DIET-COMPOSITION OF *GUDUSIA CHAPRA* (HAMILTON) FROM THE GANGA RIVER SYSTEM*

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Planktonic Crustacea were found to be of regular major importance as food of *G. chapra* belonging to all age groups. The 0-group was characterised by sole consumption of plankton while the age groups I to VIII appeared to have acquired some plasticity with regard to food consumption, originating as a tendency to consume food particles of bigger sizes as well. Feeding on surface-inhabiting plankton, the older age groups were found to switch over to feeding on marginal and bottom food also when the surface food reached its lowest ebb in the environment. Changes in the life cycle of *G. chapra* were found to affect its feeding intensity and they could be correlated with the changes in sexual cycle. The maturation period coincided with a phase of subdued feeding. Active feeding was observed during pre-and post-spawning phases.

INTRODUCTION

An understanding of the growth pattern of a fish would be incomplete without a knowledge of the diet on which it subsists and the nutritive values of the food items. The dependence of growth, one of the most important variables entering the yield equation, on food renders the latter as an important feature of the present-day research in the dynamics of fish populations. Finally, estimation of the total amount of food consumed annually by a population in a steady state, for maintenance and growth, is one of the necessary pre-requisites for constructing theoretical models for the evaluation of the yield per recruit. As a part of the investigations on the biological structure of the population of *G. chapra* in the Ganga river system at Allahabad, studies on such aspects as identification and evaluation of stomach contents, variations in the volume of food elements and the changes in food preference with increase in fish size, were made.

MATERIALS AND METHODS

The present paper is based on an investigation of 1,132 specimens in the course of four years from 1958 to 1961. Along a 100 km stretch of the Ganga river system in and around Allahabad, two sampling points viz., Sadiapur and Daraganj fish assembly centres, were selected for these studies. Samples were collected bi-weekly

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all the year round from these assembly centres. Occasionally, specimens were also collected directly from fishermen's catches at the fishing sites. Every fish was accurately weighed and measured in the laboratory and stomachs were preserved in 5 per cent formalin. The contents of each stomach were examined microsically. The identification of the food components was done to such a level as would satisfy the purpose of discussing their significance in the paper. To get a numerical expression of the importance of various food components, the 'Index of Preponderance' method was followed (Natarajan and Jhingran 1961). The symbol I_i, used in the following text, denotes the index of preponderance of a particular food item.

Food Composition

The fish were grouped into 50 mm size groups for food analysis. This was done with a view to finding out if any marked variations occurred in the food of the species with increase in its size. It was soon observed that there was virtually no apparent difference in the food ingested by the various age groups and hence, the observations, for the rest of the period, were confined only to two separate groups, i.e. the 0–age group and all the rest pooled together.

Food of the 0-age group

The exploitation of *G. chapra* in the Ganga river system is highly seasonal and the bulk of the catch is landed during monsoon and winter seasons. Proportion of juveniles in the monthly catches at the fish assembly centres remained quite high almost throughout the year, except during active spawning months when large fishes were found to preponderate. The juveniles were, therefore, not available in the commercial catches all through the year. A total of 286 specimens collected during eight months, viz., January, February, June to September, November and December, were subjected to stomach analysis. These specimens ranged in total length from 19 to 55 mm. The number of specimens examined during January and December, was relatively low. However, the number of specimens in collections, pertaining to other months, ranged from 30 to 70 per month.

Fig. 1 portrays the overall picture of the total food consumed by *G. chapra* of 0–age group. A detailed description of the seasonal variations in qualitative and quantitative abundance of various food elements is given below :

(a) *Crustacea*—Copepoda were taken by the fish in practically all the months except January when out of the 15 specimens examined, none contained copepods. Copepods wereespecially noticeable during February and June to September. The highest copepod content was noticed in the stomachs examined in February in which month they constituted 35.9 per cent by volume of the total stomachs examined. *Cyclops, Diaptomus* and *Pseudodiaptomus* were the commonest genera noticed in the stomach contents.

Cladocera formed the most important food of the species, having been recorded in all the eight months. Their average I_i ranged from 3.86 in November to 95.05 in January. The volumetric contributions of cladocerans to the total food amounted to 92.6 per cent in January when they were encountered in 54.6 per cent of the total

number of specimens examined. The common genera identified in the stomach contents were *Chydorus*, *Daphnia*, *Ceriodaphnia*, *Bosmina*, *Sida*, *Alona*, and *Diaphanosoma*.

Amphipoda were seen only occasionally in the food items. They were totally absent in January, July to September, and November. In the rest of the months their average I_i ranged between 0.19 in August and 3.81 in December. They were found only in 3 per cent of the stomachs examined in all the eight months. Gammaridae formed almost the whole of the amphipodan element in the food.

(b) *Rotifera*—Next to Crustacea, Rotifera formed the most important item of food. Rotifers were found mainly in November when as many as 30 per cent stomachs contained them and they constituted 52 per cent by bulk of the total food taken by the fish in that month. They were absent in December and January. In other months their average I_i ranged between 2.85 (September) and 10.50 (August). *Keratella*, *Brachionus*, *Synchaeta*, *Polyarthra*, *Euchlanis*, *Filinia* and *Salpina* were the important generic constituents.

(c) *Algae*—Among algae, Myxophyceae alone were recorded and there was a significant absence of Chlorophyceae altogether. Except in July, Myxophyceae were taken in all the months, their average I_i having a range of 0.18 in November to 28.43 in August. In the latter month, their volumetric percentage was estimated to be 28.0 and that of occurrence 28.2. The identified representatives of this group were *Microcystis*, *Merismopedia*, *Anabaena* and *Lyngbya*.

Protozoa—Protozoa formed a major proportion of the food in November, constituting 36.9 per cent by volume and being present in 51.7 per cent of the total number of stomachs examined (I_i=39.04). Besides November, when they stood out as the second most important food of *G. chapra* belonging to 0-group, their contribution to the food of the species was almost negligible in other months. Being totally absent in January, June, September and December, they formed very little by volume of the total food in other months (0.4 to 5.1 per cent), though their percentage occurrence ranged from 1.9 (August) to 10.2 (July) in specimens examined during these months. The identified genera were *Arcella* and *Difflugia*.

Food of I to VIII age groups

The analyses of 846 stomachs belonging to age groups I to VIII revealed that Crustacea formed by far the greater part of the food consumed by the species. The results based on stomachs taken throughout the year and referring to the total annual food intake of the species in its I to VIII year of life are depicted in a pie-diagram (Fig. 1).

A detailed description of the seasonal variations observed in the diet of the fish is given below :

(a) *Crustacea*—As in the case of 0-age group, here too, Copepoda, though present in eleven months of the year, were noticed to form a low percentage of the total food by volume that ranged between 0.5 in March and 41.5 in October. They were absent in May. Besides October, August was the only month which registered a high percentage of Copepoda-intake by the fish (I_i=27.09). The common genera recorded were *Cyclops*, *Diaptomus* and *Pseudodiaptomus*.

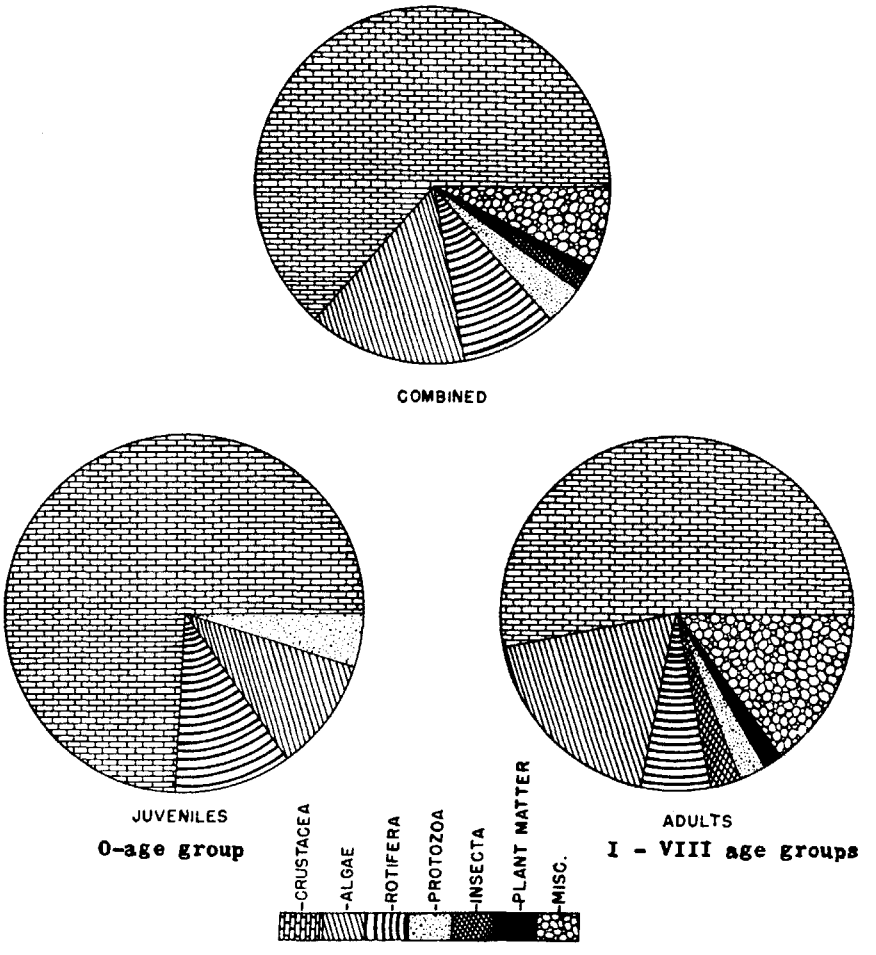

FIG. 1. Pie-diagrams showing food composition of *G. chapra*.

The predominance of Cladocera, as the most important food of the fish, was noticed in most of the months. The values of I_i were quite high during the months December to March, ranging from 62.26 in February to 94.16 in December. But for the month of October when the I_i of Cladocera went too low (0.07), in other months these values fell within a range of 4.57 (November) to 38.65 (April). Cladocera provided the highest volume of the total food content in Jaunary (76.2 per cent). However, their occurrence in maximum number of specimens was recorded in December (39.7 per cent). The commonest representatives were *Chydorus*, *Bosmina*, *Ceriodaphnia*, *Sida* and *Alona*.

Ostracoda formed a small but consistent part of the food, being most common in the months of March, April, June, October and December. Their I_i values ranged throughout between 0.1 (January) and 4.0 (October). They did not form part of the food of *G. chapra* in February, May and July. The only representative was *Cypris* sp.

The proportion of Amphipoda in the total volume of the food in the stomachs was very little, especially so when compared to their contribution to the diet of 0-group fish. Out of the only two months, February and March, when they were consumed by the fish, amphipods were maximum in March forming 6.7 per cent of the total food volume and occurring in 3.7 per cent of the stomachs. *Gammarus* was the only species found in the food.

Decapoda, too, appeared only occasionally in the stomach contents with a low percental volumetric contribution to the total food. They were observed in the stomach contents only in January and March, the I_i in these two months being 0.08 and 0.02 respectively.

(b) *Insecta*—Among insects, Coleoptera, completely aquatic in all stages, and aquaticl arvae of those generally living on water margins, were recorded from the stomachs. Beetles as a whole did not form an important food item of the species as they occurred only sparingly. Their presence was noticed only during April, September and October, the average I_i in these months being 0.81, 8.19 and 9.20 respectively *Dytiscus*, *Hydrophilus*, *Hydrus* and *Cybister*, were the identified Coleoptera in the food.

Hemipteran larvae too were of rare occurrence in the food of *G. chapra*, registering their presence in the stomach contents only in August and October. In these months their volumetric percentages were observed to be 4.3 and 1.3 respectively. In August, Hemiptera, though constituting very little in bulk, occurred in 10.2 per cent of the total number of stomachs examined. A number of genera could be identified from the stomachs. The important representatives of this group, as identified in the stomach contents, were *Ranatra* and *Nepa*.

Diptera, solely represented by chironomid larvae, were very poorly represented in the stomach contents. Occurring only in 8.4 and 4.7 per cent of the stomachs examined in January and July respectively, they formed only 1.4 and 4.9 per cent by volume of the total food consumed by the fish in these months. The only identified genus was *Chironomus*.

Nymphs of Ephemeroptera showed only accidental appearance in the stomachs examined in November and formed a very small proportion of food (3.4 per cent of the total volume). Only 6.8 per cent of the fishes appeared to have ingested them.

Odonata nymphs were encountered in March and October only and that too in meagre quantities. Their volumetric percentages were calculated to be 7.2 in March and 0.3 in October. 2.5 and 1.9 per cent of the stomachs, examined in March and October respectively, contained them.

Plecoptera formed a very insignificant proportion of the diet. Occurring in 1.3 per cent of the stomachs analysed in July, they formed 0.4 per cent by volume of the total food consumed in this month. They were absent in rest of the months.

(c) *Algae*—Myxophyceae were present in the food throughout, except in February. Though they formed relatively small proportion of the total food volume of the fish, they were fairly consistent in their occurrence in the stomachs. The avera ge value of I_i ranged between 0.02 (March) and 29.05 (September). Their percentages by volume and occurrence were comparatively high during November when they

formed 12.4 per cent of the total food volume and 18.5 per cent of the fish seemed to have subsisted on them. Of the total genera observed in the stomach contents, the important ones were *Merismopedia, Microcystis, Oscillatoria, Lyngbya, Anabaena, Nostoc* and *Rivularia.*

Chlorophyceae, totally absent in fish of the 0-group, were strikingly present in large proportions in the stomachs of other age groups (I to VIII). They were present in the food all the year round. Chlorophyceae were most common in February, June, and July, the average I_i in these months being 31.70, 14.48, and 26.57 respectively. In other months their average I_i ranged between 0.59 and 6.82. In general, though they contributed less by bulk to the food of the fish, their occurrence was recorded in a large number of specimens. Thus in January they formed only 1.1 per cent of the total food while their occurrence was noticed in 11.0 per cent stomachs. The important generic constituents were *Spirogyra, Mougeotia, Ulothrix, Pediastrum, Coelastrum, Zygnema* and *Ankistrodesmus.*

Bacillariophyceae too consistently occurred in a large number of specimens. Though their percental contribution to the total food volume remained low, their preponderance in the stomachs during June and July (I_i=23.02 and 13.27 respectively) was significant. In June, their volumetric and occurrence percentages were almost equal (v_i=17.8, 0_i=15.8) whereas in July they formed a very low proportion of the total food (5.3 per cent by volume). Their occurrence was noticed in as much as 27.3 per cent of the specimens. Bacillariophyceae were represented by *Melosira, Synedra, Navicula, Nitzchia, Fragilaria, Gyrosigma, Pinnularia, Cymbella, Amphora, Rhopalodia, Surirella* and *Cyclotella.*

Desimds were only occasionally seen in the food of *G. chapra.* June and September were the months when they occurred only in 2.2 and 0.6 per cent stomachs respectively, forming 0.2 and 0.8 per cent of the total volume of food. The identified genera were *Closterium* and *Cosmarium.*

(d) *Rotifera*—Rotifera were present in the diet consistently all the year round. They were in abundance during April, May and November. In the latter month, they composed as much as 30.5 per cent of the total food volume and occurred in 12.8 per cent of the stomachs, registering an average I_i of 32.25. In April and May their average I_i values were 17.66 and 14.65 respectively. In other months they constituted an insignificant part of the diet. The genera recorded from the stomachs were *Brachionus, Keratella, Gastropus, Notholca, Pedalion, Asplanchna Euchlanis* and *Synchaeta.*

(e) *Protozoa*—Protozoa, though present in small quantities, were taken by the fish through- out the year except January and February. But for November when the I_i of protozoa shot up to 26.48, they did not show any marked seasonal fluctuation. The average I_i ranged between 0.04 and 1.02. Commonest genera were *Arcella, Difflugia, Phacus* and *Euglena.*

(f) *Plant matter*—The presence of hydrophytes, both rooted aquatic plants as well as submerged floating vegetation, was noticed in stomach contents during all the months except February, March, November and December. They made up appreciable proportion of food during May, July and November when their I_i values touched 5.60, 4.31 and 6.95 respectively. In November they formed 5.8 per cent of the total food volume and were present in 14.5 per cent of the stomachs analysed.

(g) *Miscellaneous*—Under this head are included Hydracarina, Polyzoa, decayed organic matter, sand and mud and other semi-digested unidentifiable food matter.

Polyzoa were noted in the stomach contents during August and September only in negligible quantities.

A considerable percentage of decayed organic matter was observed in the stomachs especially from May to August. This item, not noticed in the stomach contents from January to March was abundant in the diet in rest of the months. The I_i of this item increased from April (1.44) and rising through May (11.10) and June (17.31), attained a peak in July (33.75). Subsequently, a gradual fall in the values was noticed until October after which it never showed up in the stomach contents.

A sizeable quantity of sand and mud was also recorded from the stomachs examined from April to June, the peak month of their occurrence being May when it formed 40.2 per cent of the total food and 13.5 per cent fishes contained it. Sand and mud was also noted, though in negligible quantities, in March and September.

In some cases the stomach contents were so far digested that identification of the type of food was not possible. Occasionally, the stomachs contained only a yellowish-white pasty substance in the last stage of digestion. The frequency of occurrence of this pasty material was higher in older age groups almost throughout the year.

Comparison of the food of 0-*and other age groups*

The average index of preponderance of various food items of *G. chapra* belonging to 0-age group and the age groups I to VIII pooled, has been presented in Table I based on samples pooled for the years 1958 to 1961.

TABLE I

Index of preponderance of various food items in G. chapra. *of* 0-*age group and the age groups I to VIII combined*

Food items	Index of preponderance	
	0-age group	I to VIII age groups
Crustacea	74.2	53.2
Algae	10.3	18.7
Rotifera	10.5	6.5
Insecta	—	2.7
Protozoa	5.0	2.4
Hydrophytes	—	1.6
Miscellaneous	—	14.9

A perusal of the indices indicates that no major changes in the diet of the fish, with increase in its size, were noticed. Though fish of the older groups appeared to feed on a wide variety of organisms, the food of the 0-group comprised mainly

surface-inhabiting plankton. Two significant points that can be inferred by the comparison of the food of 0-and other age groups are discussed later in this paper.

Seasonal variations in the food intake

Figure 2 represents the average volume of food per stomach plotted against different months excluding the completely empty stomachs. It is evident from the figure that January, February, November and December were the periods of active feeding, and March to October a period of subdued feeding, the latter coinciding with the spawning season of the fish. The average food per stomach was especially low during April to June which happened to be the period of peak spawning activity. Though the period July to October represented low feeding activity, the average food volume per stomach was relatively higher when compared to that during March to June. As the spawning activity in *G. chapra* is spread over a period of 8 months and each fish sheds a number of batches of ova, it is probable that in samples collected from July to October, the specimens might have already shed one or two batches of ova and resorted to vigorous feeding after the spawning strain, bringing the volume per stomach a little higher than that observed during the initial phases of spawning. In November, an abrupt rise in the volume of food was noticed. This month denotes the end of spawning when the fish are recovering and taking to voracious feeding. It may be mentioned here that in this month recovering specimens were encountered which had their stomachs gorged with insect larvae and macrocrustacea.

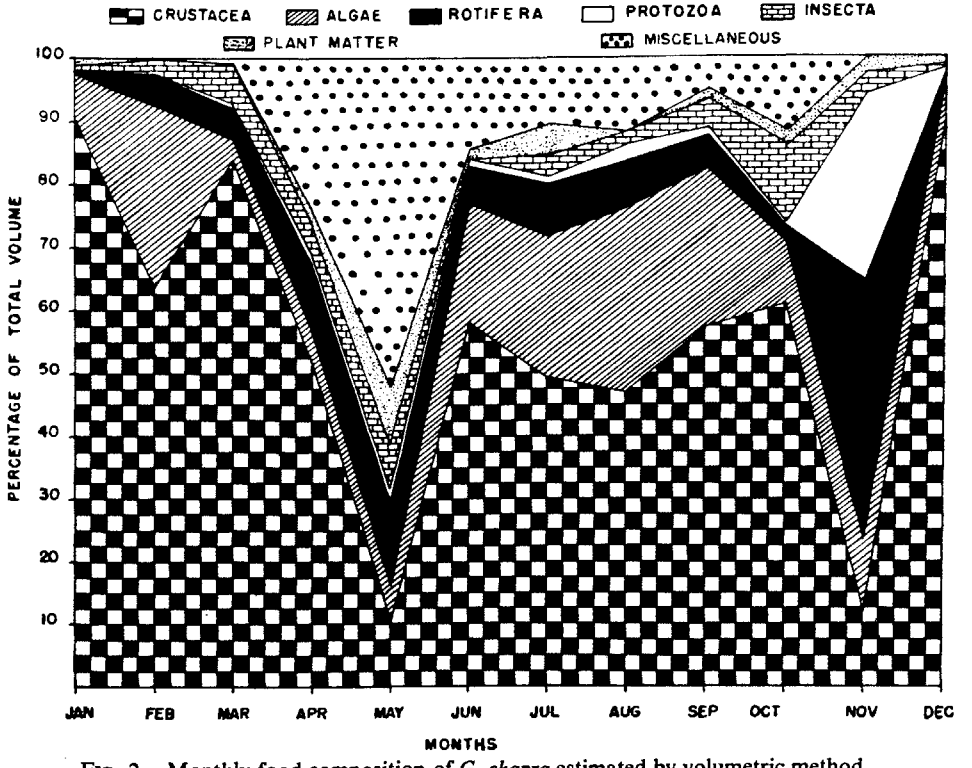

FIG. 2. Monthly food composition of *G. chapra* estimated by volumetric method.

The above observations were further corroborated by finding out the number of empty stomachs occurring in various months. The percentage of empty stomachs was highest from April to July, especially so in June when 55.8 per cent of the stomachs were found to be empty. This may be attributed to the peak breeding in these months. In other months too (August to October), covering the spawning period of the fish, the percentage of empty stomachs was relatively high.

Thus splitting the data into the pre-spawning, spawning and post-spawning periods, the average percentage of empty stomachs in these phases was found to be as follows which substantiates the conclusion drawn from the study of the volume of food per stomach that the feeding intensity in *G. chapra* goes down considerably during the maturation phase (Table II).

TABLE II

Monthly percentage of empty stomachs and the feeding intensity during different maturation phases

Spawning phase	Month	Empty stomachs (percentage)	Feeding intensity
Pres-pawning	January-February	13.1	active feeding
Spawning	March-October	35.8	subdued feeding
Post-spawning	November-December	14.9	active feeding

DISCUSSION

Published information on the food habits of *G. chapra* is scanty. Das and Moitra (1955, 1956) analysed the stomach contents of the species and concluded that *G. chapra* is an omnivorous surface feeder. They further discussed the food composition and the gut length/body length ratio. On the basis of the latter they observed that the alimentary canal in this fish is much shorter, less coiled, differentiated and with a muscular stomach wall. Kapoor (1954, 1957) studied the pharyngeal organs of *G. chapra* and other clupeoids and suggested that these organs aid in the concentration and temporary storage of small food organisms, later swallowing them after they were coalesced into a bolus.

The monthly composition of the diet of *G. chapra*, estimated by volumetric method, is presented in Fig. 2 for all the sizes combined. The diet showed considerable seasonal variations. Fig. 2 indicates that the consumption of surface food (planktonic Crustacea, rotifers, algae, adult Diptera and Hemiptera of terrestrial origin, and chironimid pupae, Ephemeroptera sub-imagines) was high all the year round. As mentioned earlier, it may be concluded that *G. chapra* is mainly a surface feeder with a wide variety of food. Though the occurrence of Ephemeroptera and Plecoptera nymphs, chironomid larvae and coricid bugs together with traces of rooted aquatics and floating marginal vegetation may indicate the bottom and marginal feeding habits, the fairly consistent occurrence of surface fauna in the stomach contents all the year round and in good volume, clearly indicated by Fig. 2;

is sufficient to justify the food proclivity of the fish, pinpointing a positive preference for exploring the surface layers for food. However, the occurrence of bottom and marginal fauna, though in meagre quantities when compared to the large proportions of the planktonic food, does indicate that the fish may also explore other layers of water for its food.

There is a clear trend of each stomach having one food object in marked abundance (here Cladocera, for instance) indicating that it was carefully selected and preferred by the fish to other items present in lesser quantities. The importance of this particular food item is further substantiated by the fact that it dominated both by its volumetric contribution as well as prevalence and thus well represented by its index of preponderance. Nilsson (1955) observed that the feeding habits of fish are ruled by a complex behaviour mechanism, involving a sort of conditioning on a certain food object being in abundance at a certain time. He further showed (1955 and 1957) in whitefishes and salmonoids the display of a sort of learning on certain food objects when these reach some state that makes them easily available than any other food occurring in the fauna at that time. This he termed as a 'changeable food specialization'. This was observed in the case of *G. chapra* also. For instance, in the month of December, Cladocera constituted 71.2 per cent of the total food organisms by volume. Out of the total Cladocera eaten by the fish, nearly 68.4 per cent consisted of *Chydorus* and *Ceriouaphnia,* though these organisms were not the most abundant in the environment in that month (Pahwa and Mehrotra 1966; Ray *et al.* 1966).

The ability of the older age groups to explore the other layers of water besides the surface one has some biological significance too. If they were confined to the surface layers only for their food thus occupying the same ecological niche as do the fish of the 0-group, this would have brought about some interspecific competition as shown by Hjort (1926) for herring and Svardson (1954 *a*, *b*) for whitefish. But Nilsson (1955) pointed out that no two sympatric species display exactly the same tendency of learning on a particular food object which he described. as the basis of the formation of food niches. This tendency is apparent in *G. chapra* too, looking at the food propensity of the older age groups. When the surface food, to which they have a positive preference, attains a low level of availability, they explore the midwater, bottom and marginal layers for their food under the pressure of competition, both interspecific as well as intra-specific implying an isolating mechanism and keeping them in different ecological niches (Svardson 1954 *a*, *b*, 1958 *a*, *b*; Nilsson 1955; Pejler 1957). When food suitable to both the groups is in preponderance in the environment, the limits of these niches are broken down.

It has been pointed out earlier that fish of the older groups feed on a wide variety of organisms whereas the food of the 0-group comprises mainly of surface inhabiting plankton. Two significant points can be inferred by this comparison :

(i) Planktonic crustacea are of regular and major importance as food of *G. chapra* belonging to all sizes and it is probable that when fish has access to planktonic food they despise other type of food.

(ii) The 0-group is characterised by the sole consumption of plankton wbole the fishes belonging to older groups seem to have occupied some plasticity with regard to the food consumption originating as a tendency to consume food particles of bigger

sizes as well. The feeding habits were found to vary as a response to the prey fauna and the food competitors present in the environment. Feeding on planktonic crustacea on the top layer of water, they switch over to feeding on the marginal and bottom food also when the surface food reaches its lowest ebb in the environment.

Bigelow and Welsh (1924) and Leim (1924) found in some anadromous species the cessation of feeding during spawning migration. Carr (1908 and 1909) observed high percentages of empty stomachs during winter months in *Pleuronectes limanda, Hypoglossus limandoides* and *Gadus merlangus*. Todd (1915) found in plaice (*Pleuronectes platessa*) high percentages of empty stomachs from November to February. Homans and Vladykov (1954) found that the haddock (*Melanogrammus aeglefinus*) continues to fast throughout the spawning period. Similar observations on Indian fishes were made by Pillay (1953) and Jhingran (1961).

The volume of food, as observed during stomach analysis, does not reveal the volume of food consumed by the fish during actual feeding, depend as it does on the differential rates of digestion of different food items. It is expected that most of the food in the stomach would have already been digested at the time it was examined. However, assuming that food in all the stomachs had reached the same state of digestion at the time of analysis, an attempt was made to elucidate the different phases of the feeding activity of the fish. These studies indicated that *G. chapra* ceases to take food during the maturation phase. The specimens collected during the spawning period showed that those which were in less advanced stages of maturity had been feeding, but those in the advanced stages of maturity had not been feeding, their body cavities completely occupied by the ripe gonads. As mentioned earlier, Stage I specimens were observed to have their stomachs gorged with food, indicating a voracious feeding after undergoing a heavy strain of spawning. This spurt of heavy feeding in spent specimens is probably to regain the lost weight (Homans and Vladykov 1954). Thus it may be concluded that changes in the life cycle of *G. chapra* affect its feeding habits and they can be correlated with the changes in the sexual cycle.

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