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Feeding Habits of Larvae and Juveniles for Hilsa Shad *Tenualosa ilisha* (Hamilton, 1822) in Southern Iraq

Muna Taha Al-Okailee[1], Falah Maarouf Mutlak[2], Ali Taha Yaseen[2*], Abbas Jasim Al-Faisal[2]

[1]Department of Environmental Sciences, College of Energy and Environmental Sciences, Al Karakh University of Sciences, Baghdad, Iraq
[2]Department of Marine Vertebrates, Marine Science Center, University of Basrah, Iraq
[*]**Corresponding Author: ali.taha@uobasrah.edu.iq**

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ABSTRACT

A total of 646 stomachs were examined to assess the food components of *Tenualosa ilisha* at different developmental stages—209 from larvae and 437 from juveniles. Ichthyoplankton samples were collected from the eastern part of Al-Hammar and the Shatt al-Arab River using conical nets equipped with a flow meter. The larvae of *T. ilisha* fed primarily on zooplankton. Throughout the larval stage of their life cycle, the larvae exhibited continuous feeding activity and did not show any signs of cessation. In contrast, phytoplankton constituted the dominant food source for juvenile fish. The relative importance index (IRI) of *T. ilisha* larvae revealed five main dietary groups: Copepoda (including adult and larval stages), Cladocera (*Daphnia* spp.), Rotifera, and detritus. The respective proportions of these groups in the IRI were 28, 15, 26, 20, and 11% for copepods, cladocerans, rotifers, and detritus, respectively. Among the juveniles, diatoms represented the largest portion of the IRI at 42%, followed by algae (27%) and detritus (11%), while Cladocera contributed almost as much as Copepoda (10%).

INTRODUCTION

Tenualosa ilisha, belonging to the subfamily Alosinae of the family Dorosomatidae, occurs in the Shatt al-Arab River, along the coasts of Iran, Pakistan, India, Bangladesh, Burma, and as far as South Vietnam **(Bhaumik, 2015)**. They often inhabit the shoreline and lower estuarine regions, migrate upstream during the breeding season, and return to their native habitat after spawning **(Panhwar *et al.*, 2011)**.

Understanding fish diets is important for research into food webs, trophodynamics, resource partitioning, and ecological energetics **(Debasis *et al.*, 2013)**. As the primary energy source, food significantly influences fish population sizes, growth rates, and overall health **(Karna *et al.*, 2014)**. Knowledge of dietary composition and feeding patterns is essential for the effective management and exploitation of fish species **(Khan & Fatima, 1994)**. Stomach content analysis provides insights into diet composition, feeding strategies, and selectivity **(Kuruppasamy & Menon, 2004)**.

Studies on the food habits of *T. ilisha* larvae and juveniles in Iraqi waters are limited. **(Mohamed *et al.*, 2008)** investigated the occurrence, abundance, growth, and food habits of hilsa juveniles in the recovered East Hammar marsh. **(Mohamed *et al.*, 2012)** examined variations in the occurrence, abundance, and diet of *T. ilisha* larvae in the northern Shatt al-Arab River, Basrah, Iraq. **(Jawad *et al.*, 2021)** studied the larvae and juveniles of various fish species, including *T. ilisha*, along the Omani coast of the Arabian Sea and the Arabian Gulf. **(Yaseen *et al.*, 2024a, b)** analyzed the impact of marine heatwaves on the patterns of abundance and diversity of Iraqi marine fish, showing that both large and small individuals of this species may be affected by rising surface water temperatures due to changes in the biomass of their food sources.

The aim of the present study was to investigate the monthly variation in the relative importance of various dietary items for *T. ilisha* larvae and juveniles.

MATERIALS AND METHODS

Ichthyoplankton samples were caught from the eastern part of Al-Hammar and the Shatt al-Arab River, as shown in Fig. (1). A conical net was used for sampling; it was 1.25 meters in length and equipped with a flowmeter. The net used has an opening diameter of 50cm and a mesh size of 500 µm. An oblique tow was conducted for approximately ten minutes, from near the bottom to the surface, at a speed of 0.5 m/s **(Robinson *et al.*, 1996)**. The samples were preserved in 10% formalin.

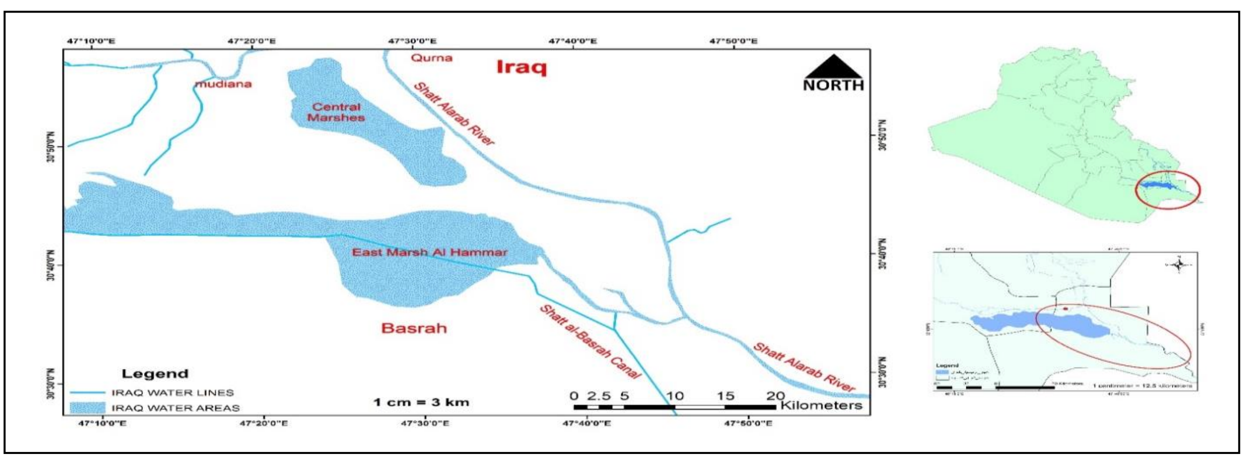

Fig. 1. Map showing the sampling areas where *Tenualosa ilisha* were collected

Tenualosa ilisha juveniles were captured using dip nets, fixed gill nets (500–1000m long, 2.5–10cm mesh size), and seines (20m long, 2.5cm mesh). In the laboratory, identification of *T. ilisha* larvae from other species was done using a dissecting microscope **(Leis & Carson-Ewart, 2000),** and each specimen's overall length was measured. According to **Sinha and Jones (1967)**, each specimen was then sliced open, the entire digestive tract was taken out, and scores were awarded for fullness. The gut contents were identified under a dissecting microscope, according to the method of **Hadi *et al*. (1984)**. Feeding activity and feeding intensity of each monthly sample were calculated after **Dipper *et al*. (1977)** and **Gordon (1977)**, respectively. The stomach contents were examined using two analytical techniques, i.e. points and frequency of occurrence **(Hynes, 1950)**. To evaluate the significance of different foods, an index of relative importance (IRI) created by **Stergion (1988)** was used as follows: IRI % = P% × O%, where P% represents each food item's percentage of total points and O% represents its percentage of occurrence.

RESULTS

A total of 646 stomachs, were examined to assess the food components (209 stomachs belong to larvae of *T. ilisha* and 437 belong to juvenile of *T. ilisha*).

Monthly changes in diet composition

1- Larvae of *T. ilisha*

Table (1) presents the percentage composition of the diet based on two selected analytical methods. The larvae of *T. ilisha* fed primarily on zooplankton. Among the zooplankton, Cladocera (*Daphnia* spp.) were the dominant prey item, with an occurrence (O) of 27.5%. Copepods, including adult (O = 25%) and larval stages (O = 15.6%), along with Rotifera (O = 21.9%) and detritus (O = 10%), were also found in the guts of *T. ilisha* larvae. The table also illustrates the monthly mean variations in feeding activity, expressed as a feeding index scaled to 100.

Table 1. Monthly changes in diet composition of *T. ilisha* larvae. Data are presented as proportion of weighted points (P%), proportion of occurrence (O%), feeding activity (%) as well as the intensity of feeding.

Months	Method of food analysis	Food item: Cladocera	Copepods nauplii	Copepods	Rotifera	Detritus	No. of fish larvae	No. of feeding fish larvae	Feeding activity%	Feeding Intensity
Mar.	P%	30	20	10	35	5	12	5	100	25
	O%	100	100	70	100	100				
Apr.	P%	35	25	10	20	10	23	15	100	23.3
	O%	100	100	100	75	100				
May	P%	30	20	10	35	5	46	35	100	23.5
	O%	100	90	80	100	100				
Jun.	P%	20	15	30	30	5	50	44	100	23.4
	O%	100	100	100	100	100				
Jul.	P%	15	15	35	20	15	34	30	100	23.3
	O%	75	100	100	25	100				
Aug.	P%	30	10	30	15	15	20	18	100	24.1
	O%	40	100	100	80	100				
Sep.	P%	35	5	40	15	5	18	10	100	25
	O%	75	20	100	60	100				
Oct.	P%	25	15	35	5	20	6	5	100	23
	O%	60	30	100	50	100				
Total	P%	27.5	15.6	25	21.9	10	209	162		

It is clear that larvae of *T. ilisha* were active in feeding around the period of larval stage and never cease feeding. Monthly changes in mean feeding intensities are given in Table (2). The mean intensity has no variations around the months (between 23 to 25 point/ larvae).

2- Juveniles of *T. ilisha*

Monthly changes in percentage composition of various dietary items by points and frequency of occurrence methods are shown in Table (2). It is evident that diatoms constituted the highest proportion of dietary components, as determined by both analytical methods, with a maximum composition of 34.1%. This was followed by algae

(30%), Cladocera (15.8%), Copepoda (10.8%), and detritus (9.8%). Table (2) presents data on the monthly variations in feeding activity and feeding intensity of *T. ilisha* juveniles. Feeding activity values ranged from 60.31% in October to 81.81% in August. The minimum feeding intensity, 20.2 points per fish, was recorded in July, while the highest mean intensity, 61.3 points per fish, was observed in both August and September.

Table 2. Monthly changes in diet composition of *T. ilisha* juvenile. Data are present as percentage of weighted points (P%), percentage of occurrence (O%), feeding activity (%) and feeding intensity

Months	Method of food analysis	Food Item					No. of juveniles	No. of feeding juveniles	Feeding activity%	Feeding Intensity
		Cladocera	Diatoms	Copepoda	Algae	Detritus				
Jun.	P%	20	30	15	30	5	76	53	69.73	42
	O%	40	100	80	100	100				
Jul.	P%	15	30	10	30	15	103	78	75.72	20.2
	O%	30	100	75	100	100	-	-	-	-
Aug.	P%	10	40	5	30	15	63	38	60.31	61.3
	O%	40	100	60	50	100	-	-	-	-
Sep.	P%	20	30	10	30	10	87	69	79.31	61.3
	O%	75	100	50	40	100	-	-	-	-
Oct.	P%	10	40	15	30	5	66	54	81.81	20.5
	O%	30	100	80	50	100	-	-	-	-
Nov.	P%	20	35	10	30	5	42	34	80.95	36.4
	O%	75	100	60	100	100	-	-	-	-
Total	P%	15.8	34.1	10.8	30	9.2	437	326	-	-

Indices of relative importance of food items (IRI)

Fig. (2) shows the monthly variation in the index of relative importance (IRI) values for various food items consumed by *T. ilisha* larvae. Copepods ranked the highest in dietary importance during five months—June, July, August, September, and October—with a peak IRI value of 40% in September. The lowest IRI for copepods (7%) was recorded in March. Rotifers were the most important dietary item in three months—March, May, and June—with peak IRI values of 35% in March and May, and the lowest value (2.5%) in October. Cladocera ranked first in April with an IRI of 35%. Although copepod nauplii and detritus were ingested throughout all larval stages, they played a relatively minor role in the overall diet composition.

Fig. (3) illustrates the monthly variation in the IRI values of various food items consumed by *T. ilisha* juveniles. Diatoms consistently dominated the diet across all months. In June and July, however, their importance was nearly matched by algae, both contributing approximately 30%. Diatoms reached their peak dietary contribution (40%) in August and October. Cladocera, copepods, and detritus were present throughout the juvenile stage but contributed only minimally to the overall diet.

Fig. (4) presents the IRI values for key dietary components of *T. ilisha* larvae. Five major groups constituted the primary diet: copepods (including adult and larval stages), Cladocera (*Daphnia* spp.), rotifers, and detritus. These groups contributed 28%, 15%, 26%, 20%, and 11% to the overall IRI, respectively.

Fig. (5) displays the IRI proportions for various food items consumed by *T. ilisha* juveniles. The data reveal clear differences in dietary composition, with diatoms forming the largest share (42%), followed by algae (27%) and detritus (11%). Cladocera and copepods contributed equally, each accounting for 10% of the juvenile diet.

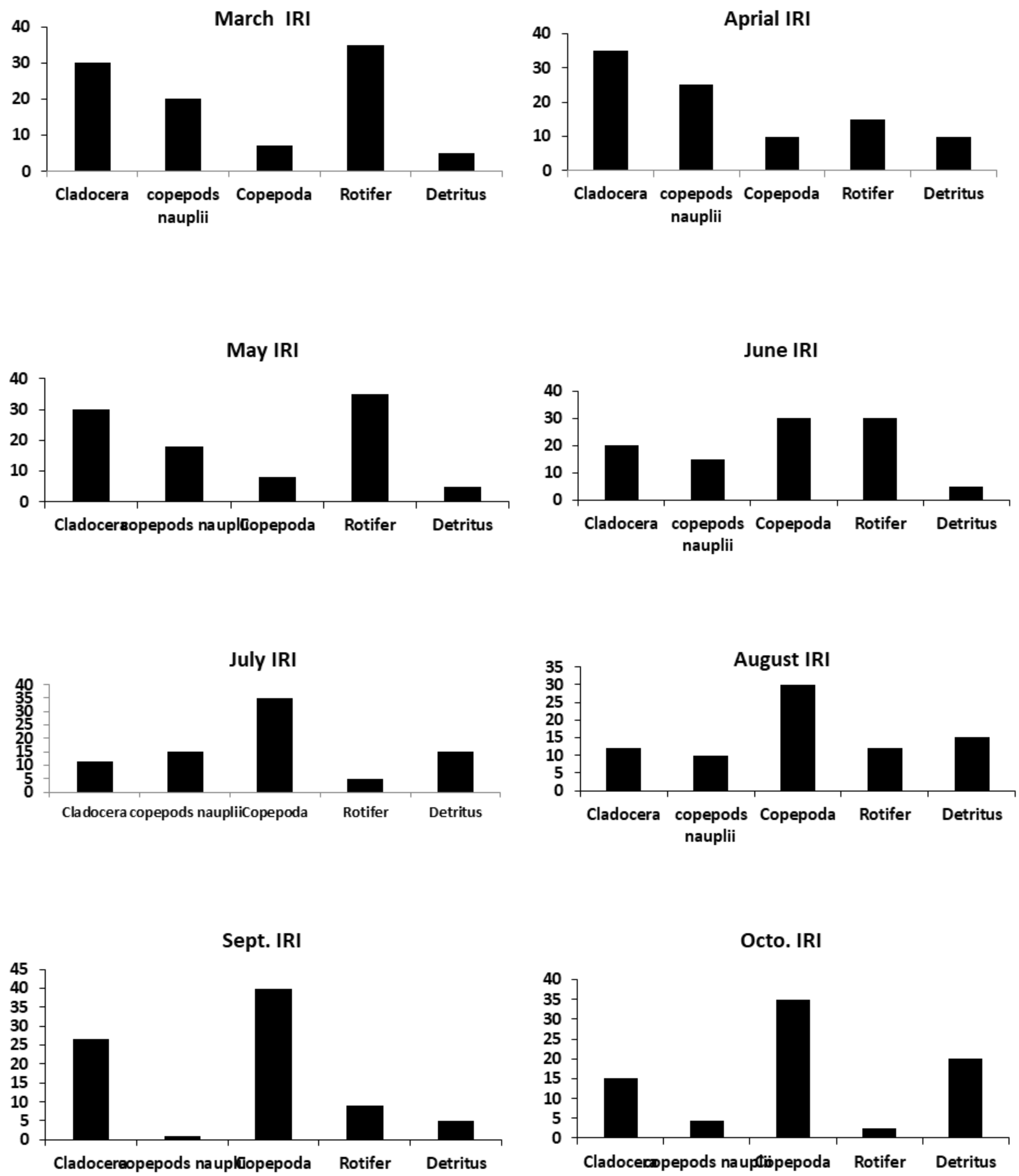

Fig. 2. Monthly variation in values of various foods' index of relative importance (IRI) items consumed by larvae of *T. ilisha*

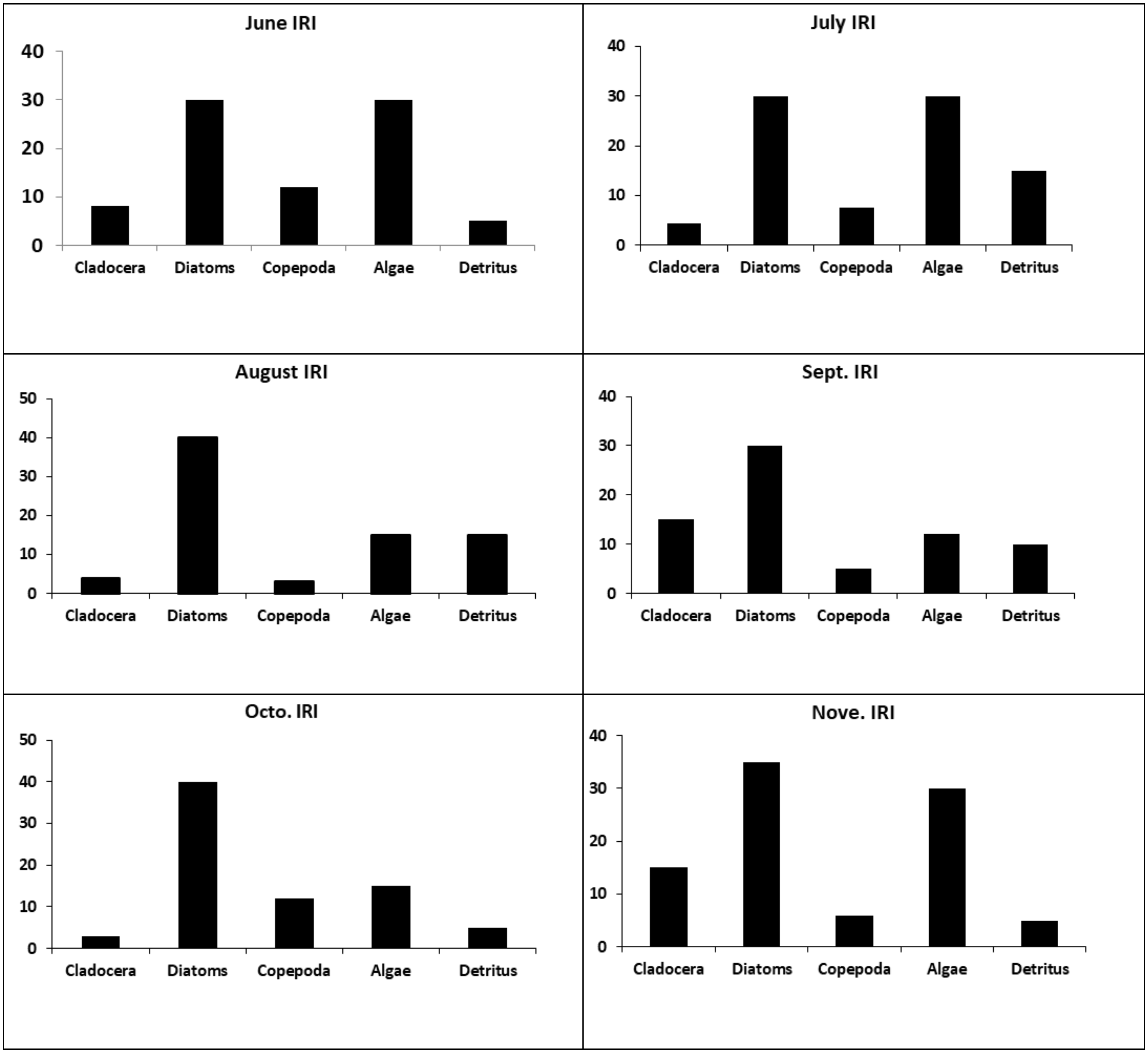

Fig. 3. Monthly variance in the index of relative importance (IRI) values of the foods that *T. ilisha* juveniles eat

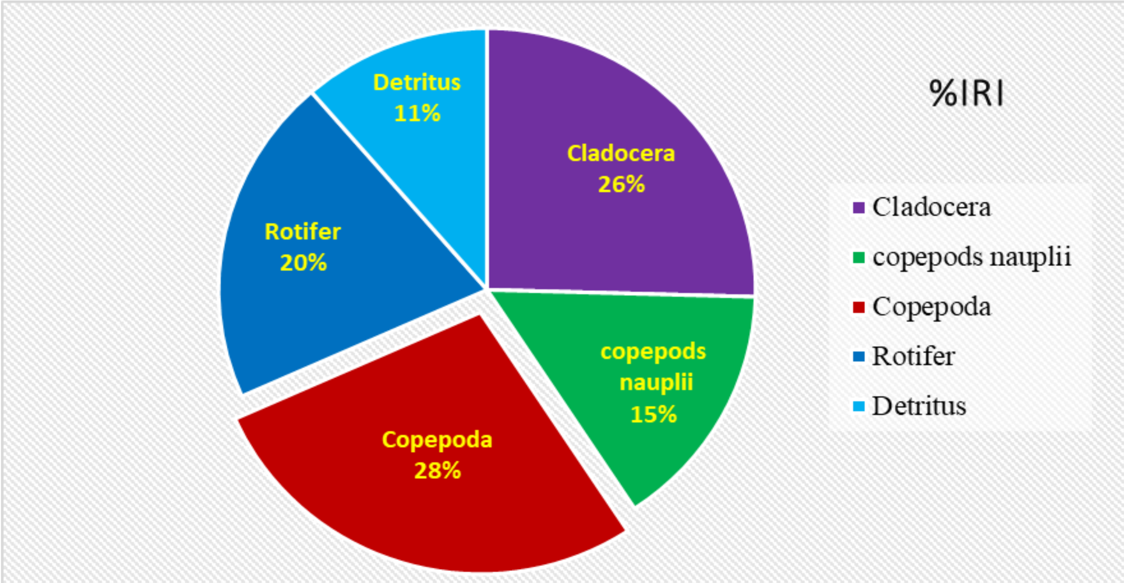

Fig. 4. The percentage of *T. ilisha* larvae's index of relative significance values

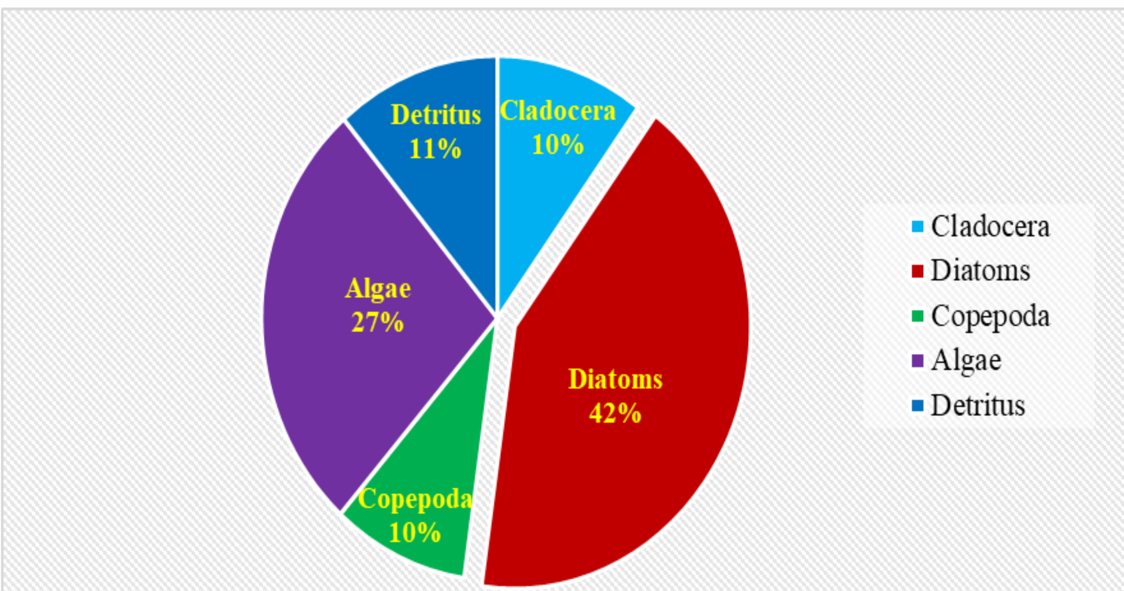

Fig. 5. *T. ilisha* juveniles' proportion of index of relative significance (IRI%) values

DISCUSSION

The study of fish feeding behavior is an ongoing endeavor, as it provides critical data for effective fisheries management. It has been observed that the distribution of fish species in specific water bodies depends largely on the availability of food items **(Agbabiaka, 2012)**.

Tenualosa ilisha is an anadromous species with a migratory nature and a wide geographic distribution. Because this species occupies different habitats during various life stages, its feeding habits may vary depending on environmental conditions **(Bhaumik, 2015)**. However, there have been relatively few investigations focused on the feeding patterns of *T. ilisha* larvae and juveniles. **Mohamed *et al.* (2008)** reported that the diet of *T. ilisha* juveniles (3.0–14.0 cm) in the East Hammar Marsh comprised ostracods (2%), copepods (7%), Cladocera (5%), rotifers (4%), organic debris (8%), filamentous algae (40%), and diatoms (34%). In contrast, **Mohamed *et al.* (2012)** found that the diet of larvae was primarily composed of Cladocera (27.3%), adult and larval copepods (55.7%), and organic detritus (17.0%).

The findings highlight notable shifts in feeding patterns related to fish size. These shifts may be attributed to changes in gill raker number and length, mouth position, and developmental changes in the digestive tract **(De, 1986)**. This observation was further supported by **De and Datta (1990)**, who noted that adult *T. ilisha* possess fully developed gill rakers equipped with fine papillae, forming an effective filtering system for sieving small food particles. In contrast, immature fish (less than 50 mm in length) have underdeveloped gill rakers lacking papillae and thus do not possess the same filtering efficiency. They concluded that copepods were the most significant dietary item consumed year-round by fry, juveniles, and adults. While adult *T. ilisha* also consumed large amounts of organic material, fry and juveniles relied more heavily on copepods. Aside from this, other small food items such as diatoms, rotifers, green algae, and protozoans were consistently present in the diet.

Variations in feeding behavior may also result from limited availability of appropriately sized prey, leading to selective feeding based on prey size **(Rendt *et al.*, 2001; Joyce *et al.*, 2002)**.

Stomach content analysis in the present study indicated that *T. ilisha* larvae were generalist feeders, consuming both larval and adult copepods, Cladocera (*Daphnia* spp.), rotifers, and detritus. These findings align with those of **Al-Okailee (2010)**, who studied *T. ilisha* larvae in the northern Shatt al-Arab River—though in that study, rotifers were absent from the diet. In contrast, *T. ilisha* juveniles in the present study consumed diatoms, algae, Cladocera, copepods, and detritus. **Al-Hassan (1999)** reported that the primary food sources for *T. ilisha* (locally known as Sbour or Hilsa) were diatoms, blue-green algae, and, to a lesser extent, zooplankton.

Zooplankton—including Cladocera, adult and naupliar copepods, and rotifers—form the bulk of the larval diet. These prey items are high in protein and are more easily digested than plant-derived food sources **(Kajmunke *et al.*, 2002; Contente *et al.*, 2009)**. In contrast, the digestive systems of juveniles are more developed, enabling them to digest more complex items such as diatoms and algae **(Park *et al.*, 2015)**. Smaller specimens, which exhibit the highest growth rates during their first year of life, may require more energy-dense food sources. This may explain why individuals in the smaller size groups from both study locations had consistently full stomachs **(Vassilopoulou & Ondrias, 1999)**.

CONCLUSION

The study revealed that *Tenualosa ilisha* larvae primarily feed on zooplankton, with Cladocera (*Daphnia* spp.) comprising 27.5% of their diet. In contrast, diatoms represented the most abundant food item for *T. ilisha* juveniles during the study period, accounting for up to 34.1% of the diet. Crustaceans ranked the highest in the Index of Relative Importance (IRI) for larval fish. For juveniles, diatoms dominated the diet across all months in which they were present, with peak contributions of 40% recorded in August and October.

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