

## Diet composition and seasonality of *Chrysochir aurea* (Richardson, 1846) along Digha coast, West Bengal, India

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A pioneering study on food and feeding habits and seasonal variation in diet of *Chrysochir aurea* was conducted along the Digha coast of West Bengal, India, from October 2021 to September 2022. The analysis involved a total of 562 specimens with lengths ranging from 124 mm to 417 mm that were collected by commercial trawlers. The indices of preponderance and relative importance revealed that the crustaceans dominated the stomach content of *C. aurea*, followed by fishes, unidentified digested matter and molluscs. Among crustaceans, the important food items recorded were penaeid shrimps, *Acetes* spp., crabs, *Squilla* spp., and semi-digested shrimps; among teleosts *Secutor* spp., *Bregmaceros* sp., *Stolephorus* spp., ribbon fish, flatfishes, *Coilia* spp., and semi-digested fish bodies were recorded; whereas, among molluscs *Octopus* spp. and *Sepia* spp. were recorded occasionally. Relative length of gut for both sexes was less than one, indicating *C. aurea* is a carnivore fish. Males and females had the highest gastro-somatic index during the monsoon (2.716 %) and pre-monsoon (2.856 %) seasons, respectively; whereas, the highest hepato-somatic index (male: 1.134 %, female: 1.080 %) was observed during the monsoon and lowest during the post-monsoon (male: 0.777 %, female: 0.769 %) seasons. Based on the overall vacuity index (31.14 %), *C. aurea* could be categorized as a 'relatively edacious feeder'. During the monsoon season, the feeding intensity observed was low compared to the other seasons, as revealed in the stomach fullness index (males: 0.656 %, females: 0.907 %). Cluster analysis performed with seasonal percentage gravimetric values of the prey groups revealed that the similarity of food items between monsoon and post-monsoon varied between 87.5 and 90.0 %, respectively. The current findings would abridge an existing knowledge gap in the feeding biology of *C. aurea*, and, thus, will aid in fisheries management.

[**Keywords:** *Chrysochir aurea*, Croaker, Diet seasonality, Feeding dynamics, Feeding indices, India]

### Introduction

Studies on food and feeding habits are an essential part of fish biology and are also crucial in aquaculture operations for the selection of appropriate cultivable species<sup>1</sup>. It not only determines the feeding behaviour of fishes but also helps in understanding the nature of preference for different types of food items in relation to their age, length, sex, and maturity stages. It also provides information on their relative position in the ecosystem and ecological changes required for successful fisheries management<sup>2</sup>. Furthermore, accurate knowledge of the interaction between fish and their food sources is also crucial for forecasting and exploiting fish populations<sup>3</sup>. Food and feeding influence fish development, reproduction and health, as well as their response to physiological and environmental stimuli<sup>4,5</sup>. Fishes have been observed to consume various food items, including phytoplankton, zooplankton, leaves, roots, crustaceans, insects, insect larvae, worms, fishes, and

other material like detritus<sup>6</sup>. Variation in fish food is a natural phenomenon that occur as a result of environmental adaptation and to prevent competition between juveniles and adult fishes<sup>7</sup>.

Fishes of the family Sciaenidae in the order Perciformes, also known as sciaenids, croakers, drummers, or jew fishes, form a significant finfish resource for coastal and demersal fisheries in Indian waters<sup>8</sup>. Sciaenids inhabit relatively shallow waters and in bottoms that are rocky, sandy, or muddy<sup>9</sup> and are chiefly distributed in Indian, Pacific, and Atlantic oceans as well as tropical and subtropical coastal areas and estuaries<sup>10</sup>. Along the Indian coast, these can be found up to 50 – 70 m depth<sup>11</sup>. Sciaenid fishery forms a significant commercial fishery, contributing about 3.3 % to the total marine landings in India in the year 2021<sup>(ref. 12)</sup>. Sciaenids prey upon diverse fauna, including polychaetes, bivalves, crustaceans, and fishes<sup>13</sup> depending on location and availability of prey items<sup>14</sup>. Reeve's croaker, *Chrysochir aurea*

(Richardson, 1846), a native of the Indian and Pacific oceans, is one of the most important benthopelagic sciaenid species living in shallow coastal waters of southern India and south China<sup>15</sup>.

From the west coast of India, extensive research has been done on the biology, diet, and feeding habits of several sciaenids such as *Pseudosciaena diacanthus* at Versova<sup>16</sup>; *Otolithoides brunneus* along the Bombay coast<sup>17,18</sup>; *Otolithoides biauritus* at Vanakbara, Diu<sup>19</sup>; *Otolithes cuvieri* from Ratnagiri, Maharashtra<sup>20</sup>; and *Johnieops sina* along Cochin coast<sup>21</sup>; however, very little work has been done from the east coast of India like, sciaenids in estuarine regions of Bengal<sup>22</sup>, of Madras<sup>23</sup> and Gulf of Mannar<sup>24</sup>; *Pennahia macrophthalmus* at Visakhapatnam<sup>25</sup>; *Otolithes ruber*, *Johnius carutta* and *P. macrophthalmus* from Paradeep coast<sup>26</sup>; and *Otolithoides pama* from Hooghly-Matlah estuary of West Bengal<sup>14</sup>. Biological information available for *C. aurea* in Indian water is very scanty, except a study by Lal Mohan<sup>27</sup>, who reported that the species feeds on small crustaceans. Trophic level of this species is reported as (3.5±0.50) based on food items<sup>28</sup>. Some studies on the reproductive biology of this species are available elsewhere<sup>29</sup>. The present study, therefore, was carried out to analyse the food and feeding habits and seasonal variation in the diet of *C. aurea* along the Digha coast, West Bengal, India, to abridge the research gap.

## Materials and Methods

### Study area and sampling

Samples of *Chrysochir aurea* were collected randomly from the mechanized trawl catch (operated with a trawl net with a cod end mesh size of 18 – 22 mm) of Digha fish landing centre of West Bengal, India (Lat: 21°37'50.16" N, Long: 87°32'35.52" E). The study was carried out for 12 months, from October 2021 to September 2022, with monthly sampling, except for May due to the fishing ban in the region.

A total of 562 specimens of *C. aurea* (267 males and 295 females) ranging from 124 mm to 417 mm in total length and 15.06 g to 958.37 g in total weight were collected. The specimens were transported in an insulated ice box to the laboratory. Fresh specimens were then cleaned, wiped down, and stored in a deep freezer until further analysis. The total length (TL) of the fish specimens was measured to the nearest 1 mm using a standard measuring board, and the weight (g) was measured to the nearest 0.01 g using an electronic balance.

### Quantitative and qualitative analysis of food composition

Gut content analysis was performed by dissecting the fish to expose the internal organs in order to determine sex and then the gut contents were extracted and examined in the fresh condition as possible. After separating the stomach contents, they were placed in petri dishes for qualitative and quantitative analysis. The qualitative analysis focused on identifying the organisms in the gut<sup>30,31</sup>. Food items were identified with the naked eye up to the generic level whenever possible, using the FAO species identification sheets<sup>32</sup>. The food items at the advanced state of digestion were considered as 'digested matter'. Quantitative analysis was done following the gravimetric method involving estimation of the weight of each food item, which is expressed as a proportion of the total weight of the gut contents<sup>33</sup>. The numerical method involved counting the number of individuals of each food item in each stomach, which is expressed as a percentage of the total number of food items in the sample<sup>33</sup>. Volumetric displacement method was performed on each food item using a measuring cylinder with a volume of 50 ml. The frequency of occurrence of each prey item was also determined. For analyzing the seasonal variation in the feeding pattern of the target fish, the mean and standard deviation of several feeding indices such as relative gut length, gastro-somatic length, hepato-somatic index, stomach fullness index and vacuity index were calculated seasonally viz. pre-monsoon (January, February, March, April), monsoon (June, July, August) and post-monsoon (September, October, November and December) and the differences were recorded.

### Feeding intensity

Feeding intensity was determined by assessing the degree of distension of stomachs, which was classified as gorged, full, 3/4 full, 1/2 full, 1/4 full, trace, and empty<sup>34</sup>.

### Index of Preponderance (IP)

The index of preponderance method<sup>35</sup> was followed to analyze the gut contents of *C. aurea*, as it is a carnivorous fish. This index was calculated by following formula:

$$\text{Index of Preponderance (IP)}_i = (V_i \times O_i / \sum V_i \times O_i) \times 100$$

Where ' $V_i$ ' and ' $O_i$ ' are the volume and occurrence index of ' $i^{\text{th}}$ ' food items in percentage, respectively.

### Index of Relative Importance (IRI)

The most important food items were identified by using this index and was calculated following Pinkas<sup>36</sup>.

$$\text{Index of Relative Importance (IRI)} = (\%N_i + \%V_i) \%O_i$$

Where, ' $\%N_i$ ' is the percentage of numerical composition, ' $\%V_i$ ' is the percentage of volumetric composition, and ' $\%O_i$ ' is the percentage of frequency of occurrence of ' $i^{\text{th}}$ ' food item.

### Relative Length of Gut (RLG)

Relative Length of Gut (RLG) was computed as the ratio of the total length of gut (mm) to the total length of fish (mm)<sup>37</sup>.

### Gastro-Somatic Index (GaSI)

Gastro-Somatic Index (GaSI) was calculated as the ratio of the weight of the stomach (g) to the total body weight of fish expressed in percentage (g)<sup>38</sup>.

### Hepato-Somatic Index (HSI)

The HSI was calculated as the ratio of the weight of the liver (g) to the total body weight of fish expressed in percentage<sup>39</sup>.

### Vacuity Index (VI)

The Vacuity Index (VI) is the ratio between the number of empty stomachs and the number of total stomachs analyzed, expressed in percentage<sup>40,41</sup>.

### Stomach Fullness Index (SFI)

Stomach fullness index data is required for investigating the feeding activity of fish species in different seasons. It was estimated as the ratio of the weight of the stomach contents (g) to the difference in the total body weight (g) of the fish and their stomach contents and is expressed in percentage<sup>42</sup>.

### Statistical analyses

The results of various indices computed season-wise and sex-wise were expressed as mean ( $\pm$  standard deviation) using Microsoft Excel. Two-way ANOVA (Analysis of Variance) was performed to test significant differences among sexes and seasons using Microsoft Excel followed by post-hoc analysis. Cluster analysis was carried out using the Bray-Curtis similarity index<sup>43</sup>, and a dendrogram was generated to understand the similarity in feeding patterns among seasons using PAST ver 4.0 software.

## Results and Discussion

### Feeding intensity

Based on feeding intensity, fishes were classified into three categories, namely 'high feeding' (fishes with gorged and full stomachs), 'moderate feeding' (fishes with 3/4 full and 1/2 full stomachs) and 'low feeding' (fishes with 1/4 full, trace and empty stomachs). The season-wise feeding intensities of male and female *C. aurea* are presented in Figure 1. It was revealed that the highest values of 'high feeding' intensity were found during post-monsoon (15.77 %) in males and pre-monsoon (7.74 %) in females. While relatively lower values were recorded during monsoon (9.98 %) and pre-monsoon (8.73 %) seasons in males, and monsoon (7.14 %) and post-monsoon (7.09 %) seasons in females. Males recorded the highest value of 'low feeding' intensity in monsoon (79.48 %), while females in post-monsoon (82.86 %). The highest percentages of 'gorged stomachs' and 'empty stomachs' were found in post-monsoon (7.19 %) and monsoon (44.29 %) seasons, respectively in males; and during pre-monsoon (2.35 %) and monsoon (29.92 %) seasons, respectively in females. Whereas, the percentage intensity of 'gorged stomachs' was lower during the monsoon season in both males (1.39 %) and females (1.9 %).

Feeding intensity, the level or degree of feeding expressed by the relative fullness of the stomach<sup>44</sup>, differs with the availability of food items in the ambient environment, changes in maturity stages of

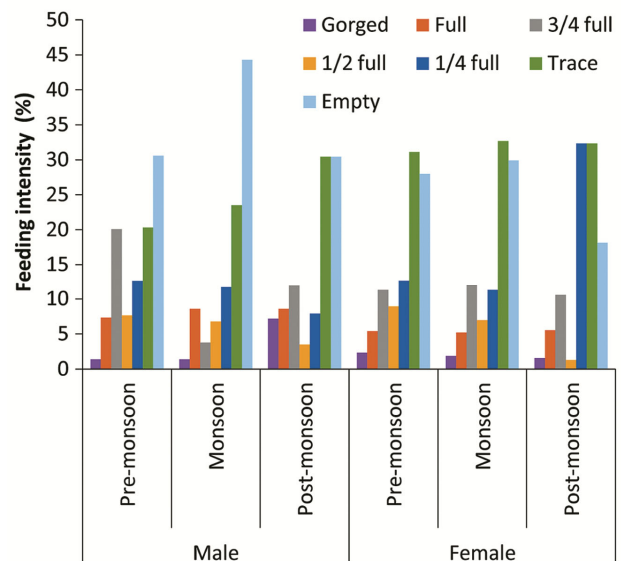


Fig. 1 — Season-wise estimated percentage of feeding intensity of male and female *Chrysochir aurea*

the fishes, seasonal variation in environmental parameters like temperature and salinity, fish health status, size of fish etc.<sup>14,45</sup>. The spawning season of *C. aurea* is reported to be from June to December, with a peak in July to September, which coincides with the monsoon season<sup>29</sup>. The higher percentage intensity of empty stomachs recorded in the present study during monsoon season indicated lesser feeding activity of fish during the spawning season. According to Rao<sup>16</sup>, during the spawning season, the feeding rate is at its lowest, and immediately after spawning, the feeding rate increases as the organisms feed voraciously to recover from fasting. The low feeding intensity during peak spawning season may be due to fully grown gonads, which allow for very limited stomach space<sup>46,47</sup>. In the present study, the occurrence of 'gorged', 'full' and '3/4 full' stomachs was less compared to the '1/2 full', '1/4 full', 'trace' and 'empty' stomachs in all the seasons and in both the sexes. 'Empty' stomachs were found throughout the study period for both sexes, which may be attributed to the fact that carnivorous fishes are known to feed less as compared to the herbivores or omnivores probably due to the energy content of the consumed prey, size of prey or digestion rate of prey. Another reason is owing to the disgorging tendency of fish at the time of harvesting due to shock during the harvesting process and over-jumping of fish while entangled in nets, which results in extroverted stomachs<sup>14</sup>. This incidence was also reported in *P. diacanthus*<sup>16,18</sup>, *O. biauritus*<sup>19</sup>, *Johnius glaucus*<sup>48</sup> and *Atrubucca nibe*<sup>49</sup>. The lower feeding activity in monsoon in females than males could be due to the fact that the former prefer less food during the spawning season<sup>41</sup>. Mathialagan & Sivakumar<sup>47</sup> stated that differentiation in high and low feeding intensity is more in females than in males as ovaries occupy more space than testes.

#### Food composition (gravimetric)

Figures 2 and 3 show the seasonal variation in the percentage composition of prey groups and individual food items, respectively. It was observed that the crustaceans predominated the prey items throughout all the seasons, with the highest abundance during the post-monsoon (72.031 %) season. Fishes were found to dominate (31.486 %) during the pre-monsoon season. It can be deduced that both the crustaceans and finfishes formed the main food groups in this species. Molluscs were absent during the post-monsoon season. Digested matter was recorded in all

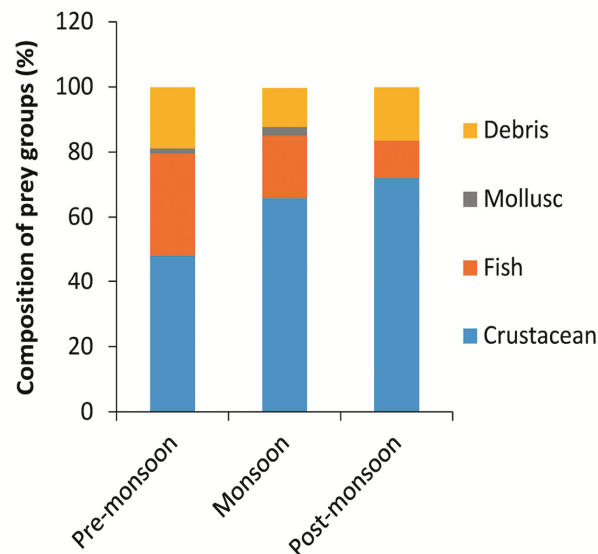


Fig. 2 — Season-wise estimated average percentage composition of different prey groups of *C. aurea*

three seasons, with highest contribution during the pre-monsoon (18.722 %). Semi-digested shrimps dominated the gut content in the crustacean group, accounting to 17.29 % of the total annual average composition, with the highest percentage during post-monsoon (19.821 %). The next dominant prey item was *Squilla* spp., with an annual average percentage composition of 16.76 %, with highest percentage occurrence in the monsoon (20.673 %) season. Penaeid shrimps occurred with an annual average percentage composition of 11.41 %. It was highest during the monsoon (13.79 %) season. *Acetes* spp. and crabs recorded less than 5 %, with the highest values in pre-monsoon (3.878 % each) season. In case of teleosts, semi-digested unidentifiable fishes accounted for 10.07 % of the annual average and were found throughout the year with the highest value during the pre-monsoon (15.694 %) season. Other fishes like *Secutor* spp., *Bregmaceros* sp., *Stolephorus* spp., *Coilia* spp., ribbon fish and flatfishes were found occasionally with an annual average percentage composition of less than 2 %. Among molluscs, *Octopus* sp. was found only in pre-monsoon (1.503 %) and *Sepia* spp. during the monsoon (2.731 %) season. Digested food materials were found throughout the year with an annual average percentage composition of 13.47 %. Biological information available for *Chrysochir aurea* in Indian water is very scanty but Lal Mohan<sup>27</sup> reported that the species feeds on small crustaceans.

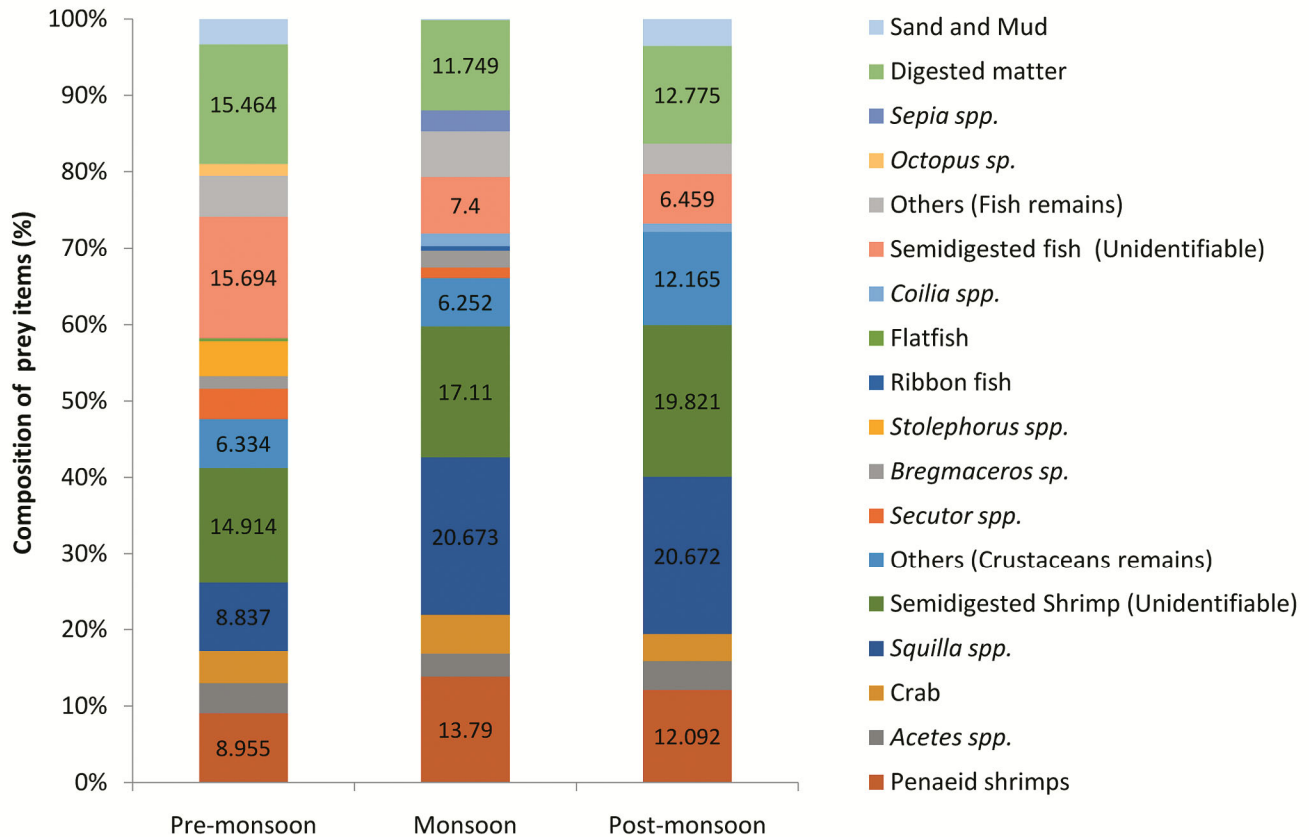


Fig. 3 — Season-wise estimated average percentage composition of individual food items of *C. aurea*

Several authors have reported carnivorous feeding habits in croakers, with crustaceans and teleosts predominating the food composition. According to Bhakta *et al.*<sup>14</sup>, *Otolithoides pama* is a carnivorous fish that primarily feeds on crustaceans, small teleosts, and crabs, which is consistent with the current study. Their observations revealed that the teleosts dominated the diet in most of the months, with highest contribution during June (14.12 %) and penaeid prawns during January (14.9 %). In accordance with the present findings, Batool & Siddiqui<sup>50</sup> observed carnivore feeding habits in *J. dussumieri* from the Karachi coast with predominant food items including crustaceans (54.14 %), followed by digested matter, fishes and molluscs. Further, they also observed that during pre-monsoon, monsoon and post-monsoon the food items were dominated by *Penaeus monodon* (10.94 %), digested matter (17.45 %), and *Metapenaeus monoceros* (12.84 %), respectively. According to Kumar *et al.*<sup>51</sup>, *J. carutta* from the Vishakhapatnam coast of India fed primarily on crustaceans, polychaetes and molluscs. They also

reported the dominance of *Squilla*, *Acetes* sp., shrimps, fish, polychaetes and crabs in the diet of *J. carutta*. Several factors, including availability of prey in the environment<sup>52</sup>, variation in the size structure of predator species, surface migration<sup>53</sup> and vertical diurnal movements of the prey species<sup>54</sup>, etc. have been attributed to influence the food composition of fishes.

In the current study, *Chrysochir aurea* specimens were found with large and whole-food organisms such as shrimp, cephalopods, and fishes, indicating that this species is a macrophagous carnivore. In this context, Kurup & Samuel<sup>55</sup> reported the similar incidence with *Daysciaena albida*, where the fish was observed to swallow the whole food items and the stomach of the fish was also developed to accommodate larger food materials. In the present study, the occurrence of pelagic fishes like *Stolephorus* spp., ribbon fish, *Bregmaceros* sp. and other demersal fauna like shrimps, crabs, *Squilla* spp., *Sepia* spp., *Octopus* sp., *Secutor* spp., flatfishes indicated that *C. aurea* is a habitant of benthopelagic region. Comparable results are also reported in

*Pseudosciaena polyactis*<sup>52</sup>. Diets of *O. biauritus* at Vanakbara were found to have the dominance of non-penaeid shrimps in its diet during the post-monsoon and fishes during the pre-monsoon months<sup>19</sup>. In the present study it was observed that *C. aurea* fed upon different varieties of food items without any specialization, indicating that the species is an opportunistic feeder. An unspecialized and opportunistic carnivorous feeding nature has been reported in other croakers as well<sup>40,52,54</sup>. Opportunistic feeding habit of fishes is associated with their trophic adaptability and response to the seasonal changes in food availability<sup>54</sup> and also to some other factors like food selection, the age of fish, influence of geographical differences and habitats<sup>21,56,57</sup>. In the present study, season-wise cluster analysis revealed 87.5 to 90 % similarity between monsoon and post-monsoon seasons with *Squilla* spp. dominating over other food items during both seasons, followed by semi-digested shrimps and digested matter.

#### Index of Preponderance (IP) and Relative Importance (IRI)

The index of preponderance and relative importance of food items of *C. aurea* are presented in Table 1. The IP of different prey groups of *C. aurea*

(Fig. 4a) depicted that the crustaceans (74.32 %) dominate the prey groups, followed by finfishes (13.07 %), digested matter (12.54 %), and molluscs (0.067 %); while, the %IRI of different prey groups (Fig. 4b) revealed that the crustaceans (73.12 %) were the most important food item followed by digested matter (14.44 %), finfishes (12.38 %) and molluscs (0.051 %). The analysis of IP as per individual prey items revealed that digested matter (34.91 %), beyond recognition, ranked first and dominated the food items, followed by semi-digested unidentifiable shrimps (22.41 %), *Squilla* spp. (16.05 %), crustacean remains (9.33 %), semi-digested unidentifiable fish (5.55 %), penaeid shrimps (5.49 %) and *Acetes* spp. (1.53 %). The remaining food items such as crabs, *Secutor* spp., *Bregmaceros* sp., *Stolephorus* spp., ribbonfish, flatfish, *Coilia* spp., *Sepia* spp. and *Octopus* sp. were found to be in negligible amounts. Prey-specific %IRI showed that the digested matter (39.56 %) was the most important food item, followed by semi-digested shrimps (20.93 %), *Squilla* spp. (12.16 %) and crustacean remains (10.45 %); while %IRI values for penaeid shrimps, semi-digested finfishes, *Acetes* spp. and finfishes remained less than 5 %. The remaining food items were scarce, contributing less than one per cent.

Table 1 — Index of preponderance and relative importance of different food items of *Chrysochir aurea*

Prey groups	Sr. No.	Food items	Percentage of occurrence ( $O_i$ )	Percentage of volume ( $V_i$ )	Percentage of number ( $N_i$ )	Index of preponderance ( $PI$ )	%IRI
Crustaceans	1	Penaeid shrimps	5.54	9.71	6.21	5.49	4.41
	2	<i>Acetes</i> spp.	4.16	3.61	13.35	1.53	3.53
	3	Crabs	2.60	3.55	2.95	0.94	0.85
	4	<i>Squilla</i> spp.	9.18	17.12	9.32	16.05	12.16
	5	Semi-digested Shrimps (Unidentifiable)	12.65	17.34	15.68	22.40	20.92
	6	Others (Crustacean remains)	11.44	7.99	10.25	9.33	10.45
	7	<i>Secutor</i> spp.	1.56	2.76	5.59	0.44	0.65
	8	<i>Bregmaceros</i> sp.	0.87	2.02	1.71	0.17	0.16
	9	<i>Stolephorus</i> spp.	0.69	1.72	1.86	0.12	0.12
Finfishes	10	Ribbonfish	0.17	0.22	0.15	0.003	0.003
	11	Flatfishes	0.69	0.58	0.93	0.04	0.05
	12	<i>Coilia</i> spp.	0.35	0.99	0.31	0.03	0.02
	13	Semi-digested finfishes (Unidentifiable)	5.37	10.11	5.9	5.54	4.30
	14	Others (Fish remains)	5.37	5.23	4.81	2.87	2.70
Molluscs	15	<i>Octopus</i> sp.	0.69	0.93	0.62	0.06	0.053
	16	<i>Sepia</i> spp.	0.35	0.82	0.31	0.029	0.019
Others	17	Digested matter	22.36	15.28	20.03	34.91	39.55

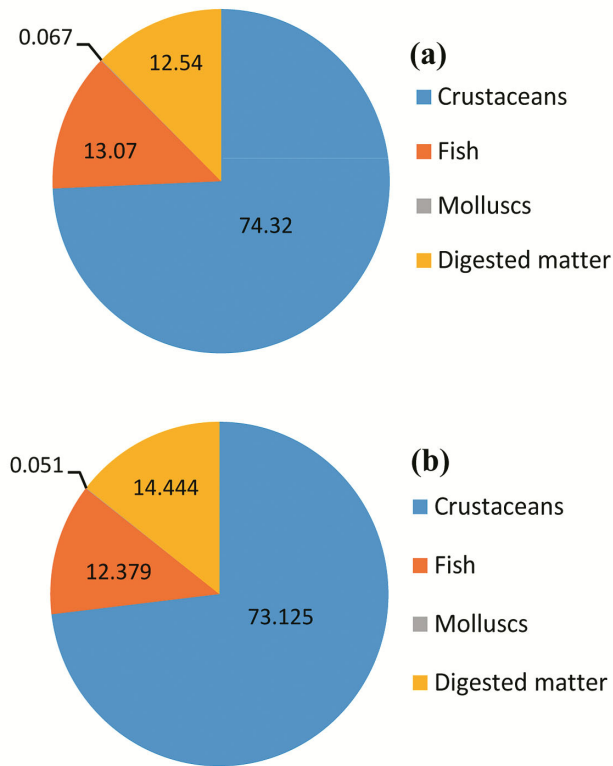


Fig. 4 — a) Index of Preponderance (%IP); and b) Percentage Index of Relative Importance (%IRI) of major food groups of *Chrysochir aurea*

The index of preponderance is used to assess the abundance and frequency of food items in the fish gut. This index aids in ranking food elements based on the preferences of the fish species<sup>35</sup>. Both the indices (IP and IRI) examined in the present study indicated that the crustaceans and finfishes were the most dominant food items throughout the year, as also opined by several other authors in different species of croakers<sup>13</sup>. According to the previous studies on *J. macrorhynchus*<sup>58</sup> and *J. sina*<sup>21</sup>, the IP was highest for crustaceans among all other food items, followed by finfishes, which are analogous to the present study. However, few other studies on *O. cuvieri*<sup>59</sup>, *Nibea maculata*<sup>60</sup> and *O. pama*<sup>14</sup> reported finfishes as the main constituent of the food items followed by shrimps. Alike present observation, Telvekar *et al.*<sup>58</sup> also reported the negligible occurrence of *Squilla* spp. and crabs in the gut contents of *J. macrorhynchus* in Mumbai waters. Interestingly, a low quantity of sand and mud was found in the gut of *C. aurea* throughout the study period and this might have been accidentally captured while scavenging in the sand on benthic organisms, as opined by Kumar *et al.*<sup>51</sup>.

Based on %IRI values Sandhya *et al.*<sup>20</sup> inferred that *Acetes* sp. ranked first (55.68 %) for *O. cuvieri*, followed by penaeid prawns (35.85 %) and *Bregmaceros maclellandi* (3.07 %) at Ratnagiri, Maharashtra. Other prey items like *Cynoglossus* sp., *Sardinella longiceps* and *Nemipterus* sp. were reported to be scarce. Similarly, Venugopal *et al.*<sup>21</sup> also reported crustaceans as the most dominant food items, followed by finfishes in *J. sina* based on %IRI. They reported penaeid prawns (37 %) at first rank, followed by *Acetes* sp. among crustaceans, and finfishes as the second most important food group comprising of *Saurida* sp., *Nemipterus* sp. and *Cynoglossus* sp. Further, Bhakta *et al.*<sup>14</sup> also reported highest %IRI for finfishes (63.19 %) followed by crustaceans (36.76 %) in *O. pama* in the Hooghly-Matlah estuary of West Bengal. The values of %IRI for *J. dussumieri* at Ratnagiri coast deduce non-penaeid shrimps as the most important food item with the first rank followed by finfishes (*Coilia dussumieri*, *Harpadon nehereus*, *O. cuvieri*, *J. glaucus*, *Apogon* sp. and *B. maclellandi*)<sup>8</sup>.

#### Relative Length of Gut (RLG)

The RLG varied between  $0.659 \pm 0.009$  and  $0.756 \pm 0.045$  with an overall average value of  $0.704 \pm 0.03$  (Fig. 5a). It is commonly used to determine the feeding behaviour of fish. In the present study, the mean RLG values for both sexes were less than one throughout the year. However, there were no significant differences ( $P > 0.05$ ) among sexes and seasons, indicating that *C. aurea* is a highly carnivorous in nature. Fishes with RLG values in the range of 0.4 – 0.8 and 4.77 – 12.0 are generally categorized as carnivores and herbivores, respectively<sup>61,62</sup>. Croakers have been regarded as benthic carnivores by many researchers<sup>63,64,14</sup>, with the reported RLG value ranging between 0.42 and 0.78.

#### Gastro-Somatic Index (GaSI)

Season-wise mean GaSI values of both males and females are presented in Figure 5(b). Males ( $2.716 \pm 1.008$ ) had the highest mean GaSI(%) during the monsoon season, whereas females ( $2.856 \pm 0.705$ ) during the pre-monsoon season. However, both the males ( $2.667 \pm 0.677$ ) and females ( $2.574 \pm 0.556$ ) recorded their lowest values during the post-monsoon season. An insignificant difference ( $P > 0.05$ ) existed in the mean GaSI among seasons and between sexes.

The GaSI is a useful tool for comparing temporal variations in the degree of feeding. It also aids in

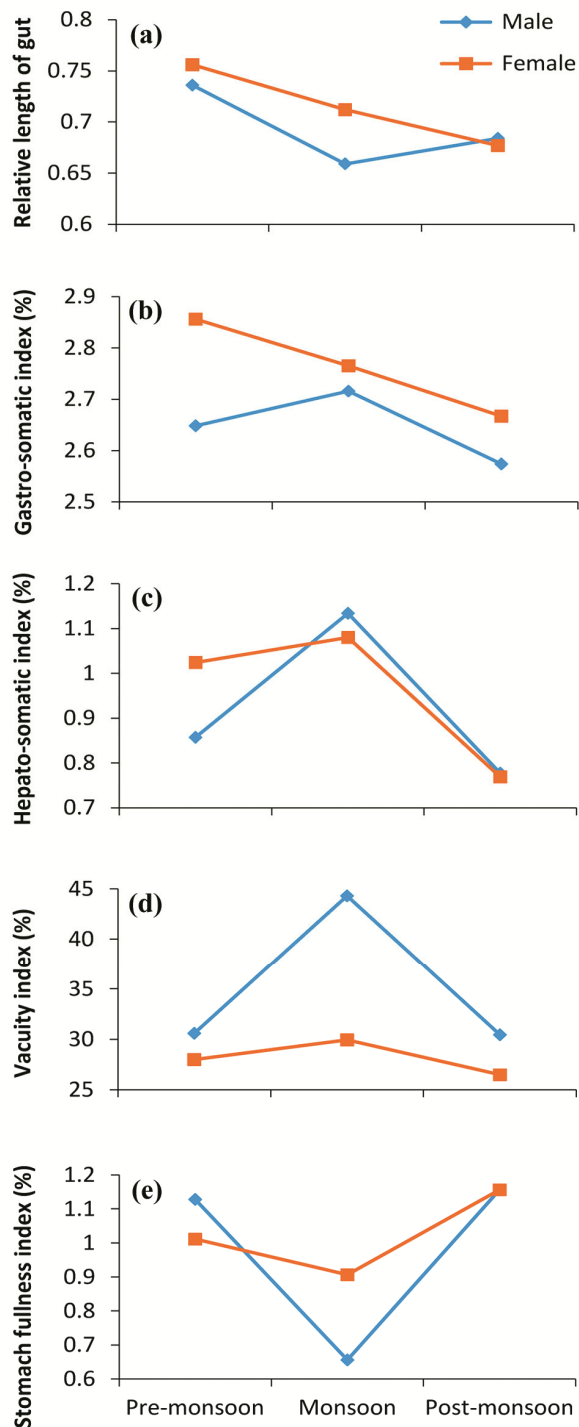


Fig. 5 — Season-wise estimated indices of male and female *Chrysochir aurea*: a) Relative Length of Gut (RLG); b) Gastro-Somatic Index (GaSI); c) Hepato-Somatic Index (HSI); d) Vacuity Index (VI); and e) Stomach Fullness Index (SFI)

understanding the effects of environment and physiology on feeding behaviour<sup>65</sup>. The overall average value of GaSI was found to be higher in

females than males in the current study, correlating with the findings of Bhakta *et al.*<sup>14</sup>. In females, the highest value of average GaSI was observed in the pre-monsoon season; however, it reduced during the monsoon (peak-spawning) season suggesting a poor feeding intensity during this period which could be due to the spawning activity in females. Krishna *et al.*<sup>66</sup> stated that the GaSI of several fish species has seasonal fluctuations, and generally, peaks during the pre- and post-spawning periods. Likewise, several other studies on croakers have reported low feeding activity during the spawning season<sup>8,49-51,58</sup>. The index is known to be affected by the spawning season, feeding intensity, gonadal maturity, feeding activity, and rate of digestion<sup>51</sup>. In this context, Salarpouri *et al.*<sup>49</sup> have opined that increased GaSI prior to gonadal maturity or spawning season is a result of efforts to gain energy for gonad development and reproduction. The gonads, especially the ovaries, significantly enlarge during the spawning period and typically fill the body cavity, permitting limited space in the stomach<sup>51</sup>. On the other hand, in males, the highest mean GaSI percentage was found during the monsoon season, which differed from the previously reported observations<sup>50,51,58</sup> but coincided with the observations of Bhakta *et al.*<sup>14</sup>, who reported high GaSI during the spawning season in *O. pama*.

#### Hepato-Somatic Index (HSI)

Seasonal variation in HSI of *C. aurea* is presented in Figure 5(c). Both males ( $1.134 \pm 0.317$  %) and females ( $1.080 \pm 0.156$  %) had the highest mean percentage values during the monsoon season. The respective lowest values were found to be  $0.777 \pm 0.163$  % and  $0.769 \pm 0.161$  % during the post-monsoon season. No significant difference ( $P > 0.05$ ) was found in values of the mean HSI among seasons and sexes.

The HSI measures the ability of fish to store fatty elements in their bodies and can provide information on the nutritional value of fish<sup>67</sup>. As a result, changes in fish feeding habits, gonadal development and reproductive behaviour have a significant impact on HSI<sup>68,69</sup>. In the present study, the overall average HSI values were found to be higher in females (0.939) than males (0.895) which are in conformity with the observations of Batool & Siddiqui<sup>50</sup> reported for *J. dussumieri*. According to many studies, HSI tends to be low during the spawning season and high during the pre- and post-spawning seasons as the high fat and energy reserve are being used during the spawning

season<sup>50,70</sup>. Ekanem *et al.*<sup>71</sup> reported an inverse relationship of HSI with the GaSI in *Pseudotolithus elongatus* owing to the transfer of energy from the visceral tissues of the liver for the development of gonads.

However, in the current study the highest HSI(%) values were found during the monsoon season (spawning period) in both males (1.134±0.317) and females (1.080±0.156), which contradicts previous observations. It may be due to the enlargement of liver during the reproductive season as a response to vitellogenin needs, which often leads to higher HSI values<sup>72</sup> or due to increased hormonal secretion during spawning, especially in females<sup>73</sup>.

#### Vacuity Index (VI)

Out of a total of 562 samples of *C. aurea*, the guts of 175 specimens were found empty. The overall VI was found to be 31.14 %. Season-wise mean VI values of both males and females are presented Figure 5(d). The seasonal average VI(%) was highest during the monsoon season in both males (44.286±7.887) and females (29.92±7.124), and comparatively lower during other seasons. There existed a significant difference ( $P < 0.05$ ) in the mean values of the vacuity index among the seasons. The post-hoc analysis revealed a significant difference between the vacuity index values of monsoon and post-monsoon ( $P < 0.05$ ) seasons.

The vacuity index, also expressed sometimes as the empty stomach ratio, depicts the degree of feeding<sup>74</sup>. The voracity of the predator fishes can be assessed with the help of this index as there is an inverse relationship between the voracity and the number of empty stomachs in the fish species. The highest values of VI found during the monsoon season are consistent with other croakers such as *A. nibe* at the northern Oman Sea<sup>74</sup> and *J. dussumieri* at the Karachi coast, Pakistan<sup>50</sup>. Overall VI recorded in the present study was higher in males (34.26 %) than females (27.97 %) and is similar to those reported by Batool & Siddiqui<sup>50</sup> and Shekari & Hashemi<sup>40</sup>.

Classification of fish based on VI values made by Euzen<sup>75</sup> was followed in the present study. The overall VI was found to be 31.71 % and accordingly, *C. aurea* could be categorized as the 'relatively edacious' feeder. Based on the VI values, Diouf *et al.*<sup>9</sup> categorized *Pseudotolithus senegalensis* from the Senegalese coast as an edacious feeder with an overall value of 8.58 %; whereas, Salarpouri *et al.*<sup>49</sup> and

Sarkhanizadeh *et al.*<sup>74</sup> classified *A. nibe* as moderate to relatively abstemious feeder with an overall VI value ranging from 71.1 to 86.5 %. Empty stomachs might be the result of the expulsion of stomach contents owing to the change in pressure brought in by changes in depth during the raising of the trawl net<sup>49,76</sup>, and for this reason, this index is not considered that robust<sup>77</sup>.

#### Stomach Fullness Index (SFI)

Figure 5(e) shows the season-wise mean SFI percentages for both males and females. Seasonally, the monsoon season had the lowest mean SFI percentage in both males (0.656±0.273) and females (0.907±0.101), while it was higher during the pre-monsoon (male: 1.128±0.235, female: 1.012±0.431) and post-monsoon seasons (male: 1.157±0.158, female: 1.157 ±0.485). There were no significant differences in the SFI values among seasons and between the sexes ( $P > 0.05$ ).

Stomach fullness index help investigate the feeding activity of different fish species in different seasons. The lower values of SFI (%) observed during the monsoon season could be attributed to the lower level of feeding activity of *C. aurea* during the spawning period. Furthermore, as reported by Baloch *et al.*<sup>78</sup>, this decreased level of feeding activity during the monsoon season may also be due to temperature fluctuations and a lack of food availability. The current finding supports the findings of Vagh *et al.*<sup>41</sup>, who concluded that SFI is negatively correlated with spawning activity. In croakers the overall values of SFI have been reported ranging from 2.79 % in *A. nibe* at the Northern Oman Sea<sup>74</sup> to 41.89 % in *J. dussumieri* from Karachi coast<sup>50</sup>.

#### Cluster analysis

Cluster analysis using the Bray-Curtis similarity score (Fig. 6) revealed 87.5 % and 90.0 % similarity in food items during the monsoon and post-monsoon seasons, respectively. The pre-monsoon season, on the other hand, shared 77.5 % to 80.0 % of its similarities with the other two seasons. This may be ascribed to the greater availability of similar kind of food items, such as crustaceans and finfishes, during the monsoon and post-monsoon seasons. However, the intake of crustaceans is reduced during the pre-monsoon season due to their scarcity (Fig. 2). Several fish species diets have been shown to alter across the seasons due to seasonal changes in food availability<sup>79</sup>.

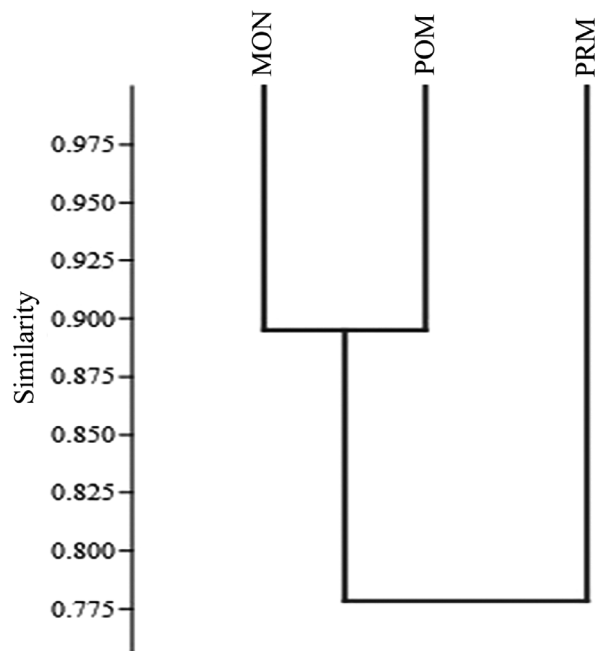


Fig. 6 — Dendrogram of season-wise cluster analysis based on percentage gravimetric composition of prey groups

### Conclusion

The current investigation on the food and feeding habits of *Chrysochir aurea* revealed that the species is a macrophagous, relatively edacious carnivorous, and opportunistic feeder. The species primarily feed upon crustaceans and finfishes especially on *Squilla* spp., Penaeid shrimps, and *Acetes* spp. among crustaceans, and a variety of finfishes. Further, significant differences was observed in the feeding intensity during the monsoon season against the pre- and post-monsoon season. The findings of this study not only fill a gap in *C. aurea* feeding biology, but also aid in understanding the feeding dynamics and trophic relationship of this species, which will eventually aid in its fishery management.

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### Conflict of Interest

The authors declare that there is no conflict of interest in this paper.

### Ethical Statement

All the research meets the ethical guidelines including adherence to the legal requirements of India.

### Author Contributions

SC: Data collection, laboratory analysis and manuscript writing; TSN: Conceptualization, review, and editing; and SJ: Laboratory analysis and review.

### References

- Begum M, Alam M J, Islam M A & Pal H K, On the food and feeding habit of an estuarine catfish (*Mystus gulio*, Hamilton) in the south-west coast of Bangladesh, *Univ J Zool Rajshahi Univ*, 27 (2008) 91-94. <https://doi.org/10.3329/ujzr.v27i0.1962>
- Agbabiaka L A, Food and feeding habits of *Tilapia zillii* (Pisces: Cichlidae) in river Otamiri south-eastern Nigeria, *Biosci Discov*, 3 (2) (2012) 146-148.
- Rao K S, Food and feeding habits of fishes from trawl catches in the Bay of Bengal with observations on diurnal variation in the nature of the feed, *Indian J Fish*, 11 (1) (1964) 277-314.
- Verma R, Feeding biology of *Labeo dyocheilus*: a vulnerable fish species of India, *Int J Fish Aquat*, 3 (3) (2013) 85-88.
- Lall S P & Tibbetts S M, Nutrition, feeding, and behavior of fish, *Vet Clin North Am Exot Anim Pract*, 12 (2) (2009) 361-372. <https://doi.org/10.1016/j.cvex.2009.01.005>
- Shalloof K A S & Khalifa N, Stomach contents and feeding habits of *Oreochromis niloticus* (Linnaeus, 1758) from Abu-Zabal lakes, Egypt, *World Appl Sci J*, 6 (1) (2009) 1-5.
- Gomathy S & Vivekanandan E, Changes in the diet of predatory ribbonfish *Trichiurus lepturus* (Linnaeus, 1758) with increasing body size along Chennai coast, *Indian J Fish*, 64 (4) (2017) 34-43. <https://doi.org/10.21077/ijf.2017.64.4.54702-05>
- Kumar T, Chakraborty S K, Jaiswar A K, Panda D, Sandhya K M, *et al.*, Diet composition and feeding strategy of *Johnius dussumieri* (Cuvier, 1830) from Ratnagiri coast of India, *Indian J Geo-Mar Sci*, 49 (7) (2020) 1242-1249. <http://nopr.niscpr.res.in/handle/123456789/55092>
- Diouf K, Ba A & Ndiour Y, Diet of the Cassava Croaker (*Pseudotolithus senegalensis*) (Valenciennes, 1833) (Sciaenidae) from the Senegalese coast, West Africa: effects of season, maturity stage, sex and location on diet, *Egypt J Aquat Biol Fish*, 25 (1) (2021) 843-863. <https://doi.org/10.21608/ejabf.2021.152678>
- Mohamed A R M & Abood A N, Feeding ecology of two sciaenid species (*Johnius belangerii* and *Johnius dussumieri*) in the Shatt Al-Arab River, Iraq, *Int J Fish Aquat Stud*, 7 (5) (2019) 08-13.
- Gaihiangam K, Chakraborty S K, Deshmukhe G, Jaiswar A K, Devi H M, *et al.*, Assessment of economic impact of juvenile fishing of sciaenids along Mumbai Coast, India, *Indian J Geo-Mar Sci*, 42 (5) (2013) 617-621.
- FRAD, CMFRI, *Marine Fish Landings in India 2021*, Technical Report, CMFRI Booklet Series No. 26/2022,

- (ICAR-Central Marine Fisheries Research Institute, Kochi), 2022, pp. 16.
- 13 Chao L N & Musick J A, Life-history, feeding-habits, and functional-morphology of juvenile Sciaenid fishes in York River Estuary, Virginia, *Fish Bull*, 75 (4) (1977) p. 657.
  - 14 Bhakta D, Das S K, Das B K, Nagesh T S & Behera S, Food and feeding habits of *Otolithoides pama* (Hamilton, 1822) occurring from Hooghly-Matlah estuary of West Bengal, India, *Reg Stud Mar Sci*, 32 (2019) p. 100860. <https://doi.org/10.1016/j.rsma.2019.100860>
  - 15 Carpenter K E & Niem V H, *The living marine resources of the Western Central Pacific, Bony fishes, Part 3 (Menidae to Pomacentridae)*, Vol 5, (FAO, Rome), 2001, pp. 2791-3380.
  - 16 Rao K V, Some aspects of the biology of Ghol *Pseudoseiaena diacanthus* (Lecepede), *Indian J Fish*, 10 (2) (1963) 413-459.
  - 17 Kutty M N, A note on the biology of the 'Koth', *Otolithoides brunneus* (Day), *J Mar Biol Assoc India*, 9 (1) (1967) 197-197.
  - 18 Jayaprakash A A, Food and feeding habits of juveniles of koth *Otolithoides brunneus* (Day) in Bombay waters, *Indian J Fish*, 21 (1) (1974) 127-140.
  - 19 Ghosh S, Mohanraj G, Asokan P K, Dhokia H K, Zala M S, *et al.*, Trophodynamics and reproductive biology of *Otolithoides biauritus* (Cantor) landed by trawlers at Vanakbara, Diu along the west coast of India, *Indian J Fish*, 56 (4) (2009) 261-265.
  - 20 Sandhya K M, Chakraborty S K, Jaiswar A K & Shah T H, Food and feeding habits of *Otolithes cuvieri* (Trewavas, 1974) from Ratnagiri, Maharashtra, *Indian J Fish*, 61 (4) (2014) 99-102.
  - 21 Venugopal N, Pillai N G K & Prakasan D, Food and feeding habits of *Johnnieops sina* (Cuvier, 1830) along Cochin coast of India, *Indian J Fish*, 61 (1) (2014) 103-107.
  - 22 Mookerjee H K, Ganguly D N & Mazumdar T C, On the food of estuarine fish of Bengal, *Sci Cult*, 109 (1946) 564-565.
  - 23 Jacob P K, Sciaenids of the west coast of Madras Province, *J Bombay Nat Hist Soc*, 48 (1) (1948) 118-124.
  - 24 Chacko P I, Food and feeding habits of the fishes of the Gulf of Mannar, *Proc Indian Acad Sci*, 29 (3) (1949) 83-97. <https://doi.org/10.1007/BF03049962>
  - 25 Rao T A, Food and feeding habits of *Pennahia macrophthalmus* Bleeker at Visakhapatnam, *Indian J Fish*, 27 (1&2) (1980) 61-65.
  - 26 Bhuyan S K, Jena J K, Pillai B R, Kumar P & Chakraborty S K, Studies on the growth of *Otolithes ruber* (Bloch & Schneider, 1801), *Johnius carutta* Bloch, 1793 and *Pennahia macrophthalmus* (Bleeker, 1850) from Paradeep coast, Orissa, India, *Indian J Fish*, 59 (2) (2012) 89-93.
  - 27 Lal Mohan R S, Sciaenidae, In: *FAO species identification sheets for fishery purposes: Western Indian Ocean (Fishing Area 51)*, Vol 4, edited by Fischer W & Bianchi G, (FAO, Rome), 1984. <http://www.fao.org/docrep/009/ad468e/ad468e00.HTM>
  - 28 Froese R & Pauly D (eds.), *Fishbase*, World Wide Web electronic publication. <http://www.fishbase.org>, 2022, version (08/2022).
  - 29 Ni H Y, *Reproductive biology of Chrysochir aurea and Otolithes ruber in the waters off southwestern Taiwan*, Ph.D. thesis, submitted to National Kaohsiung Sun Yat-sen University, 2018.
  - 30 Pillay T V R, A critique of the methods of study of food of fishes, *J Zool Soc India*, 4 (1952) 185-200.
  - 31 Hyslop E J, Stomach contents analysis - a review of methods and their application, *J Fish Biol*, 17 (4) (1980) 411-429. <https://doi.org/10.1111/j.1095-8649.1980.tb02775.x>
  - 32 Fischer W & Whitehead P J P, *FAO species identification sheets for fishery purposes: Eastern Indian Ocean (Fishing Area 57) and Western Central Pacific (Fishing Area 71)*, Vol 2, (FAO, UN), 1974.
  - 33 Zacharia P U & Abdurahiman K P, Methods of stomach content analysis of fishes, In: *CMFRI Winter School Technical Notes: Towards Ecosystem Based Management of Marine Fisheries—Building Mass Balance Trophic and Simulation Models*, edited by Mohamed K S, (Central Marine Fisheries Research Institute, Kochi, India), 2004, pp. 148-158.
  - 34 Zacharia P U, Trophodynamics and Review of methods for Stomach content analysis of fishes, In: *CMFRI Winter School Technical Notes: Towards Ecosystem Based Management of Marine Fisheries—Building Mass Balance Trophic and Simulation Models*, edited by Mohamed K S, (Central Marine Fisheries Research Institute, Kochi, India), 2004, pp. 1-12.
  - 35 Natarajan A V & Jhingran A G, Index of preponderance-a method of grading the food elements in the stomach analysis of fishes, *Indian J Fish*, 8 (1) (1961) 54-59.
  - 36 Pinkas L, Food habits of albacore, bluefin tuna and bonito in California waters, *California Dept Fish Game*, 152 (1971) 1-105.
  - 37 Al-Hussaini A H, On the functional morphology of the alimentary tract of some fish in relation to differences in their feeding habits: anatomy and histology, *J Cell Sci*, 3 (10) (1949) 109-139.
  - 38 Desai V R, Studies on the fishery and biology of *Tor tor* (Hamilton) from river Narmada, *J Inland Fish Soc India*, 2 (5) (1970) 101-112.
  - 39 Busacker G P, Adelman I R & Goolish E M, Growth, In: *Methods for fish biology*, edited by Schreck C B & Moyle P B, (American Fisheries Society, Bethesda, Maryland), 1990, pp. 363-377. <https://doi.org/10.47886/9780913235584>
  - 40 Shekari M & Hashemi S A R, Diet composition of Southern Meagre (*Argyrosomus hololepidotus*) in northwest of Persian Gulf, *American-Eurasian, J Agric Environ Sci*, 12 (10) (2012) 1316-1322. <https://doi.org/10.5829/idosi.ajeas.2012.12.10.66186>
  - 41 Vagh S, Kardani H K, Vase V K, Pal M, Mahavadiya D, *et al.*, Food and feeding habits of *Nemipterus japonicus* (Bloch, 1791) off Gujarat, north-west coast of India, *Indian J Geo-Mar Sci*, 50 (06) (2021) 473-479.
  - 42 Soares L S H & Vazzoler A D M, Diel changes in food and feeding activity of sciaenid fishes from the South-western Atlantic, Brazil, *Braz J Biol*, 61 (2) (2001) 197-216. <https://doi.org/10.1590/s0034-71082001000200004>
  - 43 Bray T R & Curtis J T, An ordination of the upland forest communities of southern Wisconsin, *Ecol Monogr*, 27 (4) (1957) 325-349. <http://dx.doi.org/10.2307/1942268>
  - 44 Khongngain O, Das S K & Bhakta D, Studies of biological parameters of *Trichogaster fasciata* (Bloch and Schneider, 1801) from a lentic water body Shanti Jheel, West Bengal, *J Indian Fish Assoc*, 43 (2) (2016) 01-06.

- 45 Venkataraman G, Studies on the food and feeding relationships of the inshore fishes off Calicut on the Malabar coast, *Indian J Fish*, 7 (2) (1960) 275-306.
- 46 Morte S, Redon M J & Sanz-Brau A, Diet of *Scorpaena porcus* and *Scorpaena notata* (Pisces: Scorpaenidae) in the Western Mediterranean, *Cah Biol Mar*, 42 (4) (2001) 333-344.
- 47 Mathialagan R & Sivakumar R, Few aspects of the reproductive biology of reba carp *Cirrhinus reba* (Hamilton) from Vadavay River Lower Anicut, Tamil Nadu, *Eur J Biol Sci*, 1 (2) (2012) 61-67.
- 48 Raje S G, Some aspects of the biology of *Otolithes cuvieri* (Trewavas) and *Johnius glaucus* (Day) from Veraval, *J Indian Fish Assoc*, 26 (2000) 1-6.
- 49 Salarpouri A, Valinassab T, Behzadi S, Kaymaram F, Darvishi M, *et al.*, Reproduction biology and feeding habits of the black mouth croaker, *Atroubucca nibe* (Jordan & Thompson, 1911), from Northwest of the Oman Sea, *Iran J Fish Sci*, 20 (3) (2021) 901-917. <https://doi.org/10.22092/ijfs.2021.124193>
- 50 Batool T & Siddiqui G, The diet composition and seasonal variation in feeding habits of *Johnius dussumieri* (Cuvier, 1830) from Karachi coast, Pakistan, *Int J Biol Biotech*, 17 (2) (2020) 329-337.
- 51 Kumar M S, Rajeswari G & Kishore B, Food and feeding habits of *Johnius carutta* (Bloch, 1793) off Visakhapatnam, East-coast of India, *Fish Technol*, 52 (2015) 88-94.
- 52 Xue Y, Jin X, Zhang B & Liang Z, Seasonal, diel and ontogenetic variation in feeding patterns of small yellow croaker in the central Yellow Sea, *J Fish Biol*, 67 (1) (2005) 33-50. <https://doi.org/10.1111/j.0022-1112.2005.00677.x>
- 53 Blay Jr J, Awittor W K & Agbeko D, Seasonal variation in food preference and feeding ecology of two juvenile marine fishes, *Pseudotolithus senegalensis* (Sciaenidae) and *Brachydeuterus auritus* (Haemulidae) off Cape coast, Ghana, *West Afr J Appl Ecol*, 9 (1) (2006) 1-6. <https://doi.org/10.4314/wajae.v9i1.45686>
- 54 Lucena F M, Vaske T, Ellis J R & O'brien C M, Seasonal variation in the diets of bluefish, *Pomatomus saltatrix* (Pomatomidae) and striped weakfish, *Cynoscion guatucupa* (Sciaenidae) in southern Brazil: implications of food partitioning, *Environ Biol Fishes*, 57 (4) (2000) 423-434. <https://doi.org/10.1023/A:1007604424423>
- 55 Kurup B M & Samuel C T, Food and feeding habits of *Daysciaena albida* (Cuvier) from the Vembanad lake, *Indian J Fish*, 35 (4) (1988) 317-322.
- 56 Abdel-Azis S H, Khali A N & Abdel-Magid S S, Food and feeding of guitar fish *Rhinobatos rhinobatos* in the Egyptian Mediterranean habit of the common Waters, *Indian J Geo-Mar Sci*, 22 (1993) 287-290.
- 57 Parrish J D, The Trophic Biology of Snappers and Groupers, In: *Tropical Snappers and Groupers: Biology and Fisheries Management*, edited by Polvina J & Ralston S, (West views Press), 1987, pp. 405-439.
- 58 Telvekar P A, Chakraborty S K & Jaiswar A K, Some aspects of the biology of *Johnius macrorhynchus* (Mohan, 1976) from Mumbai waters, *J Mar Biol Assoc India*, 48 (2006) 124-127.
- 59 Telvekar P A, Chakraborty S K & Jaiswar A K, Length-weight relationship and food and feeding habits of *Otolithes cuvieri* (Trewavas, 1974) from Mumbai, *Indian J Fish*, 53 (4) (2006) 131-134.
- 60 Ramana V L M & Rao M C, Food and feeding habits of *Nibeia maculata* from coastal waters of Visakhapatnam, *Eur Acad Res*, 2 (8) (2014) 11065-11075.
- 61 Das S M & Moitra S K, Studies on the food and feeding habits of some fresh water fishes of India: Review on the food and feeding habits, with general conclusions, *Acta Ichthyol Piscat*, 2 (1963) 107-115.
- 62 Dasgupta M, Morphometrics of the alimentary canal of some freshwater fishes of West Bengal in relation to their food and feeding habits, *Indian J Fish*, 49 (4) (2002) 461-464.
- 63 Johnson G D, Gill A C, Paxton J R & Eschmeyer W N, *Encyclopedia of Fishes*, (Academic Press, San Diego), 1998, pp. 186.
- 64 Rahman M M, Alam M M M & Zaman T, Relationship between total length and digestive tract of different carnivorous fishes, *Progress Agric*, 23 (1-2) (2012) 39-49. <https://doi.org/10.3329/pa.v23i1-2.16564>
- 65 Koya M K, Vase V K, Abdul Azeez P, Sreenath K R, Dash G, *et al.*, Diet composition and feeding dynamics of *Trichiurus lepturus* (Linnaeus, 1758) off Gujarat, north-west coast of India, *Indian J Fish*, 65 (2) (2018) 50-57. <https://doi.org/10.21077/ijf.2018.65.2.69184-06>
- 66 Krishna P V, Panchakshari V & Prabhavathi K, Feeding Habits and Stomach Contents of Asian seabass *Lates calcarifer* from Nizampatnam Coast, *Int J Adv Res*, 4 (4) (2016) 168-172. <http://dx.doi.org/10.21474/IJAR01/116>
- 67 Ashwini L, Benakappa S, Anjanayappa H N & Akshay L, Observation on the Gonado-Somatic Index-GSI and Hepato-Somatic Index-HSI of *Decapterus russelli* Mangaluru Coast, *Int J Eng Sci*, 6 (6) (2016) 7396-7399. <https://doi.org/10.4010/2016.1754>
- 68 Henderson R J, Sargent J R & Hopkins C C E, Changes in the content and fatty acid composition of lipid in an isolated population of the capelin *Mallotus villosus* during sexual maturation and spawning, *Mar Biol*, 78 (3) (1984) 255-263. <https://doi.org/10.1007/BF00393011>
- 69 Satheesh D & Kulkarni R S, Studies on condition factors, gonadosomatic and hepatosomatic indices of the fresh water female fish, *Tilapia mossambica* (Peters) from an aquatic body, *Indian J Res*, 5 (12) (2016) 217-219.
- 70 Kumar T, Chakraborty S K, Jaiswar A K, Sandhya K M, Shah T H, *et al.*, Gonadal maturation profile and fecundity of the *Johnnieops sina* (Cuvier, 1830) from Ratnagiri coast of India, *Indian J Geo-Mar Sci*, 43 (9) (2014) 1746-1756.
- 71 Ekanem S B, Achima M J & Ekere M M, Studies on some reproductive aspects of *Pseudotolithus elongatus* in Cross River estuary, Nigeria, *Sci Mar*, 68 (2) (2004) 265-271. <https://doi.org/10.3989/scimar.2004.68n2265>
- 72 Rogers S I, Seasonal variations in fecundity and egg size of the common goby, *Pomatoschistus microps*, *J Mar Biol Assoc UK*, 69 (3) (1989) 535-543. <https://doi.org/10.1017/S0025315400030940>
- 73 Ellis A E, Roberts R J & Tyler P, The anatomy and physiology of teleosts, In: *Fish Pathology*, edited by Roberts R J & Tindall B, (Bailliere-Tindall, London), 1978, pp. 13-54.
- 74 Sarkhanizadeh A, Valinassab T & Fatemi M R, Evaluation of some feeding indices of *Atroubucca nibe* in the Northern Oman Sea, *J Nov Appl Sci*, 3 (11) (2014) 1268-1274.
- 75 Euzen O, Food habits and diet composition of some fish of Kuwait, *Kuwait Bull J Mar Sci Eng*, 9 (1978) 65-85.

- 76 Khadem S S, Valinassab T & Shamsaie M, Survey of feeding diet of Bigeye croaker (*Pennahia anea*) in the Oman sea waters, *J Renew Nat Resour Res*, 2 (2) (2011) 14-24.
- 77 Mohammadi G H, Khodadadi M, Emadi H & Nabavi S M, The food habit of *Epinephelus coioides* (Hamilton, 1822) in Khuzestan coastal waters (Persian Gulf), *Pak J Biol Sci*, 10 (22) (2007) 4029-4035. <https://doi.org/10.3923/pjbs.2007.4029.4035>
- 78 Baloch A B, Ahmed Q, Ali M, Bat L & Bilgin S, Seasonal variation of condition factor and weight length relationship in *Thryssa hamiltonii* (Gray, 1835) (Clupeiformes: Engraulidae) collected from the Baluchistan coast of the Arabian Sea, Pakistan, *Pak J Mar Sci*, 21 (1&2) (2012) 29-35.
- 79 Vassilopoulou P, Dietary habits of the deep-sea flatfish *Lepidorhombus boscii* in North-Eastern Mediterranean waters, *J Fish Biol*, 69 (4) (2006) 1202-1220. <https://doi.org/10.1111/j.1095-8649.2006.01199.x>