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STUDIES ON THE BIOLOGY OF YOUNG GREY MULLET, *Mugil cephalus* L.

by

S.S. DE SILVA AND M.J.S. WIJEYARATNE
Department of Zoology, Vidyalankara Campus
University of Sri Lanka, Kelaniya
Sri Lanka

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, ROME, ITALY
ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE, ROME, ITALIE
ORGANIZACION DE LAS NACIONES UNIDAS PARA LA AGRICULTURA Y LA ALIMENTACION, ROMA, ITALIA

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CONTENTS

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Abstract

This is the second of a series of investigations into the biology of young grey mullet, *Mugil cephalus* L., and the feasibility of its culture in the coastal, estuarine waters of Sri Lanka. The food and feeding habits of mullet, 20-55 mm in length, from the coastal Negombo Lagoon (7°10'N latitude; 79°50'E longitude) were studied from November 1974 to October 1975.

The feeding intensity, estimated as the number of food organisms per feeding individual followed a seasonal pattern with the intensity increasing from April onward and reaching a peak during June-August. Over 80 percent of the individuals were found to feed throughout the year. The diet consisted of 18 genera of diatoms, 8 genera of green algae, some desmids, 6 genera of blue-green algae and 8 other food groups. No sand or detritus was found to occur in fish below 25 mm in length, and the percentage of occurrence of detritus and/or sand particles increased with increase in body length. Quantitatively and qualitatively, diatoms were the most predominant food items, accounting for more than 50 percent of the total diet. Although only one genus of Xanthophyceae was found to occur in the diet its contribution was significant.

M. cephalus was found to show diurnal periodicity in feeding activity; peaks of activity occurred at dawn and around mid-day and were unrelated to the state of the tide.

The significance of the nature of the diet and the occurrence of two peaks of feeding activity within a 24-hour period is evaluated in the light of known knowledge of the food and feeding behaviour of *M. cephalus* at various stages of growth, and the possibilities of polyculture with other herbivorous species is discussed briefly.

1. INTRODUCTION

Most studies of the food and feeding habits of fishes, from varying habitats, have shown that those of any one species differ in time and space and at different stages of growth (Hardy, 1924; Savage, 1937; De Silva, 1973; Staples, 1975), thereby emphasizing the need to study in more detail the food habits of a species. The food and feeding habits of at least five members of the family Mugilidae have been studied, and that of Mugil cephalus, in particular, by Luther (1962), Suzuki (1965) and Odum (1968 and 1970). The present paper presents the results of investigations carried out in Sri Lanka from November 1974 to October 1975. It is the second of a series (see De Silva and Perera, 1976) of detailed investigations into the biology of the grey mullet, M. cephalus, and the feasibility of its culture in the coastal, estuarine waters of Sri Lanka.

2. MATERIALS AND METHODS

Young grey mullet (range in total length, 20-55 mm) were caught with a cast or push net at three sampling stations, 1.5, 3.5 and 5 km respectively, from the sea-mouth in the brackishwater coastal Negombo Lagoon (7°10'N latitude; 79°50'E longitude). Sampling was carried out semi-monthly between 10.00 and 11.00 hours. The fish were put in ice immediately, brought to the laboratory, and frozen until further examination. A minimum number of 150 fish were analysed monthly.

Each fish was measured to the nearest mm and the stomach contents identified to the generic level, as far as possible. After identification, the contents of any one sample were pooled and the numbers present from each major taxonomic group (e.g., diatoms, blue-green algae, green algae, etc.) were estimated using a wet sampling technique. The relative importance of the major group of food items was calculated relative to the total number of organisms per feeding individual. In April, July and August 1975, fish were captured at 3-hour intervals to study diurnal feeding activity. The method of analyses of these samples was that of De Silva (1973).

3. RESULTS

3.1 Feeding Intensity and Dietary Composition

Monthly variation in feeding intensity, measured by the number of food organisms per feeding individual, during the study period, is shown in Fig. 1. It is seen from this that the feeding intensity increases from April onward reaching a peak during the June-August period and thereafter shows a downward trend. Over 80 percent of the individuals were found to feed every month and the variations in the percentage of feeding individuals generally followed that of feeding intensity, except perhaps in February.

The monthly dietary composition from November 1974 to October 1975 is summarized in Table I. A total of 18 genera of diatoms (Bacillariophyceae), 8 genera of green algae plus some desmids (Chlorophyceae), 6 genera of blue-green algae (Cyanophyceae) and 8 other food groups were found to consitute the diet of young grey mullet. Foraminiferans and other animal material were found to occur only in the diet of fish obtained from the station closest to the sea-mouth and were taken, as indicated by Table I and Fig. 5, rather rarely and sparsely. The importance of diatoms and the other three major taxonomic groups in the diet of young mullet is further shown in Figs. 2 and 3, which give the percentage of occurrence of each major taxonomic group in feeding individuals month by month and for the full length of the investigation, respectively. The minimum length of mullet in which sand particles and/or detritus found in the stomach was 25 mm. The percentage of individuals which had detritus or sand in the stomach in each cm-group was calculated; the relationship which is shown in Fig. 4 appears to be a part of a sigmoid curve, i.e., with increasing length there is an increase in the occurrence of sand or detritus in the food.

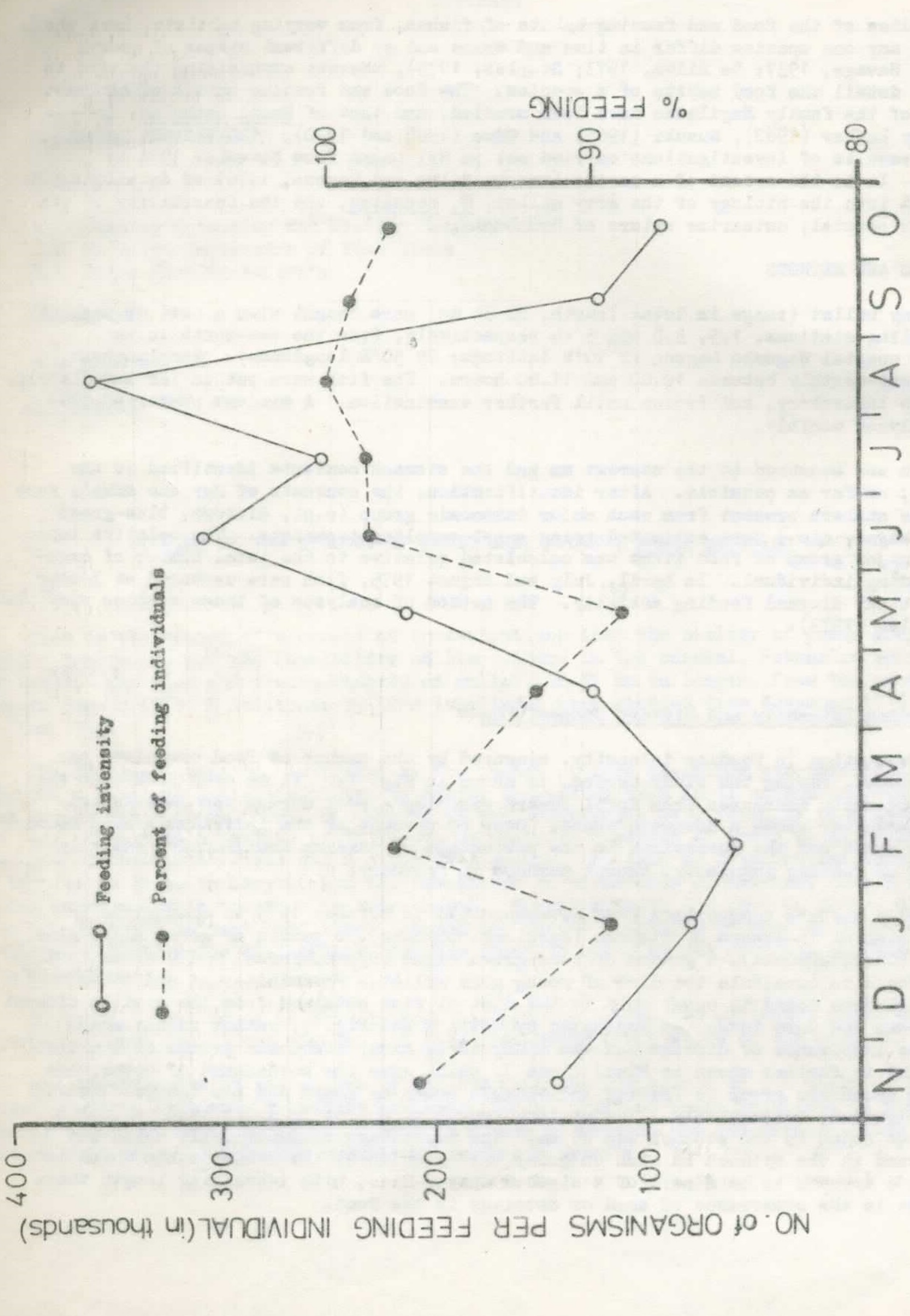

Fig. 1 Monthly changes in feeding intensity and the percentage of occurrence of feeding individuals

Table I

Detailed dietary composition of juvenile mullet

Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
DIATOMS (Bacillariophyceae)												
Achnanthes	(+) [1]		(+)	(+)		(+)	(+)	(+)				(+)
Amphiprora			+	+		+	+	+	+	+	+	(+)
Anomoeoneis	+ [2]		+	+		+	+	+	+	+	+	+
Biddulphia			(+)									
Cocconeis	+		+	+		+	+	+	+	+	+	+
Cymatopleura	(+)		(+)	(+)		(+)	(+)	+	(+)	+	+	(+)
Cymbella	+		+	+		+	+	+		+	+	+
Diatoma	+		(+)				+	+	+	+	+	+
Diploneis	(+)		+	+			+	(+)	+	(+)	+	(+)
Eunotia	+		+	+		+	(+)			(+)		
Frustulia			+	(+)		+	+	(+)	(+)		(+)	+
Gomphorema	+		+	+		+	+	+	+	+	(+)	+
Mastogloia			(+)				+	+	+	+	+	+
Navicula	+		+	+		+	+	+	+	+	+	+
Pinnularia	+		+	+		+	+	+	+	+	+	+
Pleurosigma	+		+	+		+	(+)	+	+	+	+	+
Stauroneis			+	+		+	+	+	+	(+)	(+)	+
Tabellaria			(+)	+		(+)	(+)	(+)	(+)	(+)	(+)	(+)
GREEN ALGAE (Chlorophyceae)												
Chlorococcum	+			(+)								+
Desmids	(+)											
Microspora	+		+	+		(+)	(+)	(+)				(+)
Occardium	+		+	+		+		+	+	(+)	+	+
Ourococcus	+					+		+	(+)	+	+	+
Pandorina	+		(+)	+		+		(+)	+	+	+	(+)
Pediastrum								(+)	(+)		(+)	(+)
Shroederia	+		(+)	(+)		(+)		(+)	(+)	(+)		+
Ulothrix							(+)					
BLUE-GREEN ALGAE (Cyanophyceae)												
Chroococcus	+		+	+		+	+	+	+	+	+	+
Gomphosphaeria			+						(+)	(+)		(+)
Merismopedia	+		+	+		(+)		(+)				(+)
Microcystis	+		+	(+)		(+)		(+)	+			
Nostoc							(+)	+	(+)	+	+	(+)
Oscillatoria	+		+	+		+		+	+	+	+	+
Xanthophyceae												
Halosphaera			+	+		+	+	+	+	+	+	+
Foraminifera	+		+	+		+	(+)	+				
Radiolaria	+		+	+		+	(+)	(+)				
Cladocera			(+)	(+)		(+)						(+)
Copepoda	(+)		(+)	(+)			(+)					
Nematoda (eggs)							(+)	+	(+)	(+)	(+)	(+)
Penaeid shrimp			(+)	(+)		(+)						(+)
Detritus/Sand	+		+	+		+	+	+	+	+	+	+

1/ Occurrence of items in less than 10 percent of feeding individuals

2/ Occurrence of items in more than 10 percent of feeding individuals

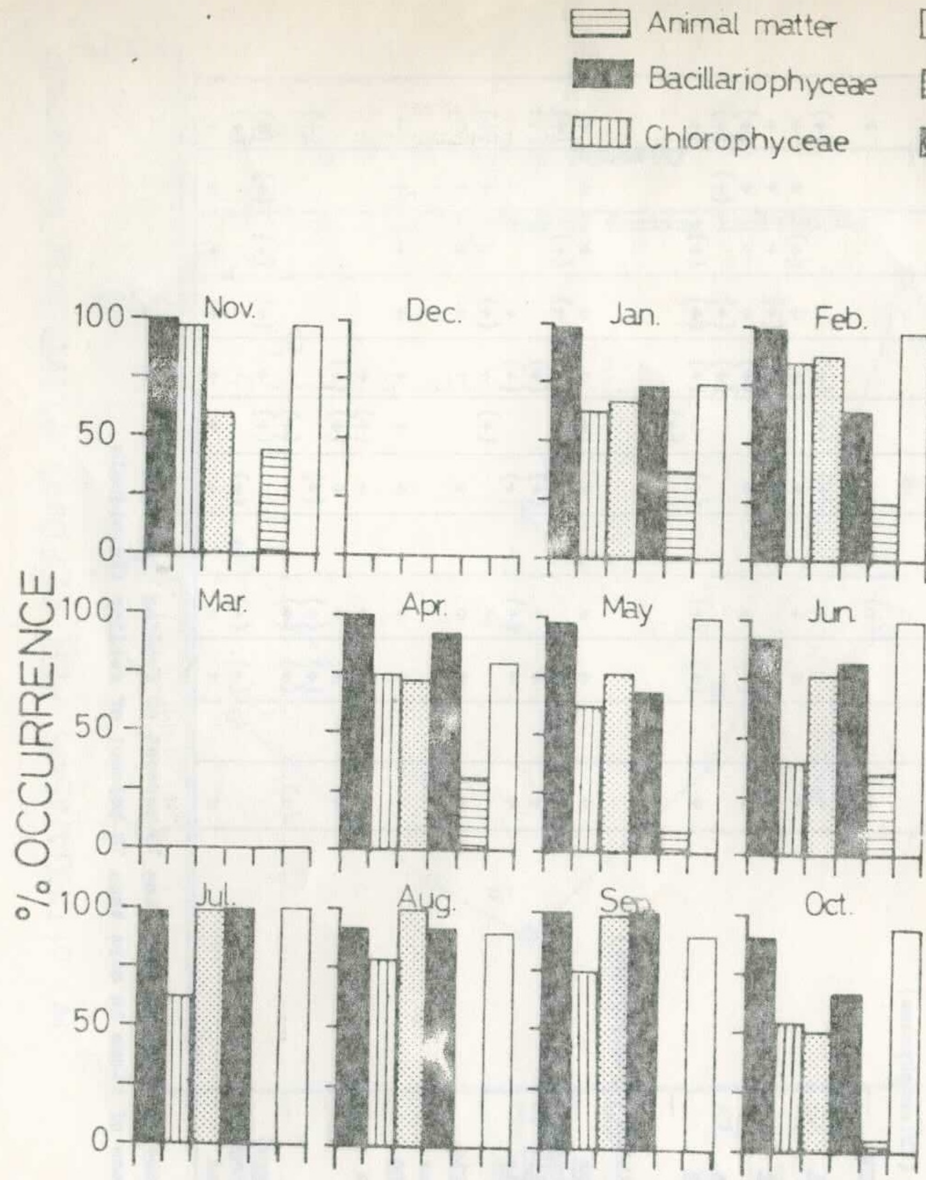

Fig. 2 Monthly changes in occurrence of the major food items in the diet of feeding individuals

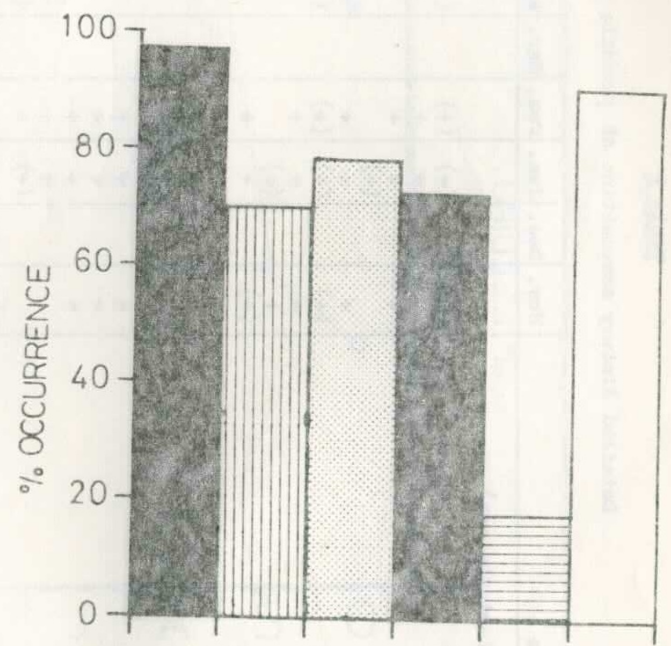

Fig. 3 Occurrence of major food items in feeding individuals for the full length of the investigation

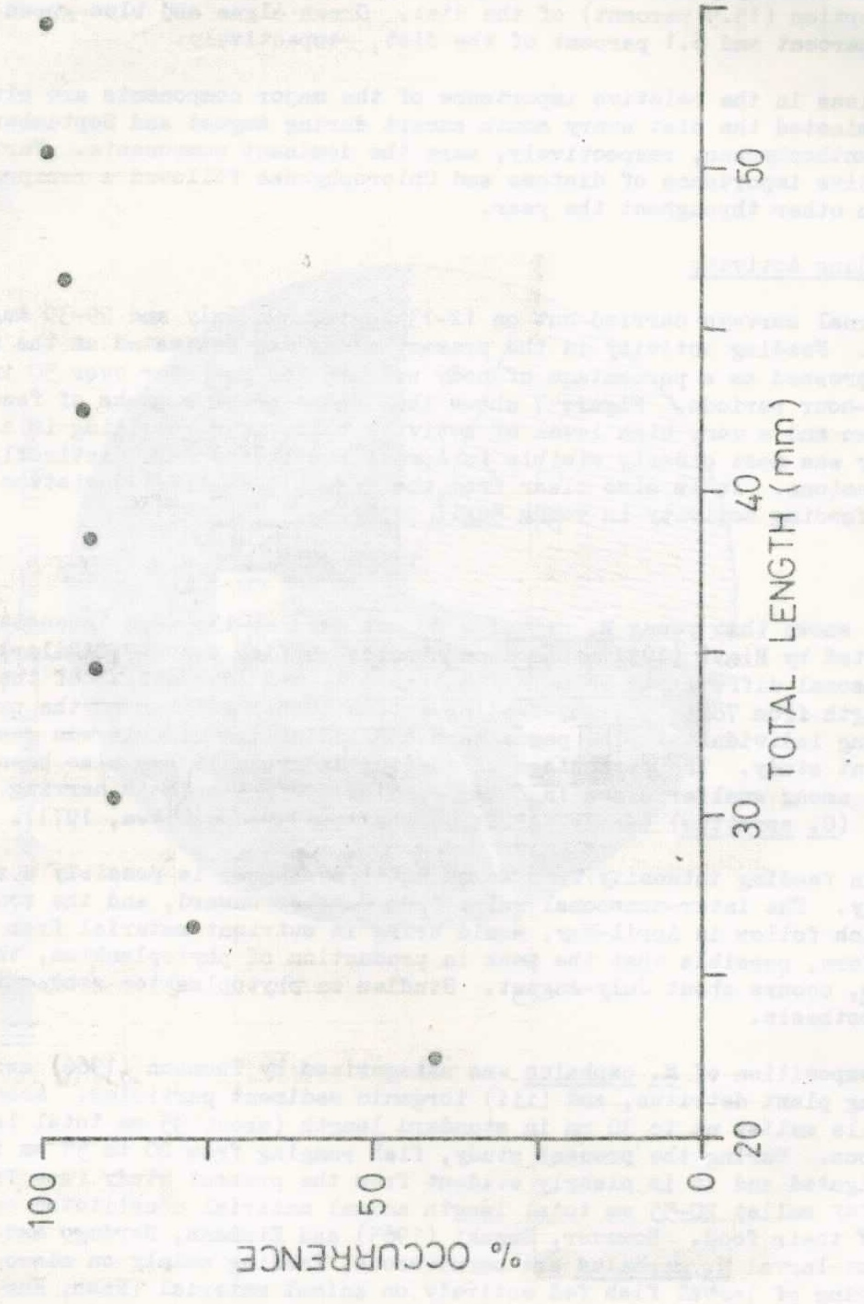

Fig. 4 Relationship of occurrence of sand and/or detritus in gut contents to length of fish

3.2 Relative Importance of Food Items

The relative importance of the major food items for the whole year, excluding sand and detritus, is shown in Fig. 5. It is evident that by far the biggest component of the diet was diatoms (Bacillariophyceae) which accounted for 55.5 percent while all the animal material put together accounted for less than 1 percent. It is also of importance to note that although only one genus of the Xanthophyceae was taken by young mullet, quantitatively it accounted for a significant portion (15.5 percent) of the diet. Green algae and blue-green algae accounted for 22.3 percent and 6.1 percent of the diet, respectively.

Monthly variations in the relative importance of the major components are given in Fig. 6. Diatoms dominated the diet every month except during August and September when Chlorophyceae and Xanthophyceae, respectively, were the dominant components. Further, the changes in the relative importance of diatoms and Chlorophyceae followed a reciprocal relationship to each other throughout the year.

3.3 Daily Feeding Activity

Results of diurnal surveys carried out on 12-13 April, 5-6 July and 29-30 August 1975 are shown in Fig. 7. Feeding activity in the present study was estimated as the weight of stomach contents expressed as a percentage of body weight; the mean for over 50 individuals being obtained at 3-hour periods. Figure 7 shows that there are two peaks of feeding activity, one around dawn and a very high level of activity thereafter resulting in a peak around mid-day. The former was most clearly visible in April; the latter peak distinctly showed up on all three occasions. It is also clear from the figure that tidal variation does not seem to affect the feeding activity in young *Mugil cephalus*.

4. DISCUSSION

This study has shown that young *M. cephalus* do not feed at the same intensity throughout the year, as suggested by Hiatt (1944), based on studies in fish ponds. Similarly, Luther (1962) observed seasonal differences both in the intensity and composition of the diet of fish ranging in length from 78 to 300 mm, feeding intensity being taken as the percentage occurrence of feeding individuals. The percentage of feeding individuals was generally much higher in the present study. The percentage of feeding individuals has also been found to be generally higher among smaller sizes in other species of fish such as herring (*Clupea harengus*) and sprat (*C. sprattus*) (Hardy, 1924; Marshall, 1939; De Silva, 1973).

The increase in feeding intensity from March until September is possibly a reflection of food availability. The inter-monsoonal rains from October onward, and the southwest monsoonal rains which follow in April-May, would bring in nutrient material from land run-off. It is, therefore, possible that the peak in production of phytoplankton, the principal food of *M. cephalus*, occurs about July-August. Studies on phytoplankton production are needed to confirm this hypothesis.

The dietary composition of *M. cephalus* was categorized by Thomson (1966) as: (i) micro-algae, (ii) decaying plant detritus, and (iii) iorganic sediment particles. According to Odum (1970), juvenile mullet up to 30 mm in standard length (about 35 mm total length) are primarily carnivorous. During the present study, fish ranging from 20 to 55 mm in total length were investigated and it is clearly evident from the present study (see Table I and Fig. 5) that in grey mullet 20-55 mm total length animal material constituted only a very minor proportion of their food. However, Suzuki (1965) and Zismann, Berdugo and Kimor (1975) have shown that post-larval *M. cephalus* are carnivorous, feeding mainly on micro-crustaceans. The successful rearing of larval fish fed entirely on animal material (Nash, Kuo and McConnel, 1974) also demonstrates the carnivorous nature of larval and post-larval grey mullet. The present study shows that the carnivorous habit is given up at a size much earlier than 30 mm.

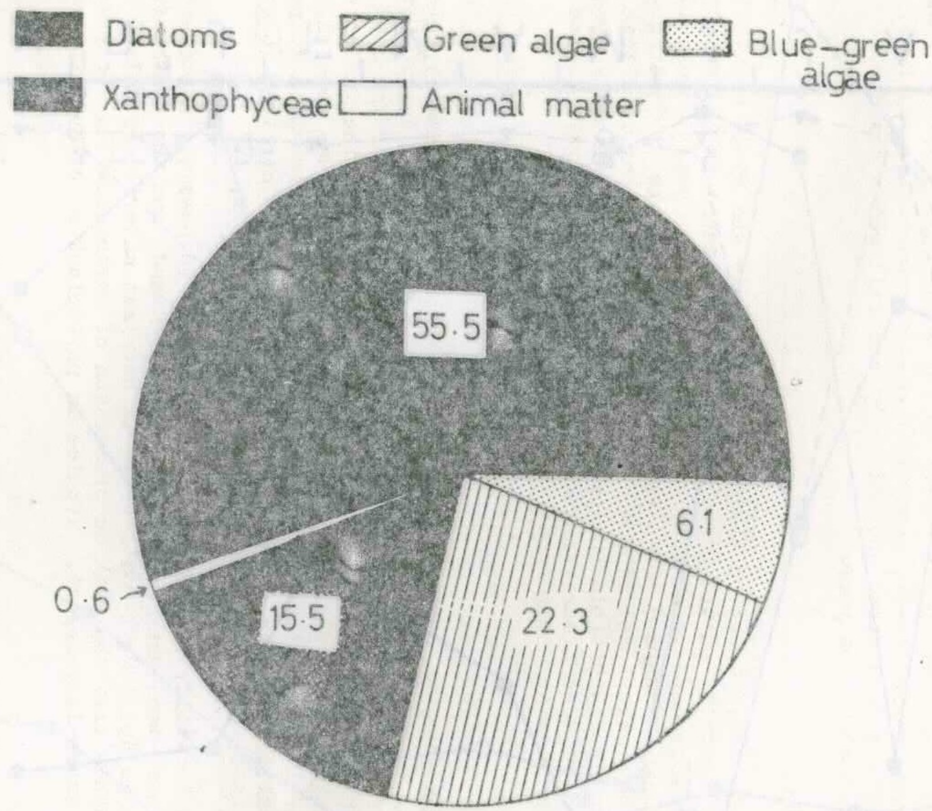

Fig. 5 Relative importance of the major food items, excluding detritus and sand, in the diet of young grey mullet

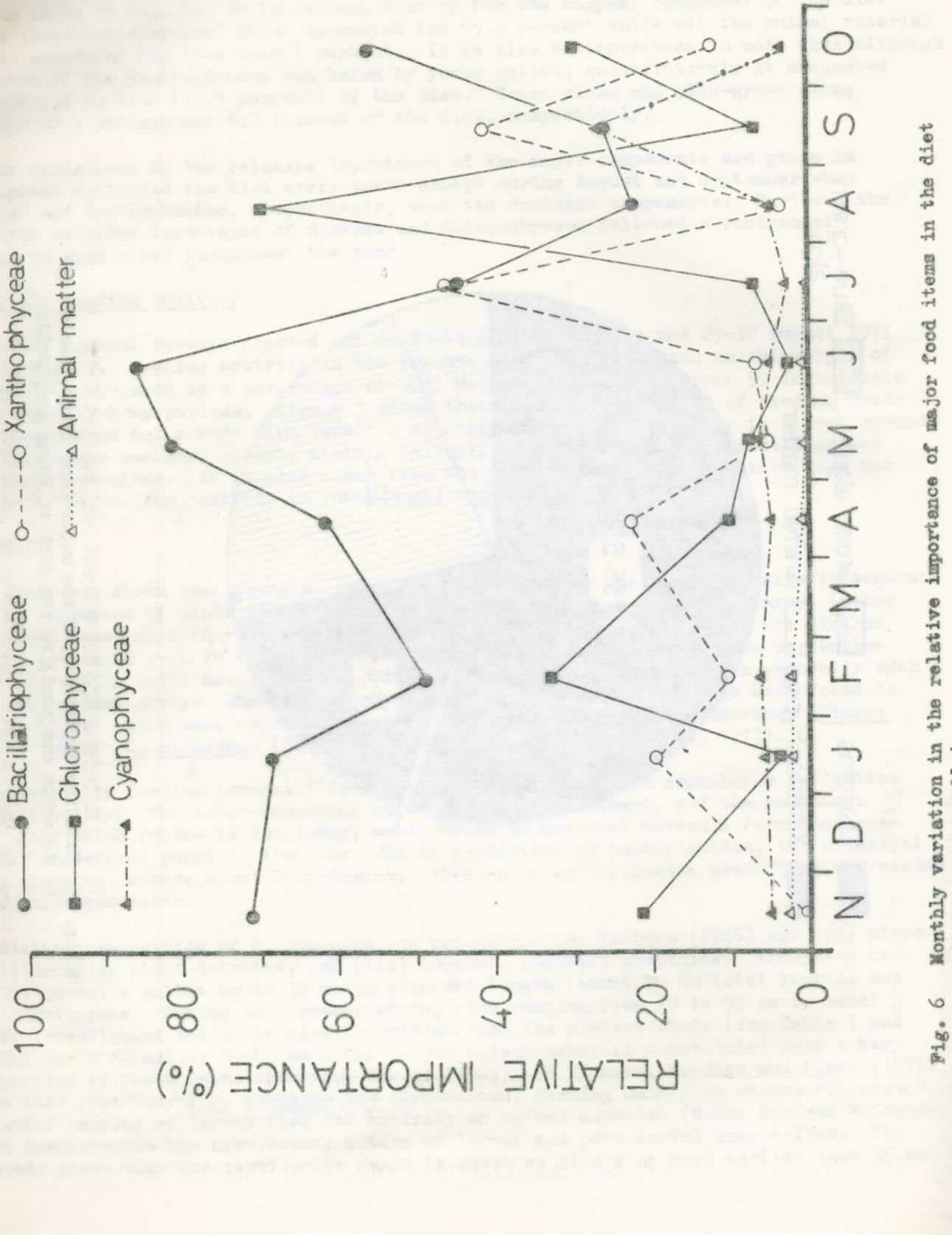

Fig. 6 Monthly variation in the relative importance of major food items in the diet of young grey mullet

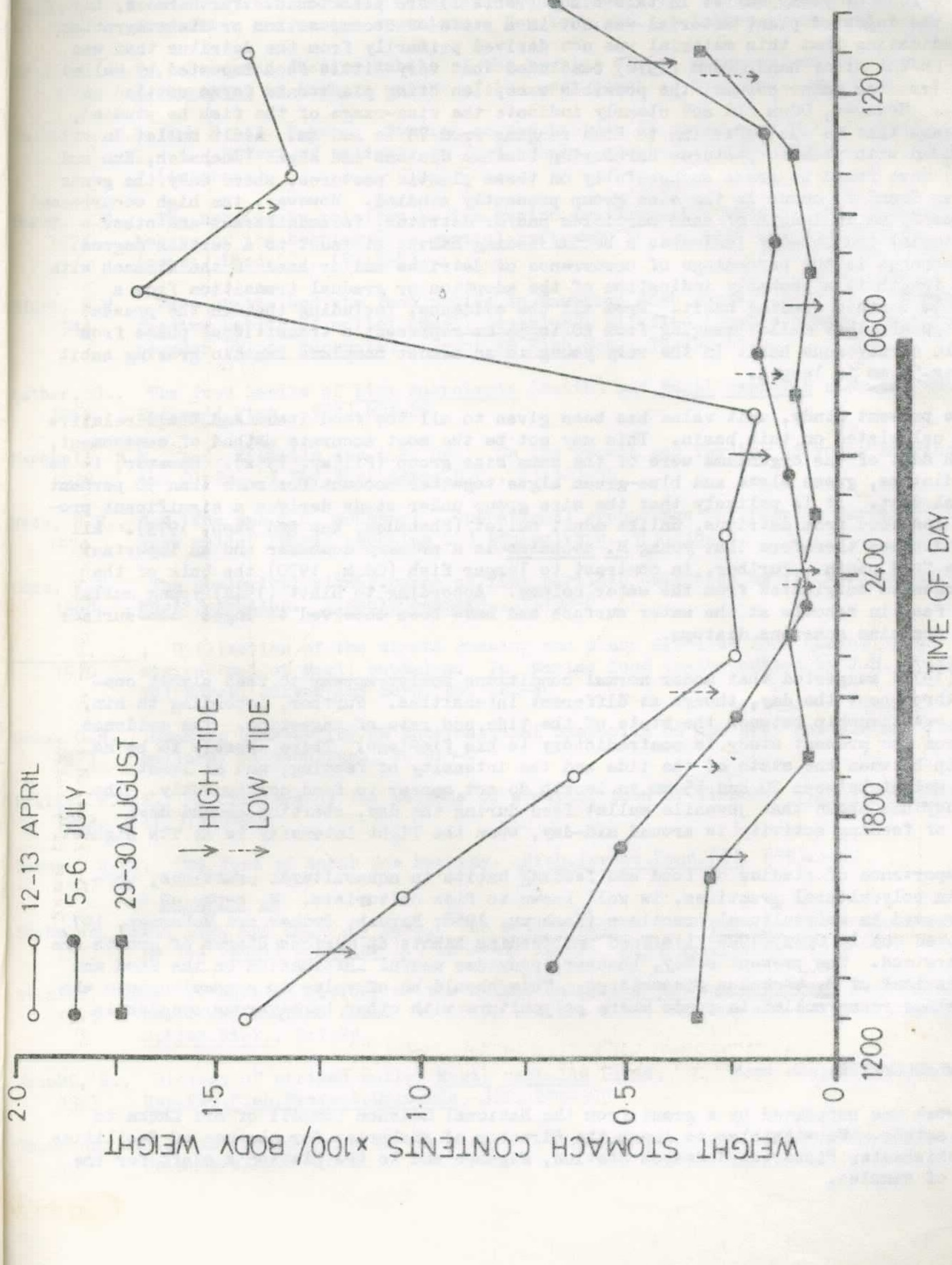

Fig. 7 Changes in diurnal feeding ativity of young grey mullet during three surveys (see text, 3.3 for clarification)

Of the items given in Table I, four genera of diatoms have also been observed to occur in the diet of M. cephalus of 16.2 to 400 mm in length in Hawaiian fish ponds (Hiatt, 1944). The great majority of the diatoms and almost all the green and blue-green algae that constitutes the food of young mullet in this study (Table I) are planktonic. Furthermore, in most cases the ingested plant material was not in a state of decomposition or disintegration, possibly indicating that this material was not derived primarily from the detritus that was ingested. On the other hand, Odum (1970) concluded that very little food ingested by mullet originated from the water column, the possible exception being planktonic forms settled on the benthos. However, Odum did not clearly indicate the size-range of the fish he studied, and it appears that he was referring to fish ranging from 75 to 200 mm. Adult mullet in ponds provided with plastic pastures harbouring benthic diatoms and algae (Shehadeh, Kuo and Nash, 1973) were found to graze successfully on these plastic pastures, where only the genus Navicula was found to occur in the size group presently studied. However, the high occurrence in fish over 25 mm in length of sand particles and/or detritus, foraminiferans and other benthic material undoubtedly indicates a bottom feeding habit, at least to a certain degree. Further, increase in the percentage of occurrence of detritus and/or sand in the stomach with increasing length is a probably indication of the adoption or gradual transition from a planktonic to benthic feeding habit. From all the evidence, including that in the present study, it appears that mullet ranging from 20 to 55 mm represent a transitional phase from a planktonic carnivorous habit in the very young to an almost complete benthic grazing habit in fish over 55 mm in length.

In the present study, unit value has been given to all the food items and their relative importance calculated on this basis. This may not be the most accurate method of assessment, even though most of the organisms were of the same size group (Pillay, 1952). However, it is seen that diatoms, green algae and blue-green algae together account for more than 90 percent of the total diet. It is unlikely that the size group under study derives a significant proportion of its food from detritus, unlike adult mullet (Shehadeh, Kuo and Nash, 1973). All evidence indicates therefore that young M. cephalus is a primary consumer and an important link in the food chain. Further, in contrast to larger fish (Odum, 1970) the bulk of the material ingested originates from the water column. According to Hiatt (1944) young mullet frequently feed in schools at the water surface and have been observed to ingest the surface scum which contains numerous diatoms.

Odum (1970) suggested that under normal conditions mullet appear to feed almost continuously throughout the day, though at different intensities. Further, according to him, there is a relationship between the state of the tide and rate of ingestion. The evidence gathered from the present study is contradictory to his findings. There appears to be no relationship between the state of the tide and the intensity of feeding, and at least fingerling mullet between 20 and 55 mm in length do not appear to feed continuously. The present study has shown that juvenile mullet feed during the day, starting around dawn. Their peak of feeding activity is around mid-day, when the light intensity is at its highest.

The importance of studies on food and feeding habits in aquacultural practices, particularly in polycultural practices, is well known to fish culturists. M. cephalus is extensively used in polycultural practices (Yashouv, 1968; Bardah, Ryther and McLarney, 1972) but as pointed out by Oren (1975) its food and feeding habits at various stages of growth are little understood. The present study, however, provides useful information on the food and feeding behaviour of M. cephalus fingerlings. This should be of value to aquaculturists who wish to include young mullet in ponds where polyculture with other herbivorous species is practised.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Bardach, J.E., J.H. Ryther and W.O. McLarney, 1972 Aquaculture: the farming and husbandry of freshwater and marine organisms. New York, Willey Interscience, 868 p.

De Silva, S.S., 1973 Food and feeding habits of the herring Clupea harengus and the sprat C. sprattus in inshore waters of the west coast of Scotland. Mar.Biol., 20:282-90

De Silva, S.S. and P.A.B. Perera, Studies on the biology of young grey mullet, Mugil cephalus L. 1. Effect of salinity on food intake, growth and food conversion. Aquaculture 7 (in press)

Hardy, A.C., 1924 The herring in relation to its marine environment. Part 1. The food and feeding habits of the herring with special reference to the east coast of England. Fish. Invest., Lond.(2), (7):1-53

Hiatt, R.W., 1944 Food chains and the food cycles in Hawaiian fish ponds. Part 1. The food and feeding habits of mullet (Mugil cephalus), milkfish (Chanos chanos), and the ten-pounder (Elops machnata). Trans.Am.Fish.Soc., 74:250-61

Luther, G., 1962 The food habits of Liza macrolepis (Smith) and Mugil cephalus Linnaeus (Mugilidae) Indian J.Fish., 9(2):604-26

Marshall, S.M., A.G. Nicholls and A.P. Orr, 1939 On the growth and feeding of young herring in the Clyde. J.Mar.Biol.Assoc.U.K., 23:427-55

Nash, C.E., C.M. Kuo and S.C. McConnel, 1974 Operational procedures for rearing larvae of the grey mullet (Mugil cephalus L.) Aquaculture, 3(1):15-24

Odum, W.E., 1968 The ecological significance of fine particle selection by the striped mullet Mugil cephalus. Limnol.Oceanogr., 13:92-8

__________, 1970 Utilization of the direct grazing and plant detritus food chains by the striped mullet Mugil cephalus. In Marine food chains edited by J.H. Steele. Edinburgh, Oliver and Boyd, pp. 222-40

Oren, O.H., 1975 Opening address IBP/PM International Symposium on the grey mullets and their culture. Aquaculture, 5(1):3-8

Pillay, T.V.R., 1952 A critique of the methods of study of food of fishes. J.Zool.Soc.India, 4(2):185-200

Savage, R.E., 1937 The food of North Sea herring. Fish.Invest.Lond.(2), (15):1-60

Shehadeh, Z.H., C.M. Kuo and C.E. Nash, 1973 The establishment of a captive brood stock of grey mullet (Mugil cephalus L.) in small ponds. Aquaculture, 2(4):379-84

Staples, D.J., 1975 Production biology of the upland bully Philypnodon breviceps Stokell in a small New Zealand Lake. 1. Life history food, feeding and activity rhythms. J.Fish.Biol., 7:1-24

Suzuki, K., 1965 Biology of striped mullet Mugil cephalus Linne. 1. Food contents of young. Rep.Fac.Fish.Prefect.Univ.Mie, 5(2):295-305

Thompson, J.M., 1966 An introduction to the study of tropical plankton. Hutchinson, Tropical Oceanography. 160 p.