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Food and Feeding Ecology of *Mugil cephalus* from Krishnapatnam and Mypadu Coasts of Nellore District, Andhra Pradesh, India

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A B S T R A C T

The flathead grey mullet, *Mugil cephalus*, is a mullet of the genus Mugil in the family Mugilidae, Kingdom: Animalia; Class: Actinopterygii; and Order: Mugiliformes; is a brackish water fish also can thrive well in fresh water and marine waters. Study on the food and feeding habits of *Mugil cephalus* was conducted between April, 2016 to March, 2017 at monthly intervals from Krishnapatnam and Mypadu coasts of Nellore District, Andhra Pradesh. Observation of feeding habits indicated flathead grey mullet as omnivorous feeder. Although sand and mud comprises highest amount (35.52% from Krishnapatnam and 37.953% from Mypadu coast), diatoms and algal matter forms the basic food of the fish. High feeding intensity in *M. cephalus* was observed during May, 2016 and March, 2017 in Krishnapatnam and Mypadu coasts respectively. Maximum number of empty stomachs observed during February, 2017 and December, 2016 from Krishnapatnam and Mypadu coasts respectively.The values of gastro-somatic index in the present study ranged 1.56–4.15 (males - 1.72 to 3.08; females - 1.56 to 4.15) from Krishnapatnam coast and 1.99–3.89 (males - 1.99 to 3.14; females - 2.02 to 3.89) from Mypadu coast.

Introduction

Grey mullets contribute significantly to the fishery of tropical and subtropical regions of the world (Wijeyaratne and Costa, 1986; Koutrakis *et al.*, 1994). Subsequently, they are a major source of protein requirements of the peoples of many countries (ICLARM, 1980). Food is the basic source of energy required to perform the physiological activities such as growth and reproduction for survival and to maintain homeostasis. Fishes acquire food

from the surrounding aquatic environment and are highly adopted in their food and feeding habits, utilizing most of the readily available food. The different feeding habits of adults and juveniles of the grey mullet make them not competitive for food in an ecosystem.

Mullets comprise one of the most important fisheries in coastal waters of India. The flathead grey mullet is one of the common mullet found along the coasts of Mypadu and Krishnapatnam (Kp) in Nellore District and provides livelihood for the local fishermen. However information on the feeding habits of grey mullet from these coasts is not available, present study deals with the food and feeding habits.

Materials and Methods

A total of 720 specimen of *Mugil cephalus* were collected from Krishnapatnam (Kp) (14.29 ^{0} N, 80.12 ^{0} E) and Mypadu (14.51^{0} N, 80.17 ^{0} E) Coasts of Nellore district, Andhra Pradesh, randomly from April, 2016 to March, 2017 at monthly intervals. Data was collected from fishermen and several visits were made to these areas during the study period to collect accurate information regarding mullet fisheries. Based on the fish catch, species richness and fish abundance data was generated for each site respectively. *Mugil cephalus* comprised the total length ranging from 115 - 320 mm with the weight ranging from 10 – 320 g from Kp coast and at Mypadu Coast the total length ranging from 120 - 360 mm with the weight ranging from 12 - 340 g from Mypadu Coast. Fishes were observed for total length, total weight, gut weight, feeding intensity and stomach contents.

Gastro-somatic Index (GaSI)

Specimens were dissected ventrally and noted the condition of stomach with reference to the distension sex and stage of maturity of the specimen recorded. Volume of the stomach was determined by displacement method and the Gastro Somatic Index (GSI) was calculated by the formula.

$$GaSI = \frac{\text{Weight of the stomach}}{\text{Total weight of the fish}} \times 100$$

The stomach contents were emptied in a clean Petri-dish and different types of food items present in it were identified. The percentage occurrences of the different food items were visually estimated, under electron microscope.

Feeding intensity

By eye estimation, stomach were allotted certain points such as gorged, full stomach, ¾ full, ½ full, ¼ full, trace and empty. Fishes with gorged and full stomach were considered as actively fed, ¾ and ½ as moderately fed, ¼ and trace as poorly fed as adapted by Nair (1980).

Index of preponderence

The index of preponderance adopted here is expressed as:

$$Ii = \frac{\%Vi \times \%Oi}{\Sigma (\%Vi \times \%Oi)} \times 100$$

Where, Vi and Oi are the volume and occurrence index respectively of food items presented in percentage. For the examination of occurrence, total number of occurrence of all the items were scaled down to give the percentage composition of the diet i.e. if food I occurs Ni times then percentage of occurrence of food i may be given as

$$\%\ Oi = \frac{Ni}{\Sigma\ Ni} \times 100$$

Where % Oi = percentage occurrence of food

Attempts were made to identify the food item upto species level wherever possible.

Results and Discussion

Index of preponderence

Among the various types of food items found in the mullet stomach, Sand and mud accounted high in the mullet stomach shows the benthic feeding habit of the fish with 32.52% from Kp and 37.95% from Mypadu coasts.

Diatoms were the major food items comprising 34.1775% from Kp coast and 30.8167% from Mypadu coast followed by decayed organic matter (20.035% from Kp and 19.0592 from Mypadu coast).

Composition of food items

The different types of food items found in the stomach of mullet show the euryphagic/ omnivorous feeding habit. Various categories of food items observed in the mullet gut are diatoms, algae, molluscans, decayed organic matter, sand & mud and miscellaneous matter included insects, fish scales, eggs, etc. The species of diatoms observed in the gut contents of *M. cephalus* were *Cyclotella sp*., *Gyrosigma* sp., *Fragilaria sp., Nitzschia sp. Pinnularia sp.* and *Navicula* sp.

The algal species observed in the gut contents of *M.cephalus* were *Spirogyra* sp., *Chlorella* sp. and *Chaetophora* sp. belongs to Chlorophyceae; *Spirulina* sp. and *Oscillatoria* sp. belongs to Myxophyceae. Miscellaneous matter included the insects, fish scales, eggs, etc. Month-wise percentage composition of gut contents in *M. cephalus* from both the coasts was presented in the tables 1 and 2 (Fig. 1 and 2).

Feeding intensity in relation to month

Feeding intensity in relation to month in *M.cephalus* from Kp coast

In the present investigation, on an average, 13.73% of fishes examined were highly fed, 38.52% moderately fed, 38.11% low fed and 9.63% empty from Kp coast (Table 3). Moderate type of feeding intensity was observed low in the month of December (15.55%). Maximum percent of empty stomachs were observed in February (13.73%). Maximum percentage of moderately fed stomachs were encountered during July (56.41%) followed by June (52.77%) (Fig. 3).

Feeding intensity in relation to month in *M.cephalus* from Mypadu coast

In the present investigation, on an average, 14.29% of the fishes examined were highly fed, 41.67% moderately fed, 36.11% low fed and 7.95% empty (Table 4). Maximum percent of moderately fed stomachs were encountered during August (46.66%) followed by July (43.59%).

Maximum percent of highly fed stomachs were encountered in March (21.06%) and empty stomachs in the month of December (12.24%) (Fig. 4).

Gastro somatic index (GaSI)

Month-wise GaSI of *M.cephalus* from Kp coast

The values of GaSI (male and Female) is presented in Table 5. The highest GaSI values in males were estimated for the month of July (3.08) followed by February, 2017 (2.96) and June, 2016 (2.73) and the lowest value was estimated during August (1.72) followed by November (2.05) (Fig. 5).

Table.1 Month-wise percentage composition of gut contents in *M. cephalus* from Kp coast

Month	Diatoms	Algae	Mollusks	Detritus	Sand and mud	Misc. food items	Unidentified food mass
April,2016	39.82	10.26	0.24	12.88	34.27	0.12	2.41
May	36.52	7.62	0.86	20.00	31.24	0.54	3.22
June	23.26	9.11	0.57	23.97	39.48	0.60	3.01
July	24.96	12.48	0.95	20.67	39.32	0.48	1.14
Aug	48.46	13.06	0.72	18.06	17.12	0.51	2.07
Sept	32.48	11.67	0.63	12.89	39.19	0.33	2.81
Oct	39.62	10.48	0.20	26.74	21.28	0.43	1.25
Nov	28.87	9.67	0.36	31.48	26.54	0.82	2.26
Dec	29.38	9.82	0.59	19.56	37.97	0.76	1.92
Jan,2017	31.87	10.16	0.44	21.40	34.40	0.51	1.22
Feb	33.41	9.81	0.37	19.51	35.39	0.42	1.09
March	41.48	8.72	0.41	13.26	34.04	0.27	1.82

Table.2 Month-wise percentage composition of gut contents in *M. cephalus* from Mypadu coast

Month	Diatoms	Algae	Molluscs	Detritus	Sand & mud	Misc. food items	Unidentified food mass
April, 2016	35.27	9.96	0.29	13.06	38.50	0.34	2.58
May	38.48	10.04	0.38	19.87	27.36	0.27	3.60
June	34.24	8.96	0.35	18.68	35.04	0.42	2.31
July	29.51	11.42	0.52	20.00	36.15	0.51	1.89
Aug	26.47	9.48	0.32	19.43	42.42	0.23	1.65
Sept	31.01	8.36	0.43	17.68	40.35	0.33	1.84
Oct	26.67	8.28	0.35	18.04	44.72	0.29	1.65
Nov	24.88	7.32	0.66	24.20	41.11	0.34	1.49
Dec	27.32	8.91	0.36	21.60	40.16	0.38	1.27
Jan, 2017	29.48	9.01	0.42	20.72	38.54	0.27	1.56
Feb	31.69	10.22	0.37	19.80	35.81	0.39	1.72
March	34.78	11.63	0.26	15.63	35.27	0.42	2.01

Table.3 Month-wise percentage of feeding intensity in *M.cephalus* from Kp coast

Month	No. of Specimen	High feeding		Moderate feeding		Low feeding		Empty
		Gorged	Full	3/4 th full	1/2 full	1/4th full	Trace	
April,2016	32	-	18.75	15.63	25.00	18.75	12.50	9.37
May	31	-	19.35	12.90	25.82	19.35	12.90	9.68
June	36	-	16.67	22.22	30.55	16.67	13.89	-
July	39	-	17.95	25.64	30.77	15.38	10.26	-
Aug	42	-	11.90	14.29	19.05	26.19	16.67	11.90
Sept	40	-	15.00	12.50	20.00	25.00	17.50	10.00
Oct	38	-	13.16	21.06	28.95	18.42	10.53	7.88
Nov	44	-	11.36	13.65	18.18	27.27	18.18	11.36
Dec	45	-	13.33	13.33	17.78	26.67	15.56	13.33
Jan, 2017	49	-	10.20	14.29	18.37	26.53	18.37	12.24
Feb	51	-	9.80	13.72	21.57	25.49	15.69	13.73
March	41	-	12.20	14.63	19.51	24.39	17.07	12.20

Table.4 Month-wise percentage of feeding intensity in *M. cephalus* from Mypadu coast

Month	No. of Specimen	High feeding		Moderate feeding		Low feeding		Empty
		Gorged	Full	3/4 th full	1/2 full	1/4th full	Trace	
April,2016	37	-	13.51	16.22	24.32	21.62	16.22	8.11
May	32	-	12.50	15.63	25.00	21.87	15.63	9.37
June	41	-	17.07	19.51	24.40	21.95	17.07	-
July	39	-	12.82	20.51	23.08	17.95	17.95	7.69
Aug	45	-	15.56	24.44	22.22	20.00	11.11	6.67
Sept	47	-	14.89	19.15	23.40	21.28	12.77	8.51
Oct	36	-	11.11	16.67	25.00	22.22	16.67	8.33
Nov	50	-	14.00	18.00	22.00	20.00	14.00	12.00
Dec	49	-	12.24	18.37	20.41	22.45	14.29	12.24
Jan,2017	43	-	13.95	20.93	18.60	25.58	11.63	9.31
Feb	47	-	12.77	21.28	21.28	19.14	14.90	10.65
March	38	-	21.06	15.79	23.68	23.68	15.79	-

Table.5 Month-wise gastro-somatic index of *M.cephalus* from Kp coast

Month	No. of male	No. of female	Gastro-somatic index (GaSI)	
			Male	Female
April, 2016	21	16	2.32	2.45
May	22	14	2.61	3.62
June	21	14	2.73	4.13
July	28	14	3.00	4.15
Aug	24	15	1.72	1.63
Sept	23	21	2.46	3.20
Oct	22	18	2.63	2.57
Nov	27	23	2.05	2.26
Dec	20	18	2.19	2.09
Jan, 2017	24	19	2.30	2.28
Feb	24	16	2.96	2.80
March	21	17	2.71	3.33

Table.6 Month-wise gastro-somatic index of *M. cephalus* from Mypadu coast

Month	No. of male	No. of female	Gastro-somatic index (GaSI)	
			Male	Female
April,2016	22	13	2.52	2.91
May	23	12	2.30	3.26
June	20	20	2.48	3.89
July	23	18	3.14	3.82
Aug	23	21	1.99	2.02
Sept	25	26	2.21	3.11
Oct	26	18	2.06	2.51
Nov	20	19	2.25	2.46
Dec	21	17	2.61	2.54
Jan,2017	24	16	2.78	2.09
Feb	22	14	2.61	2.59
March	21	13	2.86	3.58

Fig.1 Composition of food items in *M. cephalus* from Kp coast

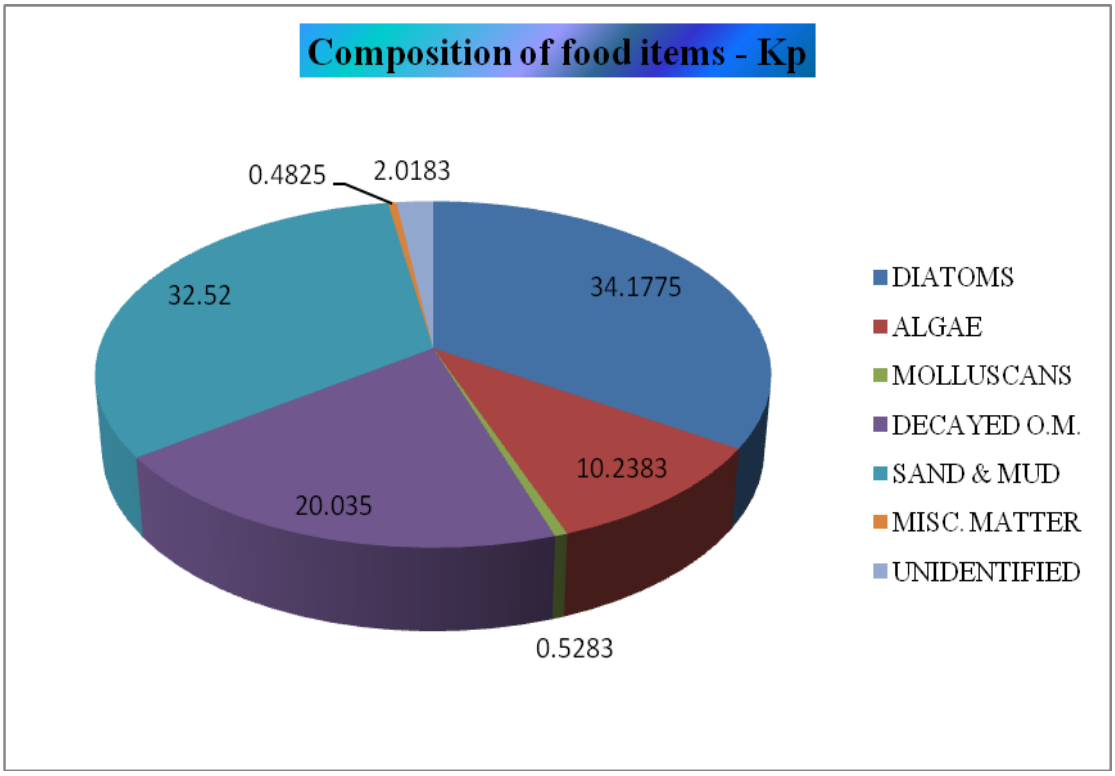


Fig.2 Composition of gut contents in *M. cephalus* from Mypadu coast

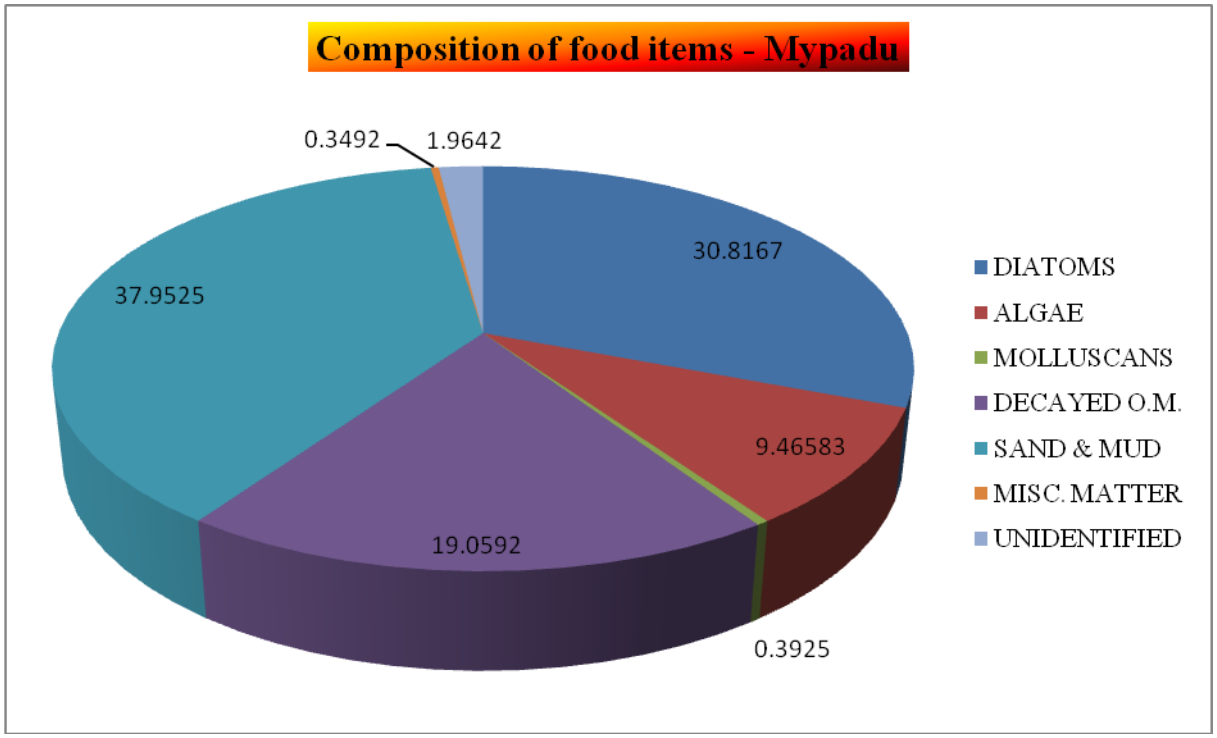


Fig.3 Month-wise feeding intensity of *M. cephalus* from Kp coast

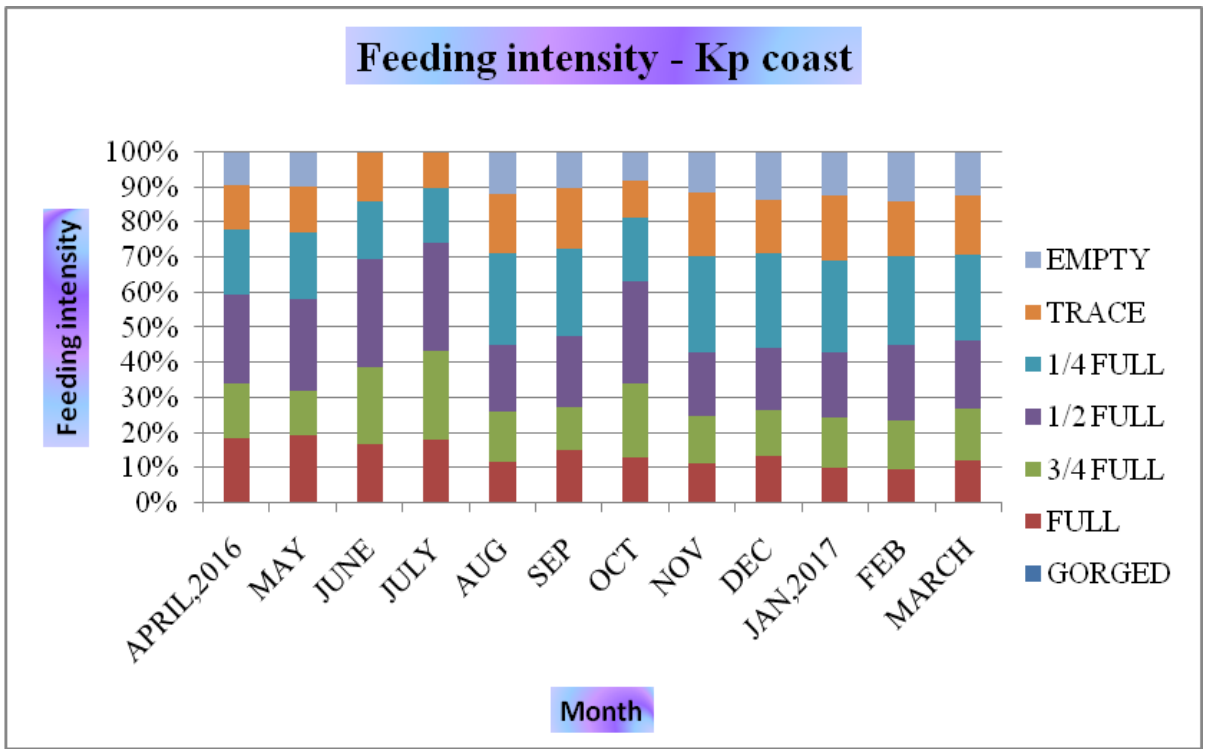


Fig.4 Month-wise feeding intensity of *M. cephalus* from Mypadu coast

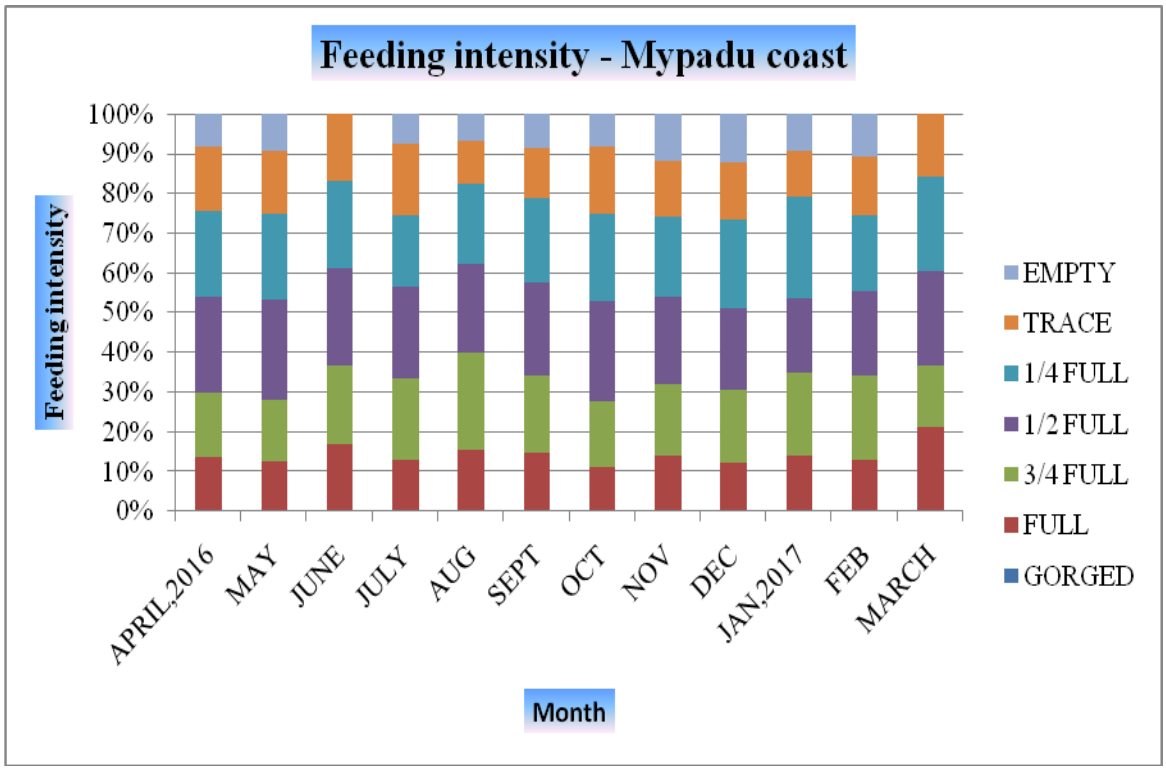


Fig.5 Month-wise percentage of GaSI of *M. cephalus* from Kp coast

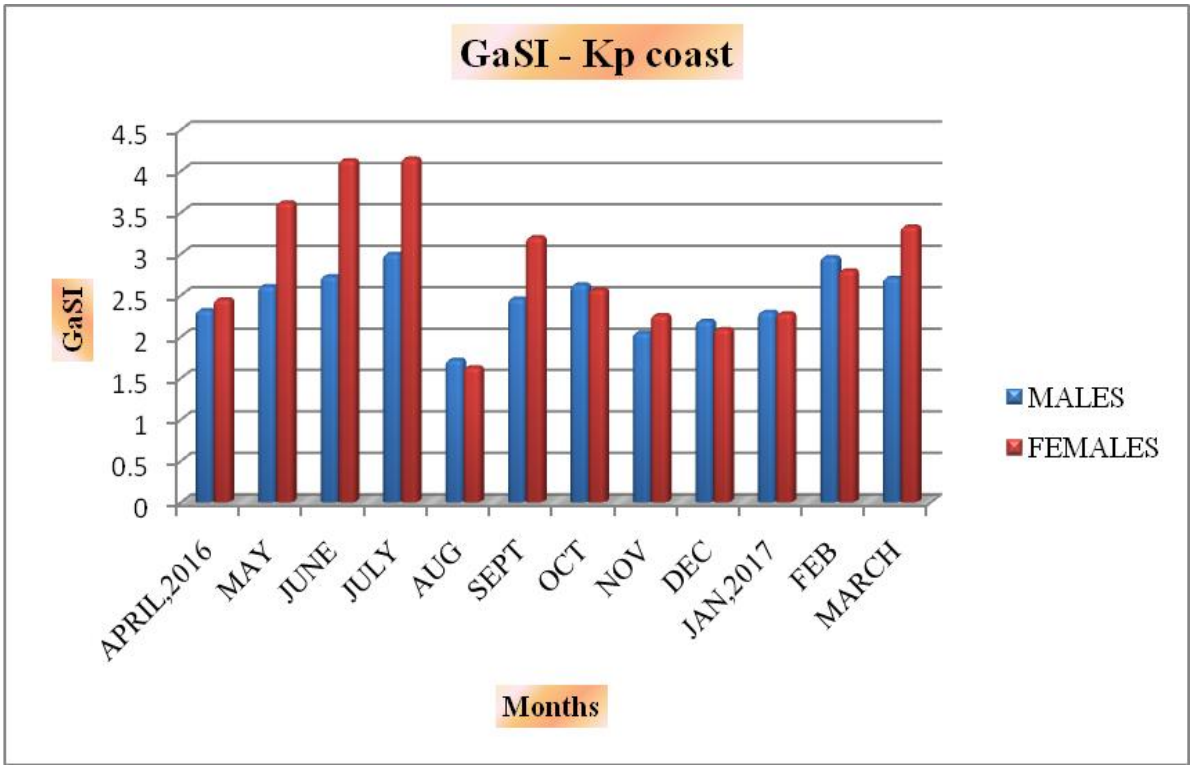


Fig.6 Month-wise percentage of GaSI of *M. cephalus* from Mypadu coast

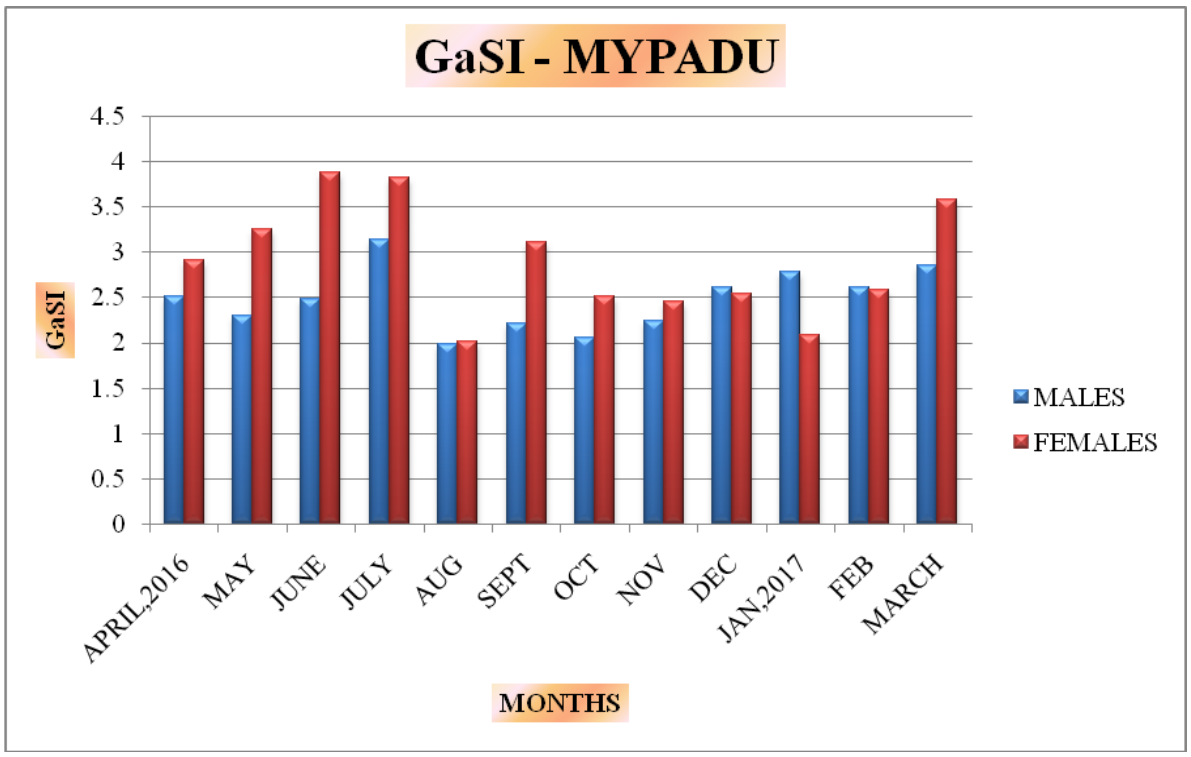


Plate.1 Anatomical view of alimentary canal of *M.cephalus*

Plate.2 Alimentary canal of *M.cephalus*

Plate.3 (Gizzard) Stomach of *M.cephalus*

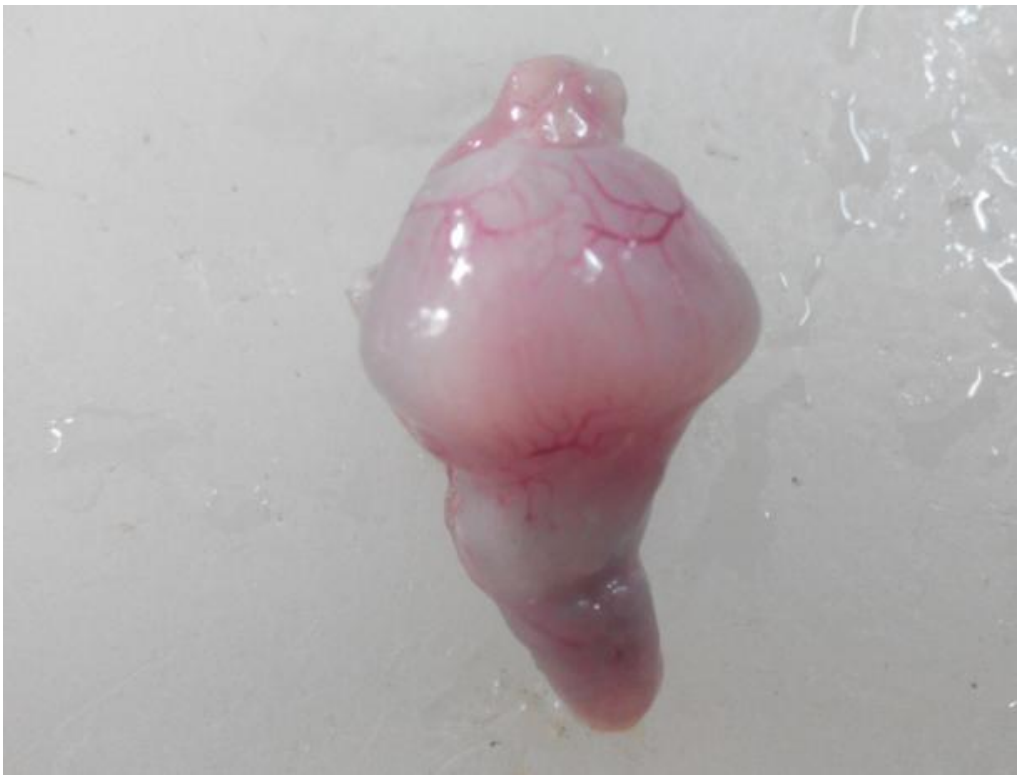


Plate.4 Microscopic observation of gut contents (A gastropod shell)

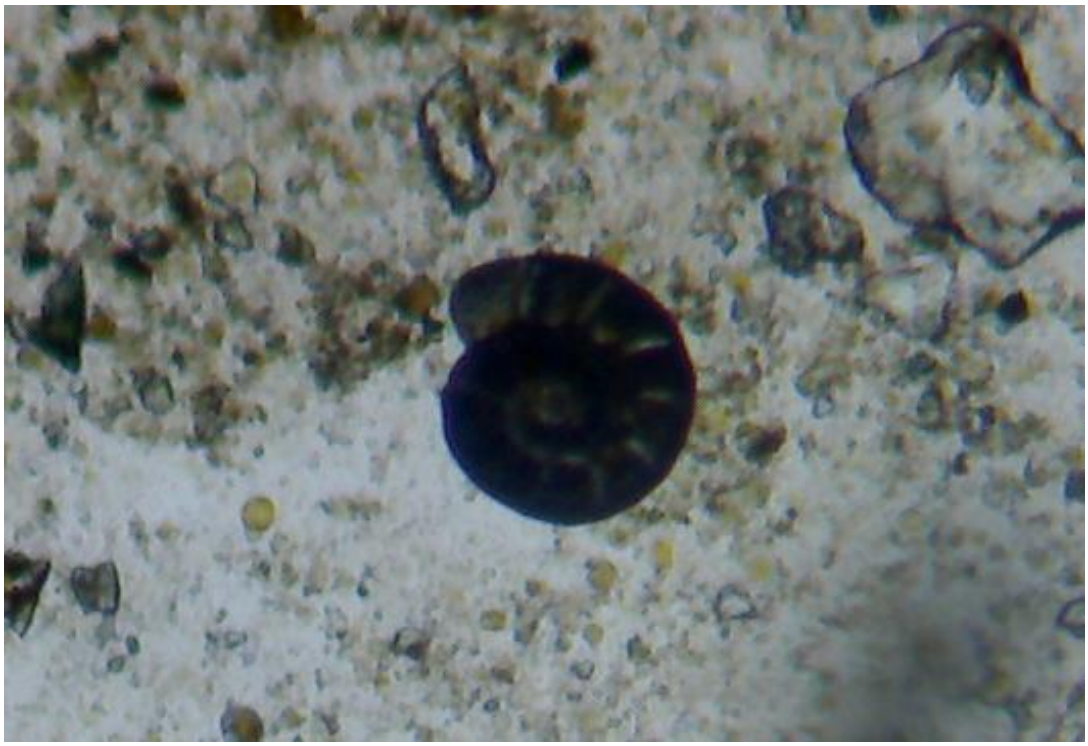


Plate.5 Microscopic observation of gut contents (Fish scale)

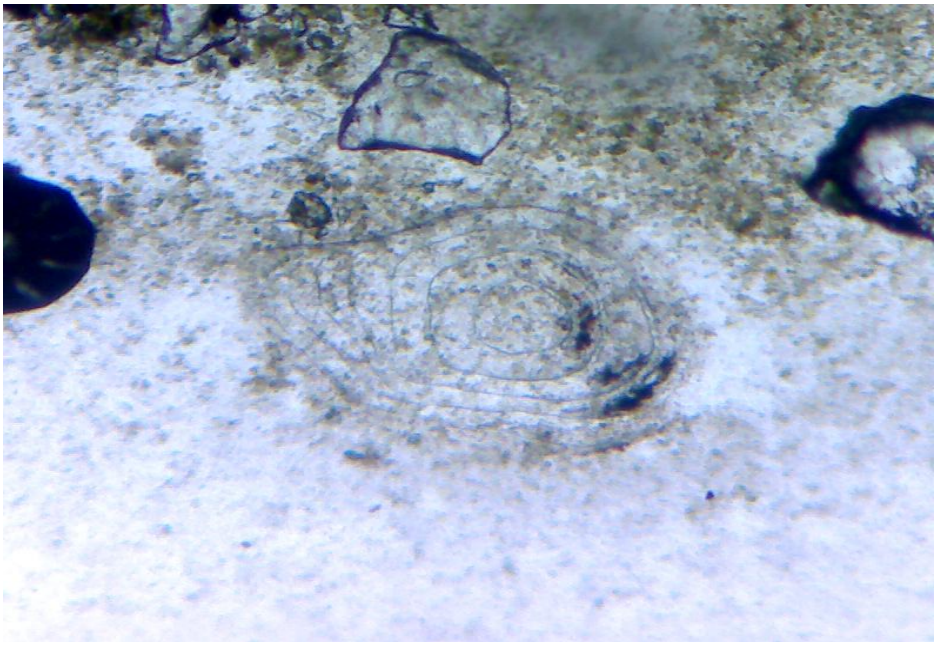
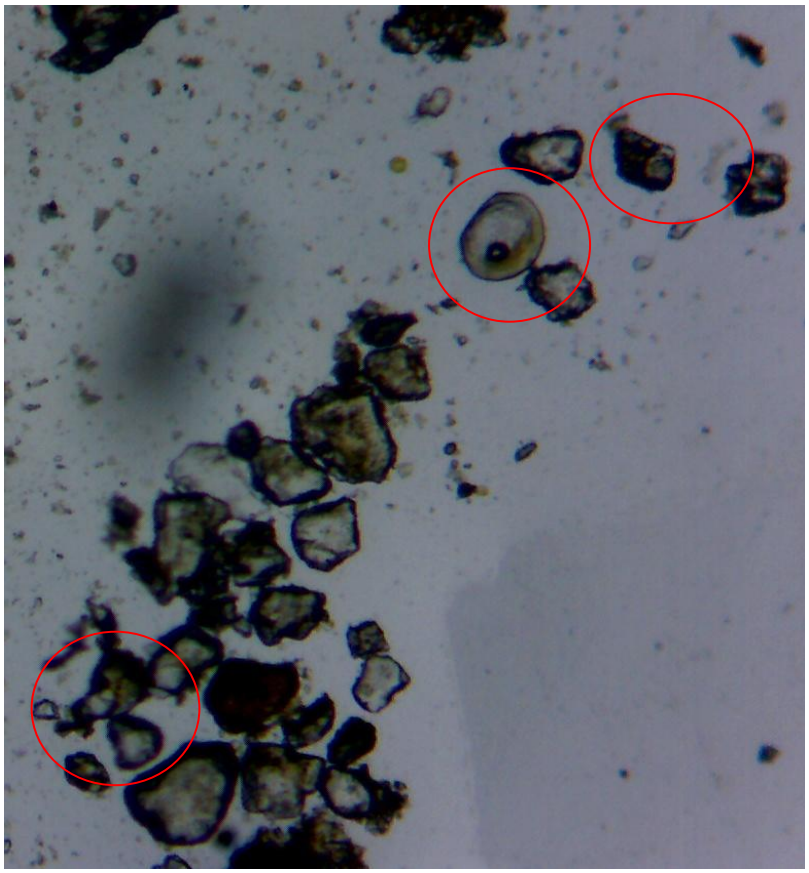


Plate.6 Microscopic observation of gut contents (bivalve spat and gastropods)



In case of female, the highest GaSI value were found in the month of July (4.15) followed by June (4.13) and May (3.62) and the lowest values were found during August (1.56) followed by December (2.09) and November (2.26).

Month-wise GaSI of *M. cephalus* from Mypadu coast

The values of GaSI (male and Female) are presented in Table 6. In males, highest GaSI values were estimated for the month of July, 2016 (3.14) followed by March, 2017 (2.86) and January, 2017 (2.78) and lowest were estimated during August (1.99) followed by October (2.06). In case of female, the highest GaSI values were found in the month of June (3.89) followed by July (3.82) and the lowest values were found during August (2.02) followed by January, 2017 (2.09) (Fig. 6).

Food items

Mullets are primarily benthic feeders. The presence of large quantities of the dead and decaying organic matter settled at the bottom layers of the habitat and algae consisting of Bacillariophyceae, Chlorophyceae and Myxophyceae along with other benthic organisms in the guts of adults, they were considered as benthic feeders by earlier workers (Egusa, 1950; Yashouv and Ben Schacher, 1970; De Silva and Wijeyaratyne, 1977). In the present investigation, *M. cephalus* is found to be omnivorous feeding habit from both Kp and Mypadu coasts feeding mainly on diatoms, algal matter, macrophytes, molluscs, detritus, sand and mud, fish scales, eggs and insects. *M. cephalus* fed majorly on diatoms (34.178%), sand and mud (32.52%), decayed organic matter (O.M.) (20.035%) and algal matter (10.238%) from Kp coast. Various items majorly comprised in the diet of *M. cephalus* from Mypadu coast are sand and mud (37.953%), diatoms (30.817%), decayed organic matter (19.059%) and algal matter (9.466%). Earlier studies indicated that the diet of young mullets consisted predominantly on the diatoms (Bachllariophyceae) followed by the green algae and blue-green algae (De Silva and Wijeyaratyne, 1977; Wells, 1984; Sanchez Rueda, 2002). In the present study Diatoms were the major food item of *M. cephalus* from both Kp (34.178%) and Mypadu coasts (30.817%).

Mullets generally feed by grazing on submerged rock and plant surface and the function of inorganic particles of the diet is suggested in the grinding activity to degrade plant cell walls in the pyloric portion (Thomson, 1966; Blaber, 1976). Sand and mud comprised the major portion in the gut contents (35.52% from Kp and 37.953% from Mypadu coasts) of the fishes. Similar results were obtained by Kurma Rao and Ramesh Babu (2013) in the study of *M. cephalus* from East Coast of India. They observed the gut contents of juveniles and adults consist of 30% of sand, silt and mud. Quantitative estimations by Anila Kumary (2015) from Kayamkulam estuary showed that diatoms are the most abundant among the total gut contents contributing to about 58.44% followed by decayed organic matter (15.02%) and sand and mud (6.69%). Wells (1984) noticed the *M. cephalus* ingested a number of gastropods in River Waikato and Lake Waahi. However, in the present study gastropods were ingested in lesser quantities.

Feeding intensity

Analysis of degrees of fullness of stomach indicated maximum percent of fishes were found as moderately fed. Moderately fed stomachs were encountered low during December, 2016 (15.55%) from Kp coast. Maximum percent of moderately fed stomachs were encountered during August,

2016 (46.66%) followed by July, 2016 (43.59%) and empty stomachs in the month of December, 2016 (12.24%) from Mypadu coast. From both the coasts fishes were found relatively low fed in the month of December, 2016. Maximum percent of fishes with full stomachs were encountered in the month of May, 2016 (19.35%) and April, 2016 (18.75%) from Kp coast; March, 2017 (21.06%) and June, 2016 (17.07%) from Mypadu coast. Kurma Rao and Ramesh Babu (2013) observed the guts were maximum in the months of October, 2010 followed by August, 2011 and September, 2010 and the volumes of gut contents were also relatively higher in the months of February, 2011 and March, 2011 shown that there were two peaks in a year i.e., one during February, 2011 and March, 2011 and another during August to October period. No regular pattern was observed in the intensity of feeding by Anila Kumary (2015) from Kayamkulam estuary. She observed an increase in the proportion of actively fed fishes from September, 2010 with its maximum during October, 2010. Monsoon season is characterized by the maximum number of poorly fed fishes (74.63%) while the maximum of actively fed fishes (28.21%) were during the post monsoon period. Tandel *et al.,* (1986) concluded that August, 1981 to December, 1981 can be attributed to the low feeding intensity in *M. cephalus* from Thana creek which was similar to the present study. A.R. Joadder and Hossain (2008) found the highest percent of emptiness of stomachs in November (1998, 1999) for *Liza parsia* from Bangladesh.

Gastro-somatic index (GaSI)

The values of gastro-somatic index in the present study ranged from 1.56 to 4.15 (males - 1.72 to 3.08; females - 1.56 to 4.15) from Kp coast and 1.99 to 3.89 (males - 1.99 to 3.14; females - 2.02 to 3.89) from Mypadu coast. Values of gastro-somatic index showed higher feeding intensity during July, 2016 (3.08) and February, 2017 (2.96) while lower feeding intensity was observed during August, 2016 (1.72) and November, 2016 (2.05) for males and in females higher feeding intensity was observed during July, 2016 (4.15) and June, 2016 (4.13) with the lower feeding intensity in August, 2016 (1.56) from Kp coast. Whereas in Mypadu coast, highest GaSI encountered for males in July, 2016 (3.14) and March, 2017 (2.86) and lowest in August, 2016 (1.99) followed by October, 2016 (2.06). In females highest GSI found in June, 2016 (3.89) and July, 2016 (3.82) and lowest in August, 2016 (2.02). In a study by D.S. Pramanik and S.S. Mohanty (2016), GaSI% in *M. cephalus* was observed to be 5.904 in summer, 4.957 in winter, 6.600 in monsoon and 6.526 in post monsoon which are higher than the present study. In their study lower value was observed in winter. But in present study, low GaSI values were observed during monsoon season. This may be due to the disturbance of benthic ecosystem due to rainfall and inflow of freshwaters.

References

Anila Kumary, K.S., 2015. Food and feeding habits of *Mugil cephalus* of Kayamkulam estuary, Kerala. International Journal of Aquaculture. 5 (6): 1-3.

Blaber, S.J.M., 1976. The food and feeding ecology of Mugilidae in the St. Lucia lake system. Biol. J. Linn. Soc. 8: 267–277.

De Silva, S.S. and Wijeyaratne, M.J.S., 1977. Studies on the biology of young grey mullet, *Mugil cephalus* L. II. Food and Feeding. Aquaculture. 12 (2): 157-167.

Egusa, S., 1950. Some notes on the feeding habit of the young of *Mugil cephalus* L. Bull. Jap. Soc. Sci. Fish. 5 (11): 715-720.

International Centre for Living Aquatic Resources Management (ICLARM), 1980. Introduction. In Review of breeding and propagation techniques for grey mullet, *Mugil cephalus* L. (C.E. Nash and Z.H. Shehadeh, ed.). ICLARM Studies and Reviews, pp. 3: 87.

Joadder, A.R. and Hossain, M.D., 2008. Convenient pattern of food and feeding habit of *Liza parsia* (Hamilton) (Mugiliformies: Mugilidae). Journal of Fisheries International. 3 (3): 61-64.

Koutrakis, E.T., Sinis A.I. and Economidis P.S., 1994. Seasonal occurrence, abundance and size distribution of grey mullet fry (Pisces: Mugilidae) in the Porto-Lagos lagoon and Lake Vistonis (Aegaean Sea, Greece). Bamidgeh. 46 (4): 182–196.

Kurma Rao and Ramesh Babu, 2013. Studies on food and feeding habits of *Mugil Cephalus* (Linnaeus, 1758) East Coast off Andhra Pradesh, India. SENRA Academic Publishers, British Columbia. 7 (3): 2499-2504.

Nair, K. V. S., 1980. Food and feeding habits of *Johnieops sina* (Cuvier). Indian J. Fish. 27 (1 & 2): 24-34.

Pramanik, D.S. and Mohanty, S.S., 2016. Length-weight relationship and biology of some common edible fish species at Chandipur, Bay of Bengal, Odisha. International Journal of Fisheries and Aquatic Studies. 4 (1): 335-340.

Sanchez Rueda, P., 2002. Stomach content analysis of *Mugil cephalus* and *Mugil curema* (Mugiliformes: Mugillidae) with emphasis an diatoms in the Tamiahua Lagoon, Mexico. Revista Biologia Tropical. 50 (1): 245-252.

Tandel, S.S., Athalye, R.P. and Gokhale, K.S., 1986. On the seasonal changes in food habit of *Mugil cephalus* of the Thana creek. Indian Journal of Fisheries. 33 (3): 270-276.

Thomson, J.M., 1966. The grey mullets. Oceanogr. Mar. Biol. Ann. Rev. 4: 301–355.

Wells, R.D.S., 1984. The food of the grey mullet (*Mugil cephalus* L.) in Lake Waahi and the Waikato river at Huntly. New Zealand Journal of Marine and Freshwater Research. 18: 13-19.

Wijeyaratne, M. J. S. and Costa, H. H., 1986. On the biology of an estuarine population of grey mullet, *Mugil cephalus* L. in Negambo lagoon, Sri Lanka. Cybium. 10: 351–363.

Yashouv, A. and Ben-Shachar, A., 1970. Breeding and growth of Mugilidae II. Feeding experiments under laboratory conditions with *Mugil cephalus* L. and *Mugil capito* Cuvier. Bamidgeh. 19: 50-66.

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