A CONTRIBUTION TO THE LIFE HISTORY AND FEEDING HABITS OF *MUGIL CEPHALUS* (LINN.)

by

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The mullets constitute an important group of marine and fresh water fishes having a wide range of distribution in the temperate and tropical waters. Of the nine species of mullets recorded in the Madras area *Mugil cephalus* formed the main bulk. The food and feeding habits of adult grey mullets have been extensively studied outside India by GUNTHER (1861 and 1880), CUNNINGHAM (1891), LINTON (1904), JORDAN (1905), HERRE and MENDOZA (1929), ISHIDAL (1935), CHAZZAWI (1933 and 1935), SAMZO (1930), SMITH (1935), HIATT (1944), BEAVAN (1877), KYLE (1926), NORMAN (1937), ORTAN (1926) and KESTEVAN (1942). In an earlier paper the author (KUTHALINGAM, 1956) has reviewed the work done on Indian mullets. Except PILLAY (1952) who has studied the early development of *Mugil corsula* our knowledge of the life history and feeding habits of the larval stages of this group of esteemed food fishes is still very meagre. An investigation of the biology of this grey mullet was undertaken in 1956 when the author was a Research Fellow of the University of Madras. Subsequently the data gathered on the feeding habits of adult *Mugil cephalus* collected from inshore, offshore, and brackish water environments are also dealt with in detail.

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Eggs:

281 perfectly spherical transparent eggs of an average diameter of 0.6 mm were collected with the surface townet at about 8 A. M. These eggs (Fig. 1) were floating freely at the surface. The perivitelline space was narrow and the egg was characterized by a conspicuous, large, cen-

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trally placed oil globule. The yolk was clear and unsegmented. The outline of the embryo was visible but the eyes and the myotomes were faintly seen. Within two hours after collection, development had advanced to a stage as shown in (Fig. 2). The myotomes, eyes and the auditory vesicle were visible. The heart was pulsating. Outline of the alimentary canal appeared faint. The head and the tail portion were quite distinct from the yolk. Dark brown pigment spots were noticed on the body of the embryo. There was a general resemblance between these eggs and those described by RAFFAELE (1888), HOLT (1888), ROULE (1917), MARTIN (1891), WIMPENNY (1936), etc. of other species of *Mugil*.

Larvae just hatched (Fig. 3):

Eight hours after the stage shown in Fig. 2 all the eggs hatched at about 6 P. M. The larvae were floating on the surface upside down with the tail held above water. The large oil globule was seen at the anterior edge of the yolk mass which projected beyond the front tip of the embryo. The eyes and the auditory vesicles appeared well differentiated. All the 281 larvae were nearly 1.1 mm in length and were perfectly transparent. The anus opened under the eleventh myotome. There were sixteen post-anal myotomes. Numerous brown pigment spots were scattered irregularly all over the body. There was no indication of the formation of the mouth or gills.

Larvae 14 hours after hatching (Fig. 4):

On the morning of the second day after hatching, the larvae were of the same pigmentation and length as when hatched. But the oil globule and the yolk mass were reduced in size and the head was curved downwards over the yolk.

Larvae 24 hours after hatching (Fig. 5):

The larvae had grown to 1.4 mm in length. The yolk sac and the oil globule, though very conspicuous, had become much smaller. The head was very prominent and the auditory vesicle had become larger in size. Though the mouth was not formed, a small depression was noted in the region. The pigmentation remained as in the previous stage.

Next day at about 2 P. M. forty-two pro-larvae died owing to reasons which could not be determined. The remaining larvae were very active moving here and there with the dorsal side up, but when disturbed they tried to swim down. However, they managed to maintain the balance and kept close to the surface. At about 4 P. M. in the evening (Fig. 6) the yolk and the oil globule were completely absorbed. The mouth was formed and the eyes became pigmented, pectoral fin and four gills began to develop. Dark black pigment patches were seen crowded just below the pectoral fin. The irregularly scattered brown pigment cells were arranged into dorsal and ventral rows on the body. Patches of brown pigments were noticed below and above the eyes. Caudal fin-rays were developed. The mouth opened into the alimentary canal and the latter opened on the eleventh myotome.

In spite of the greatest care there were heavy casualities among the larvae during the transition from the pro-larval to the post-larval stage and immediately after this transition, the post-larvae did not feed for nearly sixteen hours. On the morning of the fourth day twenty-four larvae had died and were found with empty stomachs though there was food in the containers. To determine precisely the nature of the diet required, thirty post-larvae were removed into a separate container and supplied with unsorted plankton. After about an hour and forty-five minutes, two or three larvae were taken at a time in a watch glass containing sea water and examined under the binoculars. Some of them had not fed while in the transparent stomachs of the others, diatoms and copepod nauplii were found in appreciable numbers. Having determined the composition of the diet accepted by the post-larvae, another lot of thirty larvae were removed into a second container for further observation. Into this container was introduced a plentiful supply of diatoms from a culture containing the following genera: *Asterionella* sp., *Coscinodiscus* sp., *Thallasionema* sp., *Rhizosolenia* sp., *Sceletonema* sp., *Tabellaria* sp., *Bacillaria* sp., *Nitzschia* sp., algae, *Oscillatoria* spp., *Chaetomorpha*, *Enteromorpha*, and copepod nauplii belonging to five genera (*Oithona* sp., *Acartia* sp., *Temora* sp., *Corycaeus* sp., and *Paracalanus* sp.) previously isolated from the plankton were also added. Examination of the stomach contents showed that these larvae which were supplied with plenty of these food items were well fed and there were no casualities in this lot. Thus on the second day after the emergence of the post-larvae 215 were living and these were used to determine further changes in diet. To see if these post-larvae had changed the diet twenty of them were taken into a separate container and were supplied with molluscan larvae and they started feeding on veliger larvae and larval bivalves. Nevertheless the next morning they were dead. It was inferred that they required diatoms, algae and copepod nauplii. This was confirmed by further experiments. Another lot of twenty larvae were supplied with diatoms, algae and copepod nauplii to begin with and later adding other items of food such as molluscan larvae, fish eggs, and other crustacean larvae collected from the plankton. It was found that on all occasions these post-larvae confined their menu to only diatoms, algae and copepod nauplii.

On the fifth day morning, a change was noticed in their diet. About thirty post-larvae which were supplied with diatoms, algae and nauplii of copepods, rejected these items of food for which they had a partiality till then. They did not feed on any for a period of six hours. Afterwards unsorted samples of fresh plankton were added to see the change in diet. The larvae started feeding. Examination of the gut contents after about two hours showed that protozoa, larvae of bivalves, gastropods and polychaetes were found in the stomachs. To see of this was the diet the larvae subsisted on, another lot of thirty larvae in a separate container were supplied with centrifuged samples of protozoa such as dinoflagellates, tintinnids, radiolarians, *Noctiluca* sp., and *Ceratium* sp., as well as larval bivalves, larval polychaetes, cirripede larvae, algae, diatoms, and copepod nauplii; fish eggs and larvae taken from the plankton were also added. Examination of the stomach contents showed that all other food items were rejected except larvae of molluscs and protozoa. Even amongst different species of protozoa, the majority of them were found to be *Noctiluca* sp. To see if the post-larvae would change their diet, vegetable items like diatoms and algae for which they showed a partiality earlier were added together with protozoans which now formed their favourite food. Fifty larvae were separated and supplied with these items. After about two hours the stomachs were found filled with protozoans alone indicating that the post-larvae now eschewed vegetable food altogether.

There was no change in the diet of the post-larvae for the next five days.

Larvae 11th day after hatching (Fig. 7):

The larvae 1.4 mm long when one day old, had now grown to 7.2 mm. Though longer, the pre-anal myotomes continued to be eleven in number. It is a feature distinctive of the species that the anus had not shifted its position from the time of hatching. The myotomes had increased in height and appeared slightly broader than in the previous larvae. The gills were well developed. Dark brown pigment spots arranged into dorsal and ventral rows on the body of the embryo in the earlier stage had now moved into the dorsal and ventral fin-folds. The pectoral fins were still devoid of rays. The tip of the tail was curved upwards and the fin-rays in the caudal region appeared slightly harder than the tissues around.

On the morning of the 11th day, the post-larvae were fed with protozoans and larval molluscs. Two hours later the stomachs of the larvae were examined and were found empty. Immediately fresh plankton was introduced to determine the proper type of food of these larvae. Examination of the gut showed that adult copepods, cirripede larvae, and larval polychaetes now formed their diet. Finding that the post-larvae had changed completely from its diet of protozoan and larval molluscs, it was felt necessary to see if still other items will be added to the menu. Therefore a lot of about thirty larvae was isolated and supplied with diatoms, algae, protozoans, molluscan larvae, cirripede larvae, larval polychaetes, copepod nauplii, adult sopepods, fish eggs and larvae. It was found that the post-larvae confined their diet to only adult copepods, cirripede larvae and larval polychaetes.

There was no change in the diet of the larvae for another three days.

Larvae 15th day after hatching (Fig. 8):

The larvae had grown to 10.3 mm in length. Dorsal and anal fin-rays began to appear. The myotomes had increased in height. The dark brown pigment spots on the dorsal and ventral fin-folds of the previous stage disappeared completely and the larvae had become less transparent and the myotomes could be made out only after fixing and clearing in cedarwood oil and staining in Borax carmine. Eleven pre-anal myotomes continued to be a feature of the larvae of the species.

On the 15th day morning when the larvae were supplied with copepods, cirripede larvae, and larval molluscs, as on the preceding days, it was found that they declined to feed on these food items. Therefore, fresh plankton was introduced into the container and after four hours, examination showed that the stomach was filled with ostracods, *Mysis*, megalopa, fish egg and larvae. In order to confirm this change of diet a fresh lot of post-larvae was supplied with copepod nauplii to begin with and later cirripede larvae, polychaetes, and molluscan larvae, and later still others were added. The larvae did not feed till ostracods, megalopa, *Mysis*, fish eggs, and pro-larvae also were added. The post-larvae continued this diet for another two days.

On the morning of the 18th day after hatching, the larvae measured 12.88 mm in length and remained unchanged in other respects. However, when a large number of these post-larvae were isolated, they changed in their diet, exhibiting a preference for fish eggs and larvae and adult copepods. They now declined to feed on the food items which they preferred the previous two days. The fish eggs and larvae, they preferred, were identified as belonging to species of *Engraulis, Stolephorus*, and *Caranx*, whereas the copepods they fed were identified as *Macrosetella gracilis, Labidocera acuta* (young ones), *Pontella* sp., *Pseudodiaptomus* sp., *Euterpina acutifrons, Oithona rigida, Temora* sp., *Paracalanus parvus, Acartia* sp., *Oncaea conifera*, and *Calanopia* sp. When fresh algae and diatoms were supplied, the larvae preferred to starve rather than to feed on them; as soon as copepods were introduced the larvae fed voraciously on them.

The larvae continued to have the same diet for another tree days.

Larvae 22nd day after hatching (Fig. 9):

The post-larvae measured 15.8 mm. Four spines were present in the anterior dorsal fin of which the second was the largest and well developed. The posterior dorsal had a single spine and eight rays. The larvae were silvery in colour and had become opaque and the myotomes were not visible though there was no pigmentation on any part of the body. There was an increase in width at the anterior half of the trunk. The general shape of the dorsal and anal fins resembled those in the adult fishes but were extremely soft and semi-transparent.

On the morning of the 22nd day about thirty larvae were separately fed with copepods but the larvae declined to feed on these. Fresh plankton was added to the container and since the body of the larvae was opaque, twenty larvae were killed and their stomach contents teased on to a slide. Examination showed that they had fed on fish eggs and pro-larvae of other fishes as well as a few copepods, *Lucifer* and molluscan larvae. When fish eggs and larvae and large numbers of copepods were supplied to the post-larvae along with larvae of *Balanus* sp., algae, diatoms, molluscan larvae, polychaete larvae and appendicularians, plutei, young sergestids, and decapod larvae, it was found that the post-larvae had fed more on fish eggs and larvae than on copepods and molluscan larvae. Their partiality for fish food at this stage was further tested by giving powdered dry fish to a few post-larvae. The post-larvae waited till the particles sank down into the water and became soaked and softened before eating them.

There was no change in the diet of the post-larvae till the 27th day.

On the 28th day, however, when the larvae had grown to 20.2 mm in length it was found that they did not avoid plant food at this stage for when a few filaments of *Cladomorpha* sp. were introduced into the container, they started nibbling them. Fresh plankton was introduced and the examination of 28 post-larvae showed that they had fed mainly on fish eggs,pro-larvae and copepods, and also on filaments of *Cladomorpha* and *Oscillatoria*. The post-larvae which were carnivorous till now included vegetable matter in their menu, as was confirmed by repeating the tests. Though the post-larvae had now grown to 22.1 mm on the 33rd day, during the next eigth days growth was slower, and the larvae increased in length by only 4 mm and began to exhibit all the features of the juvenile stage; the feeding also continued to be the same.

Juvenile:

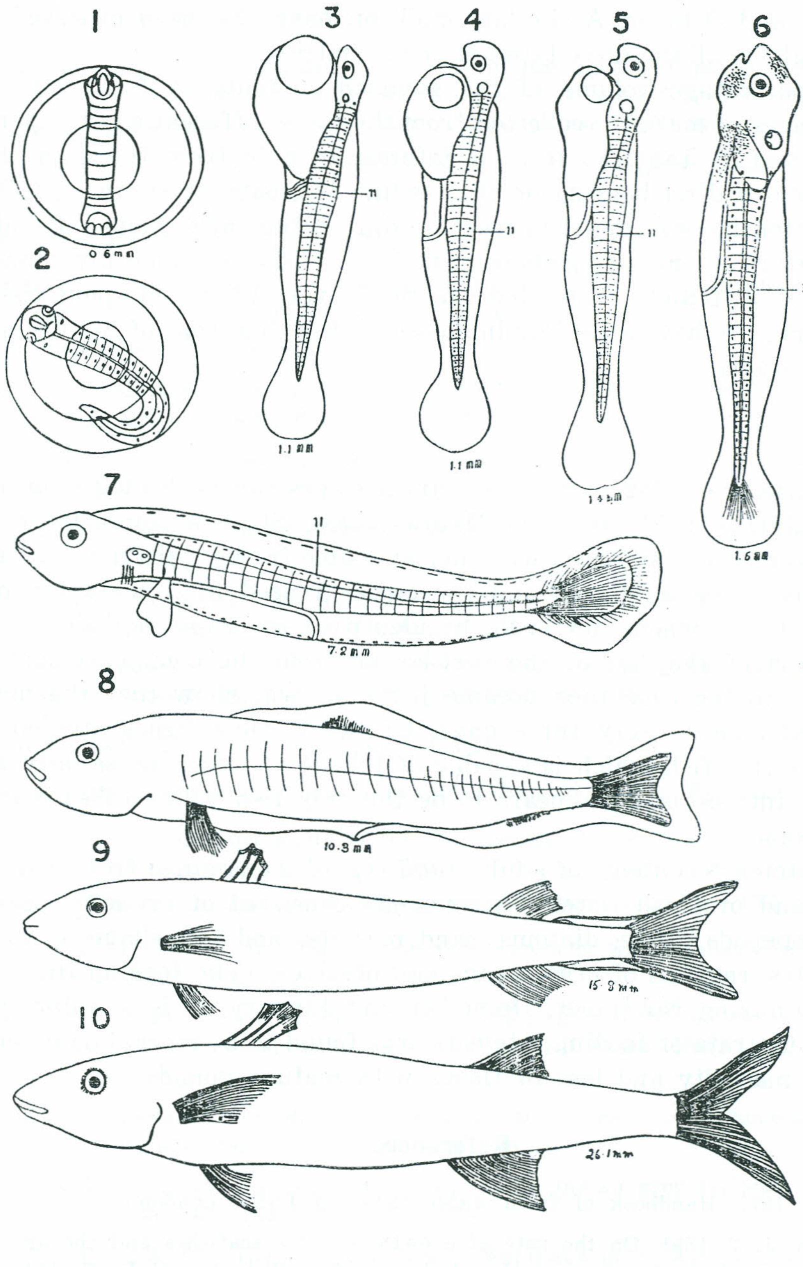
On the 42nd day aftter hatching the fish may be considered to have attained the juvenile stage because the taxonomic features of the adult were attained and the fin formula was noted as D. 4 1/8. P. 15. A. 3/8 C. 15. L. 1. 43 (Fig. 10). The thirty-three juveniles reared from the eggs hatched in the laboratory appeared healthy and normal. They measured 26.1 mm in length. About forty juveniles slightly older than those reared in the laboratory were collected from the plankton and reared. The body was cylindrical and stout with a broad head and snout. Scales were large and conspicuous. It was greyish along the back and silvery on the sides and beneath. The cheeks were golden in colour while the second dorsal and caudal were grey and yellowish in colour.

The newly formed juveniles, though slow in growth, were very active and able to capture even the swift and fast swimming planktonic organisms. When fresh plankton was introduced and twenty-four juveniles were killed and the stomach contents were analysed, three hours later, it was interesting to find a total exclusion of vegetable matter. The food appeared to consist of only animals such as copepods, *Lucifer*, molluscan larvae, polychaetes, cirripede larvae, ostracods, amphipods, cumaceans, *Squilla* larvae, young ones of *Penaeus*, *Acetes* larvae, *Engraulis* larvae, fish eggs and *Sagitta*. To confirm the inference that the juveniles were purely carnivorous, forty of them were removed in a glass tank with plenty of vegetable matter. To safeguard against death due to starvation a small quantity of zooplankton was also added. Later after three hours when thirty juveniles were killed and their stomach contents examined it was found what little food the juveniles had taken was restricted to animal item. Since there was no change in the diet of the juveniles for over ten days, rearing of the juveniles and experimental observations were both discontinued.

Feeding habits of adults:

The analysed data on the stomach contents of *Mugil cephalus* collected from inshore, offshore and brackish water environments during the different months are presented in Tables I - III. The stomach contents of the fish from all the three different environments consisted of organic decayed matter mixed with copious quantities of mucous in which nothing was identifiable, copepods, algae, diatoms, miscellaneous matter consisting mainly of animal resources and sand particles. It is obvious from the data analysed that the first four items are of importance as the food of the fish. From the average for the three environments taken, it is seen that organic decayed matter formed 31.2% and copepods figured next in importance forming 25.8% (The various forms of copepods identified are enumerated in Table I - III). The common constituents of this item were *Oithona* sp., *Acartia* sp., *Pontella* sp., *Eucalanus* sp. and *Paracalanus* sp. Algae formed 10.0% of the gut contents of the fish. Both unicellular and multicellular algae were recorded and were mainly represented by *Oscillatoria* and *Cladophora*. Diatoms constituted 8.2% and were invariably found along with sand grains and organic decayed matter. (The different varieties of diatoms identified from the stomach contents are given in Table I - III). *Pleurosigma* and *Asterionella* were the commonest forms found in the stomach contents. Miscellaneous item formed 4.8% constituted by larval bivalves, polychaetes and crustacean remains of which polychaetes formed the main bulk. Only exoskeleton was found in the stomach contents, the entire worm or even the traces of its flesh was not recorded. It is however possible that while browsing on the bottom these were swallowed automatically along with decayed matter. The inclusion of certain items may be only accidental since only their appendages were recorded. Sand particles represented 20.0% and the presence of this in large quantities indicate that the fish is a browser on bottom deposits.

The intensity of feeding of *Mugil cephalus* from the different types of environments for the various months of the year is presented in Table IV. The samples were collected mostly at 11 A. M. which was fished either in the previous evening or in the same morning. Analysis of the samples of fish collected at regular intervals several times during the same day in different seasons by the departmental vessel showed no noticeable variations in the intensity of feeding in relation to the time of the day. Data presented shows the feeding intensity of the fish in different months. Fish with gorged, full and three-fourth full conditions can be considered to have been actively feeding at the time of capture. It is therefore obvious from the data collected from all the three types of environments that most of them were actively feeding during November, December and January which are to be considered as an intensive feeding period. A reduction in the feeding intensity was noted from the presence of empty stomachs



Figs. 1-10. *Mugil cephalus* LINN.

Figs. 1-2. Eggs; Figs. 3-5. Pro-larvae; Figs. 6-9. Post-larvae; Figs. 10. Juvenile.

and those containing little food material in fishes caught during August, September and October. A similar condition have also been observed in fishes caught in all the three types of environments.

The percentage volume of the stomach contents of fishes of the various stages of maturity collected from the three different environments are presented in Table V. It is of interest to note from the data that maturity has a dirct bearing on the feeding intensity of *Mugil cephalus*. Feeding intensity was found to be more during the early stages of maturity (immature and maturing stages) and less in fishes with mature gonads. Spawners were found to have fed practically very little and spent fishes were observed to have a feeding intensity higher than that of mature and spawning stages.

Remarks:

Fertilised eggs, larval and post-larval stages were collected from the plankton during 1954 - 56 from Madras coast. Since a complete series of the different larval stages were not available in the collection, rearing experiments were conducted and the larvae reared upto early juvenile size of 26.1 mm when they could be identified as *Mugil cephalus*.

A chart of the diet of the post-larvae from the commencement of feeding up to the time they became juveniles will show that the menu is changed almost every three days. Of the various fishes studied by the author this fish which is capable of tolerating very low salinity and migrating into estuaries appears to be the only fish which takes a wide range of diet.

The stomach contents of adult *Mugil cephalus* examined from inshore, offshore and brackish water environments consisted of organic decayed matter, copepods, algae, diatoms, sand particles and miscellaneous items (polychaetes, remains of crustaceans and bivalves). The feeding intensity was more during November, December and January. It is of interest to note that the rate of feeding intensity was found to be more during early stages of maturity and less in fishes with mature gonads.

References

BEAVAN, R. 1877. Handbook of fresh water fishes of India. London.

CUNNINGHAM, J. T. 1891. On the rate of growth of some seafishes and the age and size at which they begin to breed. Journ. Mar. Biol. Ass. U. K., 2: 151 - 157.

GUNTHER, A. 1861. Catalogue of fishes in the British Museum. 6.

———, 1880. An introduction to the study of fishes. Edinburgh.

HERRE, A. W. and MENDOZA, J. 1929. Bangor culture in the Philippine island. Philipp. Journ. Sci., 38: 451 - 509.

HIATT, R. W. 1944. Food chains and food cycles in Hawaiian fish ponds. I. The food and feeding habits of mullet, (*Mugil cephalus*), milk fish (*Chanos chanos*) and ten-pounder *(Elops maclinate)*. Trans. Amer. Fish. Soc., 74: 250 - 261.

ISHIDAL, J. 1935. The stomach of *Mugil cephalus* and its digestive enzyms. Annot. Zool. Jap., 15: 182 - 189.

JORDAN, D. S. 1905. A guide to the study of fishes. New York.

KESTEVEN, G. L. 1942. Studies in the biology of the Australian mullet. Account of the fishery and preliminary statement of the biology of *Mugil dobula*. Bull. Counc. Sci. Industr. Res. Austr., 157.

KUTHALINGHAM, M. D. K. 1956. The food of two Grey mullets of the Madras coast. Journ. Madras Univ., B., 26: 319 - 326.

———, 1957. Food and feeding habits of some Madras fishes. Rec. Indian Mus., 55: 121 - 126.

———, 1959a. Development and feeding habits of *Saurida tumbil*. Journ. Zool. Soc. India, 11: 116 - 124.

———, 1959b. Life history and feeding habits of a Tripod fish (*Triacanthus brevirostris*) of the Indian sea. Treubia, 25: 159 - 164.

———, 1960. Observations on the life history and feeding habits of the Indian sardine, *Sardinella longiceps*. Treubia, 25: 207 - 213.

KYLE, H. M. 1897. The biology of Fishes. London.

LINTON, E. 1904. Parasites of fishes of Beaufort. Bull. U. S. Bur. Fish., 24: 321 - 428.

NORMAN, J. 1937. Illustrated guide to the fish gallery British Museum (Nat. Hist.), London.

ORTON J. H. 1926. Mullets as an enemy of oyster. Nature, 116: 121 - 122.

PAKVASI, B. & ALIKUNHI, K. H. 1952. On the development of Grey mullet *Mugil corsuta* (HAM.) Journ. Zool. Soc. India, 4(2) : 123 - 140.

PILLAI, T. V. R. 1949. On the culture of grey mullets in association with commercial carps in fresh water tanks in Bengal. Journ. Bomb. Nat. Hist. Soc., 48: 601 - 604.

SANZO, L. 1930. Uova e larvae di *Mugil cephalus* attenute per fecondayione artificiale. R. Co. Talass. Ital. Sci. Paris, 5: 194 - 196.

SAROJINI, K. K. 1951. The fishery and biology of the Indian grey mullets- A review. Journ. Zool. Soc. India, 3(1) : 159 - 179.

SMITH, J. L. B. 1935. The fishes of the family Mugilidae in S. Africa. Ann. S. Afr. Mus., 30: 40 - 644.

WIMPENNY, R. S. 1936. Ova and larvae of *Mugil capito* from Egypt. Ann. Mag. Nat. Hist., 17(10) : 405 - 412.

TABLE I.

Food of *Mugil cephalus* collected from inshore areas.

No. of fishes examined	18		20		22		28	
Average volume stomach contents in c.c.	1.2		1.3		1.2		1.1	
Months	January		February		March		April	
Stomach contents	Percentage	food components	Percentage	food components	Percentage	food components	Percentage	food components
Decayed organic matter	30.2	—	32.2	—	30.2	—	25.8	—
Copepods	22.4	*Euterpina* sp. *Oithona* sp. *Acartia* sp. *Paracalanus* sp.	30.8	*Corycaeus* sp. *Acartia* sp. *Pontella* sp. *Oithona* sp. *Eucalanus* sp.	19.8	*Paracalanus* sp. *Corycaeus* sp. *Pontella* sp. *Oithona* sp.	22.2	*Eucalanus* sp. *Pontella* sp. *Acartia* sp. *Oithona* sp. *Corycaeus* sp. *Macrosetella* sp.
Algae	13.2	*Oscillatoria* *Enteromorpha*	10.4	*Oscillatoria* *Cosmarium* *Symploca*	6.2	*Symploca* *Oscillatoria* *Enteromorpha* Algal spores	13.2	*Oscillatoria* *Enteromorpha* *Cladophora* *Symploca*
Diatoms	8.2	*Pleurosigma* *Asterionella*	12.0	*Asterionella* *Pleurosigma* *Rhizosolenia* *Surirella*	11.4	*Coscinodiscus* *Pleurosigma* *Navicula* *Asterionella*	8.4	*Fragilaria* *Pleurosigma* *Coscinodiscus*
Miscellaneous	10.0	Crustacean remains Polychaetes	8.2	larval bivalves Polychaetes	4.8	Crustacean & Polychaete remains	4.2	Crustacean remains
Sand particles	16.0	—	6.4	—	28.6	—	26.2	—

Continued

No. of fishes examined	22		24		28		30	
Average volume stomach contents in c.c.	1.0		0.8		0.9		1.0	
Months	May		June		July		August	
Stomach contents	Percentage	food components	Percentage	food components	Percentage	food components	Percentage	food components
Decayed organic matter	43.0	—	45.0	—	28.0	—	33.0	—
Copepods	12.0	*Macrosetella* sp. *Labiocera* sp. *Pontella* sp. *Oithona* sp. *Temora* sp. *Paracalanus* sp.	15.4	*Calanopia* sp. *Acartia* sp. *Temora* sp. *Oithona* sp. *Pontella* sp.	22.0	*Corycaeus* sp. *Oithona* sp. *Paraculanus* sp. *Acartia* sp.	20.0	*Acrocalanus* sp. *Temora* sp. *Oithona* sp. *Paracalanus* sp. *Labidocera* sp.
Algae	6.2	*Oscillatoria* *Protoccoccus*	6.4	*Protococcus* *Merismopedia* *Oscillatoria*	5.4	*Merismopedia* *Oscillatoria* *Lynoglya* *Anabaena*	10.8	*Oscillatoria* *Protococcus* *Cosmarium*
Diatoms	4.8	*Surirella* *Cyclotella* *Pleurosigma* *Nitzschia*	6.2	*Coscinodiscus* *Nitzschia* *Synedra* *Asterionella* *Cymbella*	3.8	*Asterionella* *Thalassiothrix* *Cymbella* *Bacteriastrum* *Pleurosigma*	4.0	*Nitzschia* *Coscinodiscus* *Surirella* *Bacteriastrum* *Pleurosigma*
Miscellaneous	2.5	larval bivalves Polychaetes	5.2	Polychaete remains	10.7	Crustacean remains Polychaetes	5.2	Polychaete remains
Sand particles	31.5	—	21.8	—	20.2	—	27.0	—

Continued

No. of fishes examined	18		12		21		19	
Average volume stomach contents in c.c.	1.2		0.8		0.9		0.7	
Months	September		October		November		December	
Stomach contents	Percentage	food components	Percentage	food components	Percentage	food components	Percentage	food components
Decayed organic matter	30.0	—	30.0	—	38.8	—	30.0	—
Copepods	30.0	*Acartia* sp. *Pontella* sp. *Eucalanus* sp. *Temora* sp.	38.0	*Centropages* sp. *Temora* sp. *Pontella* sp. *Acartia* sp. *Labidocera* sp.	31.2	*Euterpina* sp. *Paracalanus* sp. *Pontella* sp. *Temora* sp. *Oithona* sp. *Corycaeus* sp.	27.0	*Labidocera* sp. *Corycaeus* sp. *Acartia* sp. *Paracalanus* sp. *Pontella* sp. *Temora* sp.
Algae	10.0	*Merismopedia* *Oscillatoria* *Lyngbya* *Polysiphonia*	15.0	*Oscillatoria* *Lyngbya* *Chaetomorpha*	6.0	*Polysiphonia* *Lyngbya* *Oscillatoria*	13.0	*Lyngbya* *Oscillatoria* *Chaetomorpha* *Polysiphonia* *Merismopedia*
Diatoms	15.0	*Coscinodiscus* *Asterionella* *Pleurosigma* *Navicula* *Synedra*	3.0	*Pleurosigma* *Asterionella* *Cyclotella* *Cyrosigma* *Nitzschia*	9.0	*Nitzschia* *Asterionella* *Pleurosigma* *Navicula*	5.0	*Coscinodiscus* *Pleurosigma* *Asterionella*
Miscellaneous	6.5	Crustacean remains	2.5	Polychaete remains	4.0	Crustacean remains	3.2	—
Sand particles	13.5	—	6.5	—	16.0	—	22.8	—

TABLE II.

Food of *Mugil cephalus* collected from off shore areas.

No. of fishes examined	14		16		18		20	
Average volume stomach contents in c.c.	0.7		0.8		0.9		1.2	
Months	January		February		March		April	
Stomach contents	Percentage	food components	Percentage	food components	Percentage	food components	Percentage	food components
Decayed organic matter	32.0	—	40.0	—	28.0	—	30.0	—
Copepods	18.0	*Pseudodiaptomus* sp. *Temora* sp. *Acartia* sp. *Paracalanus* sp. *Eucalanus* sp. *Corycaeus* sp. *Acrocalanus* sp.	25.0	*Labidocera* sp. *Macrosetella* sp. *Pontella* sp. *Temora* sp.	26.0	*Paracalanus* sp. *Acartia* sp. *Oncaea sp.* *Calanopia* *Euterpina*	20.0	*Euterpina* sp. *Acartia* sp. *Temora* sp. *Oithona* sp. *Pseudodiaptomus* sp.
Algae	2.5	*Oscillatoria* *Cosmarium* *Enteromorpha* *Merismopedia* *Lyngbya*	5.5	*Oscillatoria* *Merismopedia* *Protococcus*	12.0	*Oscillatoria* *Cosmarium* *Enteromorpha* *Merismopedia* *Lyngbya* *Anabaena*	15.4	*Oscillatoria* *Cosmarium* *Symploca* *Enteromorpha* *Lyngbya* *Protococcus*
Diatoms	2.0	*Coscinodiscus* *Rhizosolenia* *Planktoniella* *Fragilaria* *Trichodesmium* *Pleurosigma*	6.5	*Surirella* *Coscinodiscus* *Cyclotella* *Bacteriastrum* *Rhizosolenia* *Pleurosigma*	4.5	*Fragilaria* *Synedra* *Pleurosigma* *Diploneis* *Navicula* *Surirella*	8.7	*Coscinodiscus* *Pleurosigma* *Surirella* *Rhizosolenia* *Asterionella* *Thallasionema*
Miscellaneous	5.5	Polychaete and Crustacean remains	3.0	Polychaete remains	5.2	Crustacean remains	5.7	Polychaete remains
Sand particles	40.0	—	20.0	—	24.0	—	20.2	—

Continued

No. of fishes examined	20		18		16		22	
Average volume stomach contents in c.c.	1.4		1.2		0.8		0.8	
Months	May		June		July		August	
Stomach contents	Percentage	food components	Percentage	food components	Percentage	food components	Percentage	food components
Decayed organic matter	32.0	—	38.0	—	31.2	—	27.0	—
Copepods	28.0	*Oithona* sp. *Temora* sp. *Paracalanus* sp. *Pontella* sp. *Eucalanus* sp. *Pseudodiaptomus* sp. *Acartia* sp.	30.0	*Labidocera* sp. *Centropages* sp. *Schmackeria* sp. *Temora* sp. *Acartia* sp. *Pontella* sp.	38.8	*Labidocera* sp. *Corycaeus* sp. *Acartia* sp. *Temora* sp. *Schmackeria* *Paraculanus* sp.	30.0	*Euterpina* sp. *Paracalanus* sp. *Oithona* sp. *Pseudodiaptomus* sp. *Corycaeus* sp. *Acartia* sp. *Temora* sp. *Labidocera* sp. *Centropages* sp.
Algae	15.0	*Oscillatoria* *Lyngbya* *Polysiphonia* *Chaetomorpha* *Merismopedia*	17.0	*Polysiphonia* *Lyngbya* *Oscillatoria* *Merismopedia*	5.0	*Oscillatoria* *Polysiphonia*	12.0	*Oscillatoria* *Lyngbya*
Diatoms	5.0	*Pleurosigma* *Nitzschia* *Coscinodiscus* *Gyrosigma* *Mastogolia* *Navicula*	6.0	*Pleurosigma* *Coscinodiscus* *Synedra*	10.0	*Gyrosigma* *Coscinodiscus* *Nitzschia* *Pleurosigma* *Synedra* *Navicula*	6.0	*Coscinodiscus* *Mastogloia* *Nitzschia*
Miscellaneous	4.5	—	3.5	—		—	2.2	—
Sand particles	15.5	—	5.5		20.0	—	22.8	—

Continued

No. of fishes examined	18		20		24		38	
Average volume stomach contents in c.c.	1.2		2.2		2.4		2.6	
Months	September		October		November		December	
Stomach contents	Percentage	food components	Percentage	food components	Percentage	food components	Percentage	food components
Decayed organic matter	18.0	—	25.0	—	28.0	—	38.1	—
Copepods	13.6	*Euterpina* sp. *Paracalanus* sp. *Acartia* sp. *Eucalanus* sp. *Oithona* sp. *Pontella* sp.	20.0	*Macrosetella* sp. *Corycaeus* sp. *Paracalanus* sp. *Oithona* sp. *Temora* sp. *Eucalanus* sp.	21.0	*Corycaeus* sp. *Acrocalanus* sp. *Temora* sp. *Oithora* sp. *Acartia* sp.	29.9	*Paracalanus* sp. *Pontella* sp. *Oithona* sp. *Acartia* sp. *Temora* sp. *Acartia* sp.
Algae	2.4	*Oscillatoria* *Enteromorpha* *Cosmarium* *Cladophora*	5.7	*Symploca* *Oscillatorian* Algal spores *Anabaena* *Symploca*	8.8	*Oscillatoria* *Enteromorpha*	6.2	*Oscillatoria* *Enteromorpha* *Cludophora*
Diatoms	20.0	*Asterionella* *Pleurosigma* *Thalassionema* *Cymbella*	20.0	*Fragilaria* *Pleurosigma* *Diploneis* *Nitzschia*	18.2	*Pleurosigma* *Asterionella* *Synedra* *Cymbella* *Navicula* *Gyrosigma*	5.8	*Navicula* *Coscinodiscus* *Gyrosigma* *Pleurosigma* *Asterionella* *Synedra*
Miscellaneous	12.0	Crustacean & Polychaete remains	4.5	Polychaete remains Larval shells	10.0	Crustacean & Polychaete remains larval shells	—	—
Sand particles	34.0	—	24.8	—	14.0	—	20.0	—

TABLE III.

Food of *Mugil cephalus* collected from Brackish water.

No. of fishes examined	22		28		14		18	
Average volume stomach contents in c.c.	1.3		1.6		1.4		1.0	
Months	January		February		March		April	
Stomach contents	Percentage	food components	Percentage	food components	Percentage	food components	Percentage	food components
Decayed organic matter	32.0	—	28.0	—	37.6	—	22.8	—
Copepods	28.0	*Paracalanus* sp. *Acartia* sp. *Oithona* sp. *Pontella* sp.	30.0	*Eucalanus* sp. *Acartia* sp. *Corycaeus* sp. *Pontella* sp. *Temora* sp.	22.4	*Pontella* sp. *Eucalanus* sp. *Acartia* sp. *Oithona* sp. *Corycaeus* sp.	45.2	*Acartia* sp. *Oithona* sp. *Euterpina* sp. *Pontella* sp.
Algae	12.0	*Oscillatoria* *Symploca* *Enteromorpha* *Oscillatoria* *Cosmarium*	12.0	*Enteromorpha* *Oscillatoria* *Cladophora* *Cosmarium*	10.0	*Oscillatoria* *Enteromorpha*	8.0	*Oscillatoria* *Symploca*
Diatoms	7.0	*Pleurosigma* *Asterionella*	8.0	*Coscinodiscus* *Asterionella* *Pleurosigma*	5.0	*Fragilaria* *Pleurosigma* *Asterionella*	7.0	*Navicula* *Asterionella* *Pleurosigma* *Rhizosolenia*
Miscellaneous	4.0	larval bivalves Crustacean remains	2.0	Polychaete remains	5.0	Crustacean remains	—	—
Sand particles	17.0	—	20.0	—	20.0	—	17.0	—

Continued

No. of fishes examined	16		14		12		10	
Average volume stomach contents in c.c.	1.0		0.6		0.4		0.6	
Months	May		June		July		August	
Stomach contents	Percentage	food components	Percentage	food components	Percentage	food components	Percentage	food components
Decayed organic matter	29.9	—	21.4	—	20.0	—	38.1	—
Copepods	38.1	*Temora* sp. *Oithona* sp. *Pontella* sp. *Calanopia* sp. *Labidocera* sp.	27.6	*Acrocalanus* sp. *Temora* sp. *Oithona* sp. *Paracalanus* sp. *Pontella* sp.	25.0	*Corycaeus* sp. *Acrocalanus* sp. *Acartia* sp. *Temora* sp. *Acartia* sp.	29.9	*Acartia* sp. *Oithona* sp. *Paracalanus* sp. *Labidocera* sp. *Temora* sp.
Algae	5.8	*Protococcus* *Oscillatoria*	16.8	*Oscillatoria* *Merismopedia* *Lyngbya*	15.7	*Merismopedia* *Oscillatoria* *Anabaena* *Cosmarium*	6.2	*Oscillatoria* *Protococcus* *Cosmarium*
Diatoms	6.2	*Asterionella* *Pleurosigma* *Coscinodiscus* *Gyrosigma*	10.2	*Synedra* *Pleurosigma* *Asterionella* *Navicula*	10.0	*Fragilaria* *Asterionella* *Pleurosigma* *Cymbella*	5.8	*Nitzschia* *Diploneis* *Asterionella* *Pleurosigma*
Miscellaneous	8.0	Cructacean remains	6.0	Polychaete remains	14.5	larval shells Crustacea & Polychaete remains	—	—
Sand particles	12.0	—	18.0	—	14.8	—	20.0	—

Continued

No. of fishes examined	18		20		19		21	
Average volume stomach contents in c.c.	0.3		0.2		0.5		0.8	
Months	September		October		November		December	
Stomach contents	Percentage	food components	Percentage	food components	Percentage	food components	Percentage	food components
Decayed organic matter	30.2	—	25.8	—	32.2	—	19.8	—
Copepods	22.4	*Eucalanus* sp. *Pontella* sp. *Acartia* sp. *Corycaeus* sp. *Macrosetella* sp. *Paracalanus* sp.	22.2	*Euterpina* sp. *Oithona* sp. *Acartia* sp. *Temora* sp.	30.8	*Paracalanus* sp. *Corycaeus* sp. *Pontella* sp. *Oithona* sp. *Acartia* sp.	30.2	*Eucalanus* sp. *Pontella* sp. *Acartia* sp. *Oithona* sp. *Paracalanus* sp.
Algae	13.2	*Oscillatoria* *Cosmarium* *Merismopedia* *Protococcus*	13.2	*Oscillatoria* *Enteromorpha* *Lyngbya* *Anabaena*	10.4	*Cosmarium* *Symploca* *Oscillatoria*	16.2	*Protococcus* *Oscillatoria* *Merismopedia* *Lyngbya*
Diatoms	8.2	*Pleurosigma* *Diploneis* *Navicula* *Asterionella*	8.4	*Fragilaria* *Synedra* *Pleurosigma* *Asterionella*	12.0	*Coscinodiscus* *Pleurosigma* *Asterionella* *Rhizosolenia* *Fragilaria*	11.4	*Pleurosigma* *Asterionella* *Navicula* *Surirella* *Thallasionema*
Miscellaneous	10.0	larval shells Crustacean remains	4.2	Crustacean remains	8.2	Polychaete & Crustacean remains	4.8	digested matter
Sand particles	16.0	—	26.2	—	6.4	—	28.6	—

TABLE IV.

Condition of feeding of *Mugil cephalus* in the various environment expressed in percentage.

Intensity of feeding	Jan.	Feb.	March	Apr.	May	June	July	Augt.	Sep.	Oct.	Nov.	Dec.	
Empty	8.4	—	—	—	—	—	—	—	—	—	—	—	
little	3.2	2.1	—	14.2	22.4	32.4	40.2	—	29.7	8.6	—	—	
¼ full	4.2	28.0	38.0	11.2	30.0	28.4	12.2	32.6	25.3	40.8	21.0	5.1	
½ full	24.4	22.4	24.6	48.2	14.8	6.7	32.8	32.4	17.2	15.6	14.8	20.0	inshore
¾ full	48.2	14.2	12.8	19.7	4.2	6.2	—	—	24.5	22.8	29.6	14.4	
full	8.5	12.5	14.2	36.2	11.2	6.1	—	—	—	14.2	43.4	15.3	
Gorged	18.6	9.2	—	—	—	—	—	—	—	2.6	2.1	6.1	
Empty	—	—	—	—	28.0	—	—	10.0	20.8	5.4	3.2	10.8	
little	70.2	66.2	48.2	52.4	48.2	50.3	30.4	—	60.4	32.4	25.2	34.4	
¼ full	30.4	19.8	20.4	16.3	10.2	28.2	38.4	12.4	32.4	—	22.8	20.4	
½ full	9.8	12.4	—	—	38.2	40.2	5.6	38.2	20.2	14.6	—	18.4	Offshore
¾ full	16.2	—	—	—	8.8	—	—	—	—	12.8	18.8	14.4	
full	4.2	—	—	—	16.2	12.0	18.2	6.4	24.4	12.8	—	—	
Gorged	—	—	—	—	—	—	—	—	—	—	4.2	—	
Empty	—	—	—	—	—	12.2	24.6	—	—	—	6.7	—	
little	2.2	—	—	—	18.2	20.4	12.2	30.4	20.4	18.9	—	—	
¼ full	5.7	6.8	12.2	—	48.2	40.4	18.2	40.2	32.4	49.2	50.2	—	Brackish
½ full	—	10.4	—	—	24.2	6.8	48.2	8.3	29.4	—	30.2	—	
¾ full	12.2	—	4.2	—	6.8	8.2	—	—	10.8	—	14.6	50.2	
full	—	58.2	8.9	28.4	6.2	—	4.2	3.2	—	—	—	—	
Gorged	—	2.2	—	—	—	—	—	—	—	—	—	—	

TABLE V.

Feeding in relation to maturity.

Environment	Average volume of stomach contents in c.c.				
	immature	maturing	mature	spawning	spent
inshore	2.4 (106)	1.8 (84)	0.8 (42)	0.1 (22)	1.0 (60)
offshore	3.6 (114)	2.4 (56)	1.1 (44)	0.2 (12)	1.2 (18)
brackish	1.8 (48)	1.4 (42)	0.6 (64)	0.08 (28)	0.2 (30)

The figures in bracket denotes the number of fishes examined in each stage.