>												
Ichapuram (Orissa)												
Bellupuda												
Kusumpuram												
Burjapalam												
<i>Madras Zone</i>												
Kovalam					249 (20-25)			2000 (75-80)	2280 (75-85)			
Thirumalairayan pattinam					3 (60-72)							
<i>Mandapam Zone</i>												
Seenisappa Dharga (backwaters)	1 (35)											
Pamban tidal pools		58 (31-56)		6101 (14-90)	375 (19-72)	88 (21-90)	88 (32-68)	12 (30-86)	—	27 (32-71)	9 (42-71)	64 (39-90)
Chinnappalam Creek	81 (38-52)	11 —	4 —	373 (30-95)	70 (35-90)	115 (37-97)	35	9 (31-61)	1 (41)	432 —	8 —	71 —
Pillaimadam	8 (43-48)											2 —
<i>Tuticorin Zone</i>												
Valinokam	1 (144)	1 (144)		1045 (10-41)								
Vaipar												2 (80-8)
Kallurani Creek											1 (17)	

Place of occurrence	Months, Number and the size range of <i>Chanos fry</i> caught											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Thottappally			2		2							
Tirukkunnappuzha			2									
Alum Kadavu				1 (13)								
Alleppey seaside			5 (9-14)									
Aruthungal								1 (14)				
Anthakaranazhi				4	4					1 (13)		
Chellanum			5 (11-14)									
Fort Cochin (barmouth)			2 (12-12.5)									
Narakkal					1	3 (6-9)						
Azhikode				1 (14)		1 (11.5)						
Kaipamangalam		2										
Nattika				1								
Ponnani			3 (6.5-13)		1							
Puthuponnani		2	2 (12-13)				1 (10.5)					
Chetwai			1									
<i>Calicut Zone</i>												
Chavai River			5 (16-20)									
Kadulundi Estuary						2 (36-42)						

Bellupude, Kusumpuram, Barjapalam and Bhimilipatnam waters of Andhra Pradesh appear to be very promising sources for milkfish fry collection. During the month of May and June as much as 988 to 2599 fry/hr could be collected from shallow areas of 30-45 cm water depth in the early hours of the day in drag-net operations. The average size of the fry collected was 12.0 mm.

MADRAS ZONE

During August and September 1976 young milkfish of 75-85 mm size were collected from Kovalam waters. However, during May 1979, 20-25 mm fry occurred in this area. From Thirumalarayanpatinam area 60-62 mm young milkfish were caught during December 1978.

MANDAPAM ZONE

Milkfish fry have been recorded from Seeni appa Dharga Backwaters, Pamban tidal pools, Chinnapalam creek and Pillaimadam areas. The monthly size range of the fry and young fish recorded during the period of investigation was January 35-48 mm, February 31-56 mm, March-April 14-95 mm, May 19-90 mm, June 21-97 mm, July 32-68 mm, August 30-86 mm, September 41 mm, October 32-71 mm, November 42-71 mm and December 39-90 mm.

TUTICORIN ZONE

Around Tuticorin and Kanyakumari areas chanos fry have been recorded from Valinokam, Kallurani Creek, Kallar Estuary, Palayakaya Estuary, Punnakayal Estuary, Arumuganeri Estuary, Tiruchendur Estuary, Thottarippu Creek, Wattakottai Creek, Wariyoor Creek and Leapuram Creek. The monthly size range of the fry and young fish occurring in this zone were as follows: January 12-83 mm, February 10-76 mm, March 11-22 mm, April 10-64 mm,

May 13-42 mm, June and July 21-129 mm, August 36-112 mm, September 143 mm, November 17 mm and December 80-83 mm.

VIZHINJAM ZONE

No milkfish has been recorded in between the waters of Kanyakumari in the south to Sakthikulankara in the north during the period of investigation.

COCHIN ZONE

Of the 33 Stations covered in this zone milkfish fry have been recorded from 16 stations *i.e.*, Ampalapuzha, Thottappally (seaside), Thrikkunnappuzha, Alumkadavu, Alleppey (sea side), Aruthingal, Anthakaran azhi, Chellannum, Fort Cochin (barmouth), Narakkal, Azhikode, Kaippamangalam, Nattika, Ponnani, Puthu ponnani and Chetwai. The monthly size range of the fry occurring was as follows in this area of investigation. January, February, March, 6.5 to 14 mm, April 13-14 mm, May-June 6-11.5 mm, July 10.5 mm, August 14 mm, September, October 13 mm.

CALICUT ZONE

Milkfish fry have been recorded from Chovai River during January 1976 and in the Kadalundi Estuary during June 1977. The size of the fry recorded was 16-20 mm and 36-42 mm in Chovai River and Kadalundi Estuary respectively.

OCCURRENCE OF EGGS, FRY AND ADULT MILKFISH FROM INDIAN WATERS— A REVIEW

Apart from the present investigations, the authors have attempted to present the details of the earlier works relating to adult milkfish,

occurrences of plankton eggs and fry from the Indian waters and this is shown in Fig. 2.

creek (Jacob and Krishnamurthy, 1948) and Kurusadai Island (Chacko, 1950).

Adult milkfish have been recorded from Indian waters along the Coromandal coast; Palk Bay and Gulf of Mannar and Malabar Coasts by earlier workers (Chacko, 1950, 1951, 1952; Chacko *et al.*, 1953; Devanesan and Chidambaram, 1953; Chacko, 1955; Chacko and Mahadevan, 1956; Tamni, 1957; Panikkar *et al.*, 1952; Chacko and Thomas, 1962).

The occurrence and abundance of the milkfish fry all along the Indian coasts have been cited by various workers during different time (Chacko, 1942; Job and Chacko, 1947; Ganapati *et al.*, 1950; Panikkar *et al.*, 1952; Alikunhi, 1957; Krishnamurthy, 1957; Mahopatra, 1966; Saha *et al.*, 1967a, 1967b; Evangeline, 1967; Rao, 1969, 1970; Tampi, 1973; Rao and

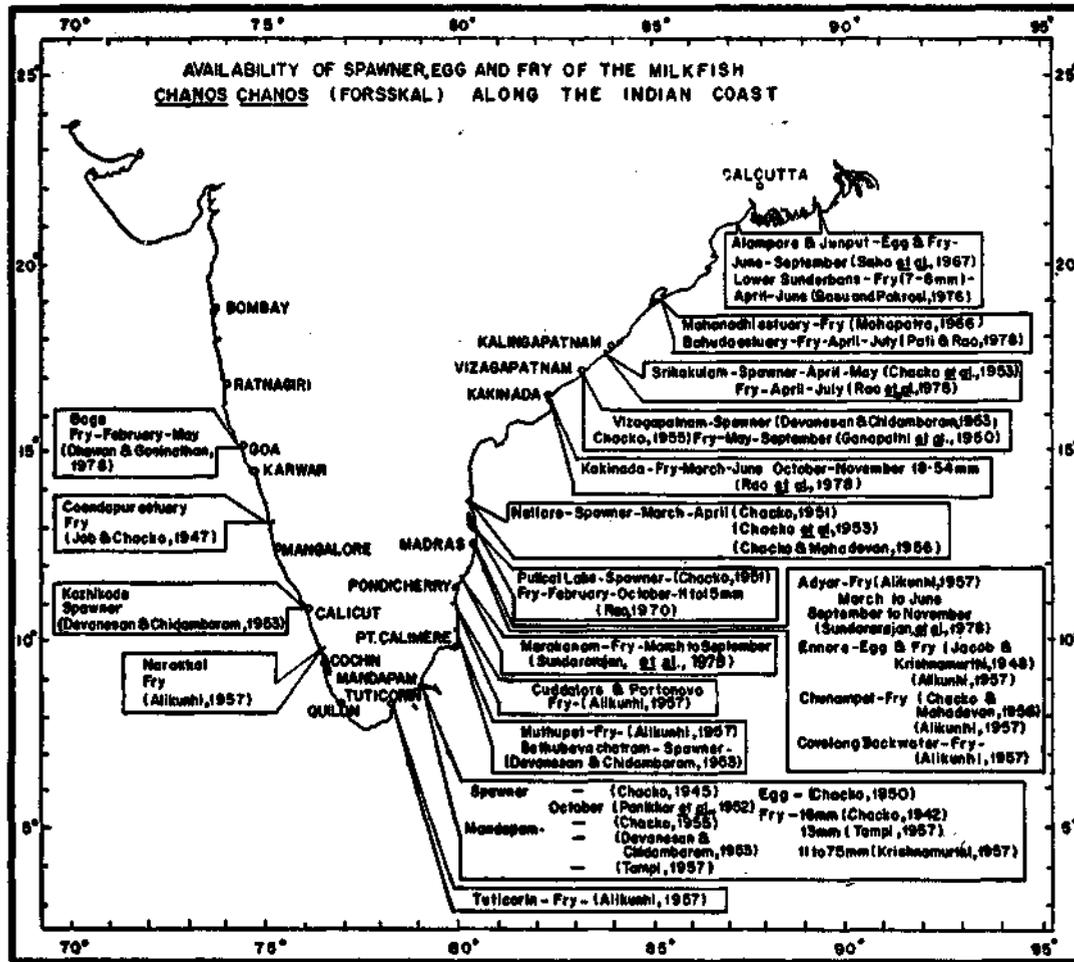


Fig. 2

Egg of *Chanos chanos* has been recorded from Junpat and Alampore coasts of West Bengal (Saha *et al.*, 1967a, 1967b); Ennore (Saha *et al.*, 1967a, 1967b); Gopalakrishanan 1975; Pati and Rao 1978; Rao *et al.*, 1978; Sundararajan *et al.*, 1978; Dhawan and Gopinathan, 1978).

SPAWNING GROUNDS OF THE MILKFISH

Along the East Coast

Based on the availability of Milkfish spawners and the fry in the present investigation and also the earlier findings of other workers on the occurrence of adult milkfish, eggs and fry all along the Indian coast, an attempt is made by the authors to map the possible spawning grounds along the Indian Coast (Fig. 3).

Availability of 7-8 mm larvae along the eastern bank of Hooghly Estuary (Basu and Pakrasi 1976) and the occurrence of uneyed ova to fry of 20 mm size along the Junput and Alampore coasts (Saha *et al.*, 1967a, 1967b) shows the possible existence of spawning grounds in the near by waters. A probable spawning ground may exist in waters around Mahanadi and Behude Estuaries and Ichapuram since small sized fry have been recorded in this area by earlier workers (Alikunhi, 1957; Mahopatra

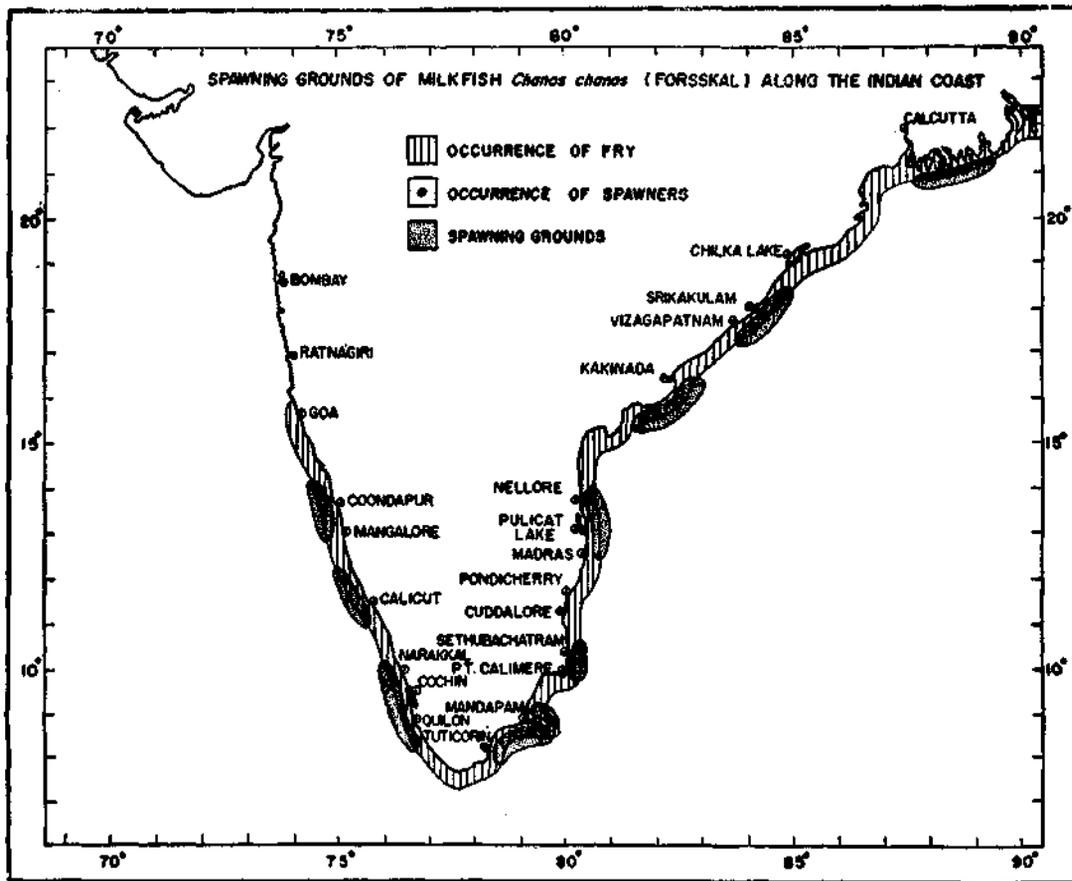


Fig. 3

The occurrence of mature fishes and fish in ripe running condition, eggs and small fry in the near shore and estuarine waters is indicative of milkfish spawning in the vicinity.

1966; Tampi, 1973; Pati and Rao, 1978) as well as in the present investigation.

Existence of potential spawning grounds along the Coramandal Coast is supported by the

occurrence of small sized fry from Bellupada, Kusumpuram, Burjapalam (12 mm) and Kovalam (Madras) waters (20-25mm). The earlier workers have also recorded spawners (Chacko 1951, 1952; Devanesan and Chidambaram, 1953; Chacko *et al.*, 1953; Chacko, 1955; and Chacko and Mahadevan, 1956), small sized fry (Ganapati *et al.*, 1950; Alikunhi, 1957; Evangeline, 1967; Rao, 1969; 1970; Tampi 1973; Rao and Gopalakrishnan, 1975; Rao *et al.*, 1978 and Sundararajan *et al.*, 1978) and egg (Jacob and Krishnamurthy, 1948) from the coastal waters, estuaries and creeks all along the Coromandal Coast which also supports the possible existence of spawning grounds in this region.

The appearance of milkfish spawners at Ariyankundu—Theedai region (Palk Bay), Pudumadam and Appatheevu (Gulf of Mannar) areas indicates the existence of potential spawning grounds along the Gulf of Mannar and Palk Bay region. This is also further supported by the occurrence of small sized fry at Seeniappa Dharga (35 mm) Pamban tidal pool (27 mm) Chinnappalam creek (30 mm) and Pillaimadam area (43 mm) in this region. In the past also appearance of adult spawners (Sablo) have been recorded (Panikkar *et al.*, 1952; Chacko, 1955; Tampi 1957; and Chacko and Thomas 1962).

Chacko (1950) could collect milkfish eggs from the waters around Kurusadai Island. Abundance of milkfish fry from Gulf of Mannar and Palk Bay area is cited by various authors (Chacko 1942; Job and Chacko 1947; Ganapati *et al.*, 1950; Panikkar *et al.*, 1952; Krishnamurthy 1957; Alikunhi 1967; and Tampi 1973). The results of the present investigation on the occurrence of the spawners and the abundance of the fry and the observations made by earlier workers clearly indicate the existence of spawning grounds in near shore waters of the Gulf of Mannar and in the Palk Bay.

Around Tuticorin and Kanyakumari, milkfish fry have been recorded in good numbers. The occurrence of small sized fry in Valinokam (10 mm), Kallurani Creek (17 mm), Kallar Estuary (11 mm), Palayakayal Estuary (10 mm), Punnakayal Estuary (14 mm), Arumuganeri Estuary (16 mm), Tiruchendur Estuary (14 mm), Thottarippu Creek (11 mm), Wattakottai Creek (12 mm), Wariyoor Creek (13 mm) and Leapuram Creek (12 mm) are clearly indicative of spawning of milkfish in inshore waters along a long stretch of the coast in the Gulf of Mannar. Earlier workers (Alikunhi, 1957; Tampi, 1973) have also indicated the abundance of milkfish fry in these waters.

Along the West Coast

Milkfish fry have been recorded from the Malabar Coast in the areas of Ampalapuzha (14 mm), Tottappalli, Thirukkunnappuzha, Alumkadavu (13 mm), Alleppey (9 mm), Aruthingal (14 mm), Anthakaran Azhi (13 mm), Chellanum (14 mm), Fort Cochin (12 mm), Narakkal (6 mm) Azhikode (11.5 mm), Kaippamangalam, Nattika, Ponnani (6.5 mm), Puthuponnani (10.5 mm) and Chetwai. The occurrence of small sized fry in these places clearly indicates the existence of spawning grounds in the coastal stretches in this area. This is further supported by the records of milkfish fry from along this coast by earlier workers (Alikunhi, 1957; Tampi, 1973).

Milkfish fry have also been recorded from the Kadalundi Estuary (36-42 mm) and Chovai River (16-20 mm) during the present study. Devanesan and Chidambaram (1953) examined a spawner from Kozhikode. Abundance of the fry in the Kozhikode waters was earlier reported by Alikunhi (1957) and Tampi (1973). The investigations in the present study and the observation made by earlier workers clearly indicate the existence of a spawning ground along Kozhikode waters. Inshore waters around Coondapur Estuary along Karnataka Coast may also be a spawning ground of the

milkfish if we look upon the abundance of the milkfish fry as reported by earlier workers (Job and Chacko 1947; Alikunhi, 1957; Tampi, 1973; Dhawan and Gopinathan, 1978). Recently Dhawan and Gopinathan (1978) have identified Baga Estuary (20 kms north of Panaji) as a potential ground for milkfish fry collection thereby indicating the possibility of the species spawning in the adjacent inshore waters.

SEASONAL ABUNDANCE OF MILKFISH FRY

East Coast

The seasonal and regional abundance of the milkfish fry all along the East and South west coasts of India is illustrated in Fig. 2.

It is found from Ichapuram area where every year thousands of milkfish fry have been collected during the period April-June, and two persons could collect as many as 20,000 fry/day during the peak season. In Bellupuda, Kusumpuram and Burjapalom areas also milkfish fry is abundant during May and June. Along Madras Coast, milkfish fry could be collected during May, August and September. However, since the seed encountered during August and September were fairly large size (60-85 mm), it becomes very difficult to be sure of any peak season for fry during August-September in this region. From the analysis of the data it is evident that milkfish seed is abundant during April-June along the Coramandal Coast.

Milkfish fry have been collected from the Gulf of Mannar and Palk Bay area almost throughout the year. Occurrence of minimum sized fry during January (31 mm), February (35 mm), April (14 mm), May (19 mm), June (21 mm), July (32 mm), August (31 mm), September (41 mm), October (32 mm), November (42 mm) and December (38 mm) indicates the availability of the fry throughout the year

with a primary peak period of abundance during April-June and a secondary peak during October to December.

It is also interesting to note the occurrence of spawning population of milkfish in this region during the months of January, April and October to December. It confirms the occurrence of two spawning seasons in these waters.

In and around waters of Tuticorin and Kanyakumari, milkfish fry was recorded during nine months, (except in June, September and October). Further the availability of the small sized fry during January (19 mm), February (10 mm), March (11 mm), April (10 mm), May (13 mm), July (21 mm), August (36 mm) and November (17 mm) indicates the prolonged seasonal abundance of the occurrence of fry in this area. The peak period of collection was found to be March-April.

Along the South West Coast

During the present investigation the authors could collect milkfish fry from the Kerala coastal waters during the months of February to August and October. No fry was encountered during November, December and January. Occurrence of small sized fry during February, March (9 mm), April (13 mm), May, June (6 mm), July (10.5 mm), August (14 mm) and October (13 mm) indicates the prolonged seasonal availability of the fry along Kerala coast. The peak period was March-June.

DISCUSSION

The location of the spawning grounds of the milkfish based on the availability of spawners/eggs/fry have been attempted by various earlier workers. While occurrence of spawners and planktonic eggs are a direct evidence of the existence of a spawning ground in the vicinity the occurrence of fry can also give some indication about the spawning ground. Schuster (1960) opined that the abundance of the fry can

be used to assess the spawning ground more or less accurately giving credit period of one or two weeks which the fry need to travel from the spawning ground to the coast. Delsman (1929) quoted by Schuster (1960) feels that the larvae occurring in the sea should of 10 days old and the larvae may be living for few days in the inshore waters before entering the lagoons, creeks and backwaters. Ten day old larvae have to cover a distance of three kilometres a day from the hatching place to the collection site and hence the fry collected from the wild may be two or three weeks old. This was recently confirmed by Liao *et al.* (1979) while tracing the larval development by artificial propagation technique, where the larvae reached 5.9 to 7.5 mm on 10th day; 6.4 to 11.8 mm on the 14-15th day and 13.5 to 16.5 mm on 21st day.

Reijntjes (1926) as quoted by Schuster (1960) reports milkfish spawning above submerged coral reefs along the south east coast of Indonesia. Delsman (1929) collected 14 nos. of ova from Java Seas at a distance of 15.17 nautical miles from the shore in clear waters of less than 40 m in depth where the salinity was between 32.0‰ and 32.8‰. Sanio *et al.* (1954) based on the abundance of the fry in Indonesian waters concluded that milkfish spawn close to the coast in clear waters of 20-30 fathoms depth. Recently Martosudarma *et al.* (1976) could observe adult milkfish in Karimum Java waters off the north coast of Indonesia from sandy and coraline bottom of 2-10 m depth indicating the existence of spawning ground in the near shore waters.

Herre and Mendoza (1929) and Blanco and Villuloiz (1939) were also of the opinion that milkfish spawns close to the coast not far from the sheltered bays, coves and gulfs in Philippine waters. Senta *et al.* (1976) and Schimittou (1977) suggested a spawning ground in the Philippines adjacent to Batbatan Island off the coast of Antique Province, Panay Island. This was later confirmed by Vanstone *et al.*

(1977), Kumagai *et al.* (1978) and Lia *et al.* (1979) from where they could get milkfish spawners for controlled breeding experiments.

In India Chacko (1945 and 1949) while investigating food of chanos had noted specimens of above 100 cms in size from the Gulf of Mannar region and later during 1950 recorded milkfish egg from waters around Krusadai Island and from this it was inferred that milkfish spawns close to the coast. Jacob and Krishnamurthy (1948) also noted milkfish ova from Ennore Estuary. Chacko (1951 and 1952) and Chacko *et al.* (1953) observed congregation of gravid milkfish of 3-5' (90-150 cm) in length and 24-30 pounds (10.9 to 13.63 kg) in weight in shoals of 60-80 in number during the new-moon periods of March, April and May and expressed the view that milkfish, though an oceanic form spawns in selected places in the inshore regions of the coastal water preferably close to backwaters and estuaries where there is a slight reduction in salinity which will facilitate drifting of eggs and larval stages into the backwaters and tidal pools. Panikker *et al.* (1952) recorded an adult milkfish from the Gulf of Mannar, which had a total length of 1240 mm with spent ovaries. Devanesan and Chidambaram (1953) could analyse adult milkfish from the coastal waters of Vizakhapatnam, Pulicat Lake, Sethubavachatram (Tanjore District); Pamban and Krusadai Island in the Gulf of Mannar and Kozhikode waters along the Kerala Coast indicating the possible existence of spawning grounds in these areas. Tampi (1957) also could analyse few adult milkfish from the Mandapam area.

Schuster (1960) while reviewing the earlier findings on the abundance of milkfish fry in the Indo-Pacific region says, 'No fry or juveniles is recorded from the shore areas affected by efflux of silt by great delta forming river like Indus, Ganges, Irravady, Mekong and other rivers of Sumatra, Java, Borneo and the fry collection end abruptly when sandy beaches change to muddy, indicating

that milkfish spawn in clear shallow waters or sandy or coral bottom'. But, Saha *et al.*, (1967a 1967b) could collect uneyed ova to 2 cm fry from Junput and Alampore coasts of West Bengal. Basu and Pakrasi (1976) collected milkfish larvae of 7-8 mm size from the Eastern Bank of Hooghly indicating the existence of a spawning ground in the adjacent sea. Hence, we have reservation about the requirement of a sandy or coral bottom for milkfish spawning.

Ganapati *et al.*, (1950) tabulated the milkfish fry abundance along parts of the south Indian coasts; however, it is not clear whether the size of the fry was taken into account by these authors. Their work gives the impression that the peak period of abundance of fry starts during April in Pamban area and June in Northern districts of Coramondal Coast. This made Tampi (1957) to suspect the movements of fry with the water currents from South to North along the east and west coasts of India. However, in the later findings of various authors as well as in the present investigation, the same sized fry have been encountered during the same period of April-June at several centres along the Indian coasts. Based on spawning behaviour of chanos, Tampi (1957) suspected the existence of two races of milkfish along the Indian Coast, spawning in two different seasons. This has not been substantiated.

It is concluded from the present investigation that the best season for the milkfish fry collection in India is April-June along Coramondal coast; April-June and October-November in the Gulf of Mannar and Palk Bay areas; January-April along the Tirunelveli and Kanyakumari Coast and March-June along the Kerala Coast.

CONTROLLED BREEDING AND CULTURE OF MILKFISH

At present milkfish culture in India mainly depends upon the natural seed availability

which is seasonal, highly irregular and subjected to many environmental factors. Hence, it is necessary to develop a dependable source of seed for intensive culture operations. Realising the importance of this Scientists in various countries are trying to develop techniques of induced maturation and artificial propagation of captive stock and wild milkfish. Limited success has been achieved in this line in recent years. (Chaudhuri *et al.*, 1977, Vanstone *et al.*, 1977, Kuo *et al.*, 1979, Liao *et al.*, 1979.) The Central Marine Fisheries Research Institute has recently taken up an active programme on priority basis for developing techniques for artificial propagation of milkfish. The technical programme includes (a) Collection, transportation and conditioning of milkfish spawners from the wild (b) Development of a viable captive brood stock (c) Developing techniques for induced maturation and artificial propagation through hypophysation (d) Developing a suitable hatchery technology including food for larvae, fry and fingerlings and (e) Monoculture and poly culture of milkfish.

Earlier workers have revealed that milkfish, seldom attain maturity in captivity (Alikunhi, 1976; Liao and Chang, 1976) and even seven to eight years old pond cultured milkfish were found to be sexually immature. However, spawners collected from the wild had given promising results in Philippines, in the artificial propagation experiments. The team working on the breeding of milkfish in the Institute is trying to develop the technique of artificial propagation by collecting spawners from the wild presently at Mandapam and development of brood stock is also under progress at Narakkal, Cochin.

The availability of spawners in the wild is highly seasonal. Fixed gear such as the Otoshi-ami or similar traps as used in the Philippines may have to be tried for obtaining spawners in good condition. Our experience on the transportation of fish caught in gill net has not been good, although on more than one

occasion they have been kept alive for a few days. We feel there is considerable stress from capturing and handling from the gill nets.

Future programme of the Institute will also attempt induced maturation of the stock presently reared in captivity.

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