

Review

Food and feeding habits of Indian sciaenids - A review

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Abstract

An attempt was made in the present article to review the food and feeding habits of the fishes of the family Sciaenidae from Indian waters. Members of the Sciaenidae family are commonly referred to as croakers or drums because of the sound produced by their swim bladders. Sciaenids are distributed in tropical and sub-tropical oceans. They are carnivorous, feeding mainly on crustaceans, small fish, molluscs, annelids and polychaetes and exhibit cannibalism. Sciaenids display differences in food preferences between early stages and adults; the former prefers zooplankton and crustaceans, and the latter mainly smaller teleosts. The feeding intensity was found to be higher in smaller groups compared to mature fish. Considerable temporal variations were recorded in food item occurrence, indicating an empty stomach during peak breeding and a wide spectrum of food items during other seasons.

Introduction

The fish of the family Sciaenidae, known as croakers or drums due to the sound produced using their swim bladders, are well distributed in the tropical and subtropical seas of the Atlantic, Pacific and Indian oceans as dominant members of the continental shelf. Sciaenids are one of the prime commercial fishery resources of India and contributed 165451 t of the demersal fish catch during the year 2018-19 (CMFRI, 2019). Nelson (1994) reported about 270 species of Sciaenids, mostly marine species belonging to 70 genera, with a few entering freshwaters. Mohanraj *et al.* (2003) reported that the family Sciaenidae comprises approximately 70 genera and 300 species, including 30 species from Indian waters, which are widely distributed throughout the world. According to Talwar (1995), sciaenid fishes are represented by 49 species from 22 genera in the Indian Ocean, of which 40 species belonging to 20 genera inhabit the seas along the Indian coast.

(Venugopal *et al.*, 2014). Estimation of foraging behaviour in fish allows us to recognise the feeding approaches and inter- or intra-specific relationships of the respective species (Bhakta *et al.*, 2019). The foraging behaviours of fish are an essential consideration in understanding their biology.

The length of the alimentary canal and the mouth gape, the two physical characteristics of fish associated with feeding, are affected by variations in fish size (Kapoor *et al.*, 1975). To know the biology of any fish and their respective management measures, studies on food and feeding habits are an essential component (Chakraborty *et al.*, 2016). Gomathy and Vivekanandan (2017) opined that shift in the feeding behaviour of fish is an adaptation to the ecosystem to reduce competition for food among juveniles and adults. Moreover, the temporal dynamics of food and feeding vary with species and habitat (Blaber, 2000; Vahneichong *et al.*, 2017). Usually, the feeding intensity of fish declines during the spawning season and varies with the availability of preferred food items, environmental conditions, maturity stages and spawning periodicity (Khogngain *et al.*, 2017; Sarkar *et al.*, 2017; Borah *et al.*, 2020).

Young sciaenids play an important role as both predators and prey in estuaries (Chao



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and Musick, 1977; Able *et al.*, 2001). Adequate knowledge on their food and feeding habits is lacking, even though it contributes substantially to the demersal fisheries of India. Across the west coast of India, the most dominant species are *Otolithes cuvieri*, *O. ruber*, *Pseudosciaena diacanthus*, *O. biauritus*, *Johnius glaucus*, *J. elongatus*, *J. belangerii*, *J. macrorhynchus*, *J. vogleri*, *J. dussumieri*, *J. aneus*, *Johneios sina*, *Nibea albida* and those from the east coast are *Daysciaena albida*, *Johnius dussumieri*, *Johnius belangerii*, *Johnius carutta*, *Johnius coitor*, *Johnius gangeticus*, *Macropsinosa cuja*, *Otolithes ruber*, *Johneios.vogleri*, *Otolithoides biauritus*, *Otolithoides pama* and *Protonibea diacanthus* (Mohan, 1983; Talwar and Jhingran, 1991). The fishing gears used to capture sciaenids are mainly trawls, gillnets, bag nets and hooks and lines. Detailed studies on biology and food and feeding habits of sciaenids have been carried out from the west coast of India by different authors (Karandikar and Thakur, 1951; Rao, 1963; Kutty, 1967; Suseelan and Nair, 1969; Jayaprakash, 1974; Manojkumar, 2003; Ghosh *et al.*, 2009; Thangavelu *et al.*, 2012; Venugopal *et al.*, 2014), but adequate studies are lacking along the east coast of India (Mookerjee *et al.*, 1946; Jacob, 1948; Chacko, 1949; Murty, 1979; Rao, 1980; Bhuyan *et al.*, 2012; Kumar *et al.*, 2015; Bhakta *et al.*, 2019; 2020). The present review on the food and feeding habits of sciaenids from Indian waters may facilitate probable interventions to enhance species-specific fisheries using the preferred food items as a measuring tool.

Food composition

The sciaenid fishes exploit an extensive range of feeding habits, comprising bivalves, crustaceans, fishes and polychaetes (Chao and Musick, 1977). It was found that the diets of sciaenids vary with locality, food availability, life stage and species. Sciaenids are highly carnivorous and feed on fish, crustaceans, mollusks and annelids (Karandikar and Thakur, 1951). Many sciaenid species have been found to consume only

Acetes spp. (George *et al.*, 1960; Venkataraman, 1960; Bhusari, 1975; Jaiswar and Chakraborty, 1988; Dukhande, 1991; Chakraborty *et al.*, 2000, 2005; Bhakta *et al.*, 2019) in their diets. Other than *Acetes* spp., sciaenids on the east coast of India mainly preferred other crustaceans like penaeid shrimps, *Squilla* spp., crab juveniles and cephalopods (Bhakta *et al.*, 2019). The preferred teleost items in their diets comprise *Arius* spp., *Bregmaceros mccllelandi*, *Coilia dussumieri*, *Cynoglossus* spp., *Conger* spp., *Harpadon nehereus*, *Leiognathus* spp., *Polynemus indicus*, *Polynemus paradesius*, *Rastrelliger kanagurta*, *Secutor* spp., *Sardinella* spp., *Setipinna* spp., *Stolephorus* spp., *Trichiurus* spp., along with other sciaenids, clupieds and mullets. On the west coast of India, sciaenids predominantly feed on crustaceans (*Acetes* spp., *Parapenaeopsis stylifera*, *Metapenaeus* spp., crabs and *Squilla* spp.), fish (*Apogon* spp., *Bregmaceros mccllelandi*, *Cynoglossus* spp., Leognathids, *Nemipterus* spp., *Sardinella longiceps*, *Saurida* spp., *Trichiurus* spp., *Thryssa* spp., *Upeneus* spp. other sciaenids, puffer fish), cephalopods (*Sepia* spp., *Octopus* spp., *Loligo* spp.), gastropods and stomatopods (Jaiswar and Chakraborty, 2005, Ghosh *et al.*, 2009).

The distribution of food organisms in the ecosystem mainly depends on environmental factors, which influences the temporal and spatial variation of food items in the diet composition (Bhakta *et al.* 2019). A comparative review of food and feeding habits is being done, referring to several researchers related to Indian sciaenids (Table 1).

Feeding habits

Sciaenids are predominantly carnivorous throughout their life. They are pelagic in the early stages and demersal in the maturing and adult stages. They exhibit vertical feeding with evidence of enough quantities of *Acetes* spp., small fishes and benthic forms like bottom-dwelling polychaetes and amphipods in their gut contents. Cannibalism habit

Table 1. Summary of food and feeding habits of sciaenids in Indian waters

Name of the species	Food and feeding habits	Area of study	Author(s)
Genus <i>Johnieops</i>			
<i>Pseudosciaena (Johnieops) sina</i> (Cuvier, 1830)	Shrimps, polychaetes, teleosts, <i>Acetes</i> spp. and amphipods as the main food	Calicut of the Malabar Coast	Venkataraman (1960)
<i>P. sina</i>	Fish, amphipods, mysids, sergestids, megalopa larvae, alima larvae, penaeid shrimps and polychaetes	Cochin waters	George <i>et al.</i> (1968)
<i>J. sina</i>	Teleosts, shrimps, <i>Squilla</i> spp., amphipods, polychaetes and molluscs	Ratnagiri coast	Bhusar, (1975)
<i>J. sina</i>	Juveniles are zooplankton feeders (copepods); adults feed on amphipods, fish, shrimps, polychaetes and <i>Squilla</i> spp.	Calicut coast	Nair (1980)
<i>J. sina</i>	Shrimps, fish, <i>Acetes</i> spp. and <i>Squilla</i> spp.	Bombay waters	Dukhande (1991)
<i>J. sina</i>	Fishes, crustaceans	Kerala waters	Chakraborty <i>et al.</i> (2000)
<i>J. sina</i>	Crustaceans and small fishes	Mumbai waters	Telvekar (2006)
<i>J. sina</i>	Fish, crustaceans and molluscs (crabs and shrimps) formed the major food items.	Malabar coast	Manojkumar (2011)
<i>J. sina</i>	Crustaceans, fishes, molluscs and <i>Acetes</i> spp.	Ratnagiri waters	Kumar (2012)
<i>J. sina</i>	Crustaceans (<i>Acetes</i> spp., crabs, Mysids, penaeid shrimps), teleosts (<i>Bregmaceros</i> spp., <i>Cynoglossus</i> spp., sciaenids), molluscs (bivalve, cuttlefish, squids, octopus), plankton	Cochin waters	Venugopal <i>et al.</i> (2014)
<i>Johnieops vogleri</i> (Bleeker, 1853) / <i>Johnius borneensis</i> (Bleeker, 1851)	Teleost fish, crustaceans and <i>Squilla</i> spp.	Bombay waters	Muthiah (1982)

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Genus <i>Johnius</i>			
<i>Johnius carutta</i> (Bloch, 1793)	Copepods, <i>Lucifer</i> spp., foraminiferans, radiolarians, crab larvae, shrimps, polychaetes, fish scales and sand grains	Madras waters	Jacob (1948)
<i>Johnius belangerii</i> (Cuvier, 1830)	Shrimps and polychaetes are main food items; <i>Squilla</i> , <i>Acetes</i> , amphipods and copepods are occasional food items.	Calicut of the Malabar Coast	Venkataraman (1960)
<i>J. carutta</i>	Benthic fauna, caridean shrimps and <i>Squilla</i> spp.	Bay of Bengal	Rao (1964)
<i>Johnius anaeus (macrorhynchus)</i> (Lal Mohan, 1976)	Crustaceans, <i>Loligo</i> spp., <i>Rastrelliger</i> sp. and other teleosts	Bay of Bengal	Rao (1964)
<i>Sciaena (Johnius) dussumieri</i> (Cuvier, 1830)	Crustaceans only	Bay of Bengal	Rao (1964)
<i>Johnius dussumieri</i> (Cuvier, 1830)	Polychaetes, <i>Lingula</i> and crustaceans	Bay of Bengal	Rao (1964)
<i>Johnius coibar (coitor)</i> (Hamilton, 1822)	Shrimps, <i>Sepia</i> and teleosts	Bay of Bengal	Rao (1964)
<i>Johnius axillaris</i> (Cuvier, 1830)/ <i>Johnius goldmani</i> (Bleeker, 1855)	Teleosts, shrimps, <i>Acetes</i> spp., stomatopods, amphipods, isopods, copepods, polychaetes and cephalopods	Bombay waters	Suseelan and Nair (1969)
<i>Johnius dussumieri</i>	Shrimps, <i>Metapenaeus</i> spp., teleosts, <i>Acetes</i> spp., crabs, amphipods, copepods, gastropods and cephalopods	Bombay waters	Suseelan and Nair (1969)
<i>J. dussumieri</i>	Crustaceans, teleost fish, molluscs, fish eggs and Salpa	Ratnagiri coast	Kumar <i>et al.</i> (2020)
<i>J. carutta</i>	Crustaceans, amphipods, fish and molluscs	Bombay waters	Suseelan and Nair (1969)
<i>J. carutta</i>	Small fish and crustaceans	Kakinada waters	Murty (1979)
<i>J. carutta</i>	Teleost fish, crustaceans, polychaetes and molluscs	Visakhapatnam waters	Kumar <i>et al.</i> (2015)
<i>Johnius glaucus</i> (Day, 1876)	Crustaceans and fishes	Off the Veraval coast	Raje (2000)
<i>J. glaucus</i>	Fish and crustaceans, crabs, copepods, <i>Loligo</i> sp., <i>Sepia</i> sp., and <i>Squilla</i> spp.	Off the Veraval coast	Thangavelu <i>et al.</i> (2012)
<i>J. elongatus</i>	Crustaceans and teleost fish	Ratnagiri coast, Maharashtra	Mehta <i>et al.</i> (2023)
Genus <i>Pennahia</i>			
<i>Johnius anaeus / Pennahia anea</i> (Bloch, 1793)	Crustaceans, <i>Loligo</i> , <i>Rastrelliger</i> and other teleosts	Bay of Bengal	Rao (1964)
<i>Johnius argentatus / Pennahia argentata</i> (Houttuyn, 1782)	Shrimps, crustaceans, <i>Anchoviella</i> and teleosts	Bay of Bengal	Rao (1964)
<i>Pennahia macrophthalmus (anea)</i> (Bloch, 1793)	Teleosts (<i>Bregmaceros maclellandi</i> , <i>Anchoviella</i> sp.) and shrimps (<i>Penaeus</i> sp., <i>Metapenaeus</i> sp., <i>Acetes</i> sp.)	Visakhapatnam waters	Rao (1980)
<i>P. anea</i>	Fish (<i>Stolephorus commersonii</i> , <i>Sardinella</i> sp., gobies), shrimps (<i>Acetes indicus</i>), <i>Sepia</i> sp., crabs	Mandapam coast	Lal Mohan (1985)
Genus <i>Otolithoides</i>			
<i>Otolithoides biauritus</i> (Cantor, 1849)	Fish, crustaceans, molluscs and annelids	Bombay waters	Karandikar and Thakur (1951)
<i>Otolithoides brunneus</i> (Day, 1873)	Shrimps and crabs	Kutch coast	Bhatt <i>et al.</i> (1964)
<i>O. biauritus</i>	Fish, shrimps, and other crustaceans (crabs and stomatopods)	Bombay waters	Kutty (1967)
<i>O. biauritus</i>	Shrimps, <i>Acetes</i> , teleosts, cephalopods, and other crustaceans	Bombay waters	Suseelan and Nair (1969)
<i>O. biauritus</i>	Teleosts, shrimps	Bombay waters	Jayaprakash (1974)
<i>O. biauritus</i>	<i>Acetes</i> spp., small fish and <i>Loligo</i> spp.	Bombay waters	Manojkumar and Acharya (1990)
<i>O. biauritus</i>	Crustaceans and teleosts	Bombay waters	Mohanraj <i>et al.</i> (2003)
<i>O. biauritus</i>	Penaeid shrimps, non-penaeid shrimps, finfish	Diu coast	Ghosh <i>et al.</i> (2009)
<i>Otolithoides pama</i> (Hamilton, 1822)	Small fishes (other sciaenids, clupieds and mullets) and shrimps (<i>Acetes</i> spp., <i>Metapenaeopsis</i> spp., <i>Metapenaeus</i> spp., <i>Parapenaeus</i> spp.)	West Bengal waters	Bhakta <i>et al.</i> (2019)
Genus <i>Otolithes</i>			
<i>Otolithes cuvieri</i> Trewavas 1974	Fish, crustaceans, molluscs and annelids	Bombay waters	Karandikar and Thakur (1951)
<i>Otolithes argenteus</i> (Cuvier, 1830)/ <i>Otolithes ruber</i> (Bloch & Schneider, 1801)	Plankton in juveniles and fish in adults	Bombay waters	Bapat and Bal (1952)
<i>O. ruber</i>	Crustaceans, teleosts and cephalopods in adults and crustaceans in juveniles	Bombay waters	Vaidya (1960)
<i>O. ruber</i>	Teleosts, shrimps, mysids, echiurid worms, amphipods, crabs and megalopa	Calicut of the Malabar Coast	Venkataraman (1960)

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<i>Otolithus argenteus</i> / <i>Otolithes ruber</i> (Bloch & Schneider, 1801)	<i>Squilla</i> , shrimps, crabs and teleosts	Bay of Bengal	Rao (1964)
<i>O. ruber</i>	Amphipods, copepods, cephalopods, isopods, shrimps, scalps, teleosts and stomatopods	Bombay water	Suseelan and Nair (1969)
<i>O. ruber</i>	<i>Acetes</i> spp., mysids, shrimps and teleosts	Calicut waters	Nair (1979)
<i>O. ruber</i>	Shrimps, mysids, <i>Acetes</i> spp., <i>Squilla</i> spp., fish and juveniles of sciaenids	Porto Novo	Pillai (1983)
<i>Otolithes cuvieri</i> Trewavas 1974	<i>Acetes</i> spp., <i>Solenoceras</i> pp. and teleosts	Veraval coast	Rao (1985)
<i>O. cuvieri</i>	<i>Cruataceans</i> , <i>Squilla</i> spp., crab zoea and fish	Bombay waters	Gulati (1987)
<i>O. cuvieri</i>	<i>Bregmaceros</i> spp., <i>Coilia</i> spp., <i>Lactarius lactarius</i> and <i>Polynemus</i> spp.	Bombay waters	Chakraborty (1988)
<i>O. cuvieri</i>	Isopods, copepods, crustaceans and small fish	Veraval coast	Manojkumar (2003)
<i>O. cuvieri</i>	Fish and shrimps	Mumbai coast	Telveker <i>et al.</i> (2006)
<i>O. cuvieri</i>	Teleosts, fish and crustaceans	Off Veraval coast	Thangavelu <i>et al.</i> (2012)
<i>O. cuvieri</i>	Crustaceans, fishes, cephalopods and gastropods	Ratnagiri coast	Sandhya <i>et al.</i> (2014)
Genus <i>Pterotolithus</i>			
<i>Otolithus (Pterotolithus) maculatus</i> (Cuvier, 1830)	Megalopa and decapods	Bay of Bengal	Rao (1964)
Genus <i>Protonibea</i>			
<i>Pseudosciaena (Protonibea) diacanthus</i> (Lacepede 1802)	Digested shrimps and shrimps remain as such.	Kutch coast	Bhatt <i>et al.</i> (1964)
<i>P. diacanthus</i>	Shrimps and fish are major food items, crabs, <i>Squilla</i> spp., alpheids, molluscs and gastropods found occasionally	Bombay waters	Rao (1968)
<i>P. diacanthus</i>	Shrimps (<i>Parapenaeopsis stylifera</i> , <i>P. sculptilis</i> , <i>Penaeus</i> sp.), finfish (<i>O. ruber</i> , <i>Otolithes</i> spp., <i>Johnius</i> spp.), crabs and stomatopods	Bombay waters	Suseelan and Nair (1969)

in major sciaenids is frequently encountered and reported by several researchers. The occurrence of their own young ones in the stomach indicated that the sciaenids exhibited cannibalism, as reported by Telveker *et al.* (2006) in *O. cuvieri*; Bhuyan *et al.* (2012) in *O. ruber* and *J. carutta* and Bhakta *et al.* (2019) in *O. pama*. The lack of correlation between the gut contents and their abundance in the environment showed that *Otolithoides brunneus* from Bombay waters exercised no selectivity and fed on whatever came its way (Jayaprakash, 1974).

Food preference as per size groups

Food preferences, as per size groups, showed that there are marked differences in feeding habits in several sciaenids (Figs. 1 and 2). Studies show that the smaller size groups of *O. brunneus* feed only on shrimps and become more ichthyophagous with age (Jayaprakash, 1974). Nair (1979) found that the young ones of *O. ruber* mostly feed on pelagic animals and zooplankton at the surface and in adult stages, they have a predacious and carnivorous habit, feeding mainly on shrimps and teleosts at the bottom. Muthiah (1982) reported that the smaller groups of *J. vogleri* mainly feed on shrimps and on reaching adult stages, diet composition shifted towards fish and shrimps became less dominant. The food items of *Pseudosciaena sina* mainly consists of the copepods Lucifer, Mysis, *Acetes* spp., small shrimps and polychaete larvae, while those of adults are shrimps, *Acetes* spp., *Squilla* spp. and fishes (Bhusari, 1975). Nair (1980) observed that juveniles of *J. sina* are predominantly zooplankton feeders and adults mainly feed on shrimps, polychaetes, amphipods and *Squilla* spp. Ghosh *et al.* (2009) observed in their study that juveniles of *O. biauritus* fed entirely on *Acetes* spp., and in adult stages, they preferred both non-penaeids and finfish. The diet of juveniles of *J. sina* mainly consisted of *Acetes* sp., while that of

adult fish includes a wide spectrum of food items like penaeid shrimps, many teleost species, stomatopods and molluscs in Cochin waters (Venugopal *et al.*, 2014). Several studies reported that in the young stage, sciaenids primarily feed on crustaceans, predominantly shrimps and once mature they show piscivorous habits, as reported by Muthiah (1982) in *J. vogleri*, Rao (1968) in *P. diacanthus*, Jayaprakash (1974) in *O. brunneus* and Bhakta *et al.* (2019) in *O. pama*.

Rao (1980) studied food and feeding habits of different size (small, medium and large) groups of *Pennahia macrophthalmus (anea)* but without any significant differences in food items between different size groups, though the occurrence of teleosts was more common in large size groups. The difference in diet between juveniles and adults could be ascribed to the varied environment in which they live (Nair, 1980). The juvenile diet was dominated mainly by bottom fauna, as they mostly remained at the bottom of the sea, while the diet of adults consisted of a wide range of food items from different layers of the water column (Venugopal *et al.*, 2014).

A gradual change in food habits from crustaceans to fish diets with an increase in the size of sciaenids was reported by Rao (1985), Chakraborty (1988), Thangavelu *et al.* (2012) and Sandhya (2014) in *O. cuvieri*, Telveker (2002) in *J. sina*, Ghosh *et al.* (2009) in *O. biauritus* and Bhakta *et al.* (2019) in *O. pama*. Manojkumar (2003), Sandhya (2014) and Kumar *et al.* (2015) reported that sciaenids become more ichthyophagous with an increase in the size, which is also corroborated by the works but differs from the finding of Raje (2000), who stated that there were not many variations in feeding habits between middle and large-sized individuals.

Table 2. Seasonal variation in feeding intensity of some Indian sciaenids (Blue: High feeding intensity; Orange: Medium feeding intensity; Green: Low feeding intensity; White: No feeding intensity)

Species name/ Indian coast	Author	Pre-monsoon				Monsoon				Post-monsoon			
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
East coast													
<i>P. macrophthalmus</i>	Rao (1980)	Green	Green	Orange	Orange	Orange	Orange	Blue	Blue	Blue	Blue	Blue	Green
<i>Otolithes ruber</i>	Bhuyan (2003)	Orange	White	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
<i>J. carutta</i>		Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
<i>P. macrophthalmus</i>		Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
<i>J. carutta</i>	Kumar <i>et al.</i> (2015)	Orange	Orange	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
<i>O. pama</i>	Bhakta <i>et al.</i> (2019)	Green	White	White	White	White	White	White	White	Blue	Green	Blue	Green
West coast													
<i>O. biauritus</i>	Suseelan and Nair (1969)	White	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
<i>O. biauritus</i>	Jayaprakash (1974)	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
<i>O. cuvieri</i>	Manojkumar (2003)	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
<i>O. cuvieri</i>	Telveker <i>et al.</i> (2006)	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
<i>O. biauritus</i>	Ghosh <i>et al.</i> (2009)	White	White	White	White	White	White	White	White	White	White	White	White
<i>J. sina</i>	Kumar (2012)	White	Green	Blue	Blue	White	White	White	White	White	White	White	White
<i>O. cuvieri</i>	Sandhya <i>et al.</i> (2014)	White	White	White	White	White	White	White	White	White	White	White	White
<i>J. sina</i>	Venugopal <i>et al.</i> (2014)	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue

Ghosh *et al.* (2009) found that the feeding intensity was higher in the post-monsoon season in the juveniles compared to mature ones in *O. biauritus*. *Otolithes cuvieri* was found to be a carnivore and *Acetes indicus* was the preferred food item by all the size groups and teleosts were present in the gut content of the size group above 150 mm (Thangavelu *et al.*, 2012). In the case of *O. cuvieri*, high feeding intensity was reported during February and December, as the maximum number and percentage of gorged stomachs and full stomachs were found during these months and the maximum number of empty stomachs was found during November (Sandhya *et al.*, 2014). Venugopal *et al.* (2014) reported that in *J. sina*, intense feeding in female fish was observed during December and January, whereas the males fed intensively during April, September, October and November. They found the maximum percentage of gorged stomachs in both sexes during October. Moreover, the percentages of actively fed juveniles were higher compared to adults and the magnitude of poorly fed fish increased with size of the fish. Bhakta *et al.* (2019) found high feeding intensity in the male of *O. pama* during December and that of females during February, October and December. They also reported low feeding intensity and the occurrence of empty stomachs throughout the year.

In almost all the species mentioned here, a high incidence of poorly fed fish or with empty stomachs was observed during most of the months, which signifies the absence of regular periodicity in the feeding intensity during different seasons. The occurrence of poorly fed *O. cuvieri* in most of the months from Calicut water indicates an irregularity in intense feeding activity (Nair, 1979). Moreover, the frequent occurrence of empty stomachs may be attributed to the faster digestion due to strong gastric secretion in carnivorous fishes (Qasim, 1972). Several studies indicated that the stomach was found empty throughout the year in the maximum numbers of sciaenids, which might be due to the disgorging tendency during the catching process leading to the extroverted position of the stomach after the harvest. It was corroborated by the works of Venkataraman (1960) in *O. ruber*; Rao (1963) in *P. diacanthus*; Ghosh *et al.* (2009) in *O. biauritus*; Sandhya (2012) in *O. cuvieri* and Bhakta *et al.* (2019) in *O. pama*.

The disgorging tendency of *O. biauritus* was reported by Ghosh *et al.* (2009), where 60% of the stomach was found empty. Enormous number of sciaenid stomachs were found empty, disgorged and in an extroverted position, which was attributed to a disturbance that occurred during the catching operation. The over-leaping tendency during entangling in fishing gear could cause suffocation of fish, leading to such disgorging behaviour (Bhakta *et al.*, 2019).

Feeding intensity in relation to spawning season

Gastro-somatic index values are frequently low during the spawning season due to less vigorous feeding, according to Chaturvedi and Saksena (2013) in *Mystus cavasius* and Khongngain *et al.* (2017) in *Trichogaster fasciata*. Gulati (1987) observed low feeding intensity in *O. cuvieri* during May to June, coinciding with the spawning season of the fish in Mumbai waters and fully developed gonads ingested minimum food during such a time. Vaidya (1960) reported that most of the stomachs in *O. ruber* were found empty with a reduced feeding tendency during the spawning period and a gradual increase in feeding intensity was observed subsequently. Suseelan and Nair (1969) investigated that the feeding intensity of *O. ruber* was inversely related to the maturity stages of the fish and the occurrences of empty stomachs were highest during the spawning months.

Telveker *et al.* (2006) reported that in *O. cuvieri* from Mumbai waters, the higher feeding intensity coincided with the advancement of the reproductive process and poor feeding with the commencement of the spawning activity. Kumar *et al.* (2015) found a relatively low GaSI value (1.27%) during the spawning season, moderate (1.74%) during the post-monsoon and relatively high (1.95%) during the pre-spawning season in *J. carutta* from the Vishakhapatnam coast, which corroborates the feeding intensity being inversely related to gonadal maturity. They found that 99% of the guts were empty during the spawning season. However, Bhakta *et al.* (2019) observed high feeding intensity in *O. pama* with high values of GaSI in the spawning season, which was attributed to its

breeding throughout the year and to maintain energy level, they required a good amount of food in the spawning season.

According to Mathialagan and Sivakumar (2012), low feeding activity during peak breeding may be ascribed to fully developed gonads, allowing limited space in the stomach. They also estimated that the high variation in feeding intensity was found in females as compared to males because ovaries occupy more space than testes. Studies revealed that the highest percentage of empty stomachs was observed during the breeding periods of sciaenids, owing to a significant decrease in food intake (Chakraborty *et al.*, 2000; Sandhya *et al.*, 2014). Low feeding activities during peak spawning seasons of the fish may be attributed to the fully developed gonads, which limit the fish from feeding more due to less space in the stomach and are mostly observed in females compared to males (Morte *et al.*, 2001; Mathialagan and Sivakumar, 2012; Chakraborty *et al.*, 2016, 2017; Khongngain *et al.*, 2017; Pramanick *et al.*, 2019; Borah *et al.*, 2020).

Strategies for conservation

Sciaenids are small, moderate and large-sized fish and form one of the major marine demersal fisheries in India. Several sciaenids are euryhaline and migrate to estuarine systems for breeding and feeding, thus forming commercially important fisheries. They are carnivores and active predators. The Indian sciaenids are found to be at moderate risk of overexploitation (Chakraborty *et al.*, 2000). Marine sciaenids are exploited through trawl nets and those of estuaries by gill nets. Overfishing and bycatch are the main threats to the marine sciaenids, whereas habitat degradation along with excess fishing pressure is found to be the main threat to the estuarine sciaenids. Estuaries seem to be an important habitat for many species of sciaenids at different stages of life, especially for nursing and seasonal foraging. Studies on spawning habitat location and environmental preferences (temperature, depth, food organisms and substrate) as well as its regular monitoring are of considerable importance in the context of conservation of the species. Anthropogenic activities leading to habitat degradation by the deterioration of water quality in estuaries and coastal areas by the unregulated discharge of sewage, industrial effluents, agricultural pesticides and chemicals pose serious threats to the fishery of sciaenids. Bycatches and discards from artisanal, motorised, and mechanised fishing are a matter of serious concern for the wanton loss of juveniles, which needs to be addressed properly. Moreover, bottom trawling adversely affects habitats by removing epifauna, shifting bathymetry and altering the assemblage of benthic communities and such losses may take several months to years for recovery. Climate change, through an increase in temperature, CO₂ level, precipitation regime and salinity pattern, influences fisheries adversely. An increase in sea temperature may cause fish to spawn early and shift habitats (Odell *et al.*, 2017), leading to enhanced competition in estuaries and coastal areas, which influence sciaenid fisheries substantially. However, conservation measures need steps to reduce bycatch, a fishing restriction period during spawning and a policy to address the discharge of effluents, sewage, and pesticides. Outreach activities to educate stakeholders on threats to the fishery, protection of spawning habitats and juveniles, bycatch loss and other challenges can be of immense use to enhance fisheries. Adequate enforcement in estuarine and coastal protected areas during the strategic fishing season can promote the conservation of sciaenids.

Conclusion

Sciaenids are found to be highly carnivorous and predominantly feed on annelids, crustaceans, fish, molluscs and polychaetes in different environments. The position of the mouth with a large mouth gap, the presence of sharp canine teeth, fewer gill rakers, relatively large stomachs and smaller intestines make it carnivorous. Specific differences in food habits can be attributed to variations in food availability in distinct habitats. In general, at the early stages, sciaenids feed on zooplankton and crustaceans (mainly *Acetes* spp.), but gradual changes in food habits are noticed from crustaceans to fish diets as the length of the fish increases and becomes mostly ichthyophagous in the fully matured stages. The relationship between the size of the fish and feeding intensity among sciaenids was observed with a definite pattern. Food is considered the most critical limiting factor influencing the distribution and abundance of a particular species in a specified area. The feeding intensity of sciaenids was found to be higher in the smaller and juvenile stages compared to the mature and adult stages, as more empty stomachs were observed in later phases of life. This might be attributed to the high food requirement of the young and early growth stages to meet the required energy as they move faster with higher metabolic activities compared to the adults having relatively slow movement.

References

- Able, K. W., Nemerson, D. M., Bush, R. and Light, P. 2001. Spatial variation in Delaware Bay (USA) marsh creek fish assemblages. *Estuaries*, 24(3): 441-452.
- Bapat, S. V. and Bal, D. V. 1952. The food of some young fishes from Bombay. *Proc. Indian Acad. Sci.*, 35B: 78-92.
- Bhakta, D., Das, S. K., Das, B. K., Nagesh, T. S. and Behera, S. 2019. Food and feeding habits of *Otolithoides pama* (Hamilton, 1822) occurring from Hooghly-Matlah estuary of West Bengal, India. *Reg. Stud. Mar. Sci.*, 32: 100860. <https://doi.org/10.1016/j.rsm.2019.100860>.
- Bhakta, D., Das, S. K., Das, B. K., Nagesh, T. S. and Samanta, R. 2020. Growth, mortality and exploitation status of *Otolithoides pama* (Hamilton, 1822) from Hooghly-Matlah Estuary of West Bengal, India. *Reg. Stud. Mar. Sci.*, 39: 101451. <https://doi.org/10.1016/j.rsm.2020.101451>.
- Bhatt, Y. M., Kutty, M. N., Rao, K. V. and Punwani, D. M. 1964. "Ghol-Dara" fishery off Bedi port in the Gulf of Kutch. *Indian J. Fish.*, 11(1): 135-156.
- Bhusari, B. V. 1975. Biology and fishery of *Pseudosciaena sina* at Ratnagiri South Maharashtra. *J. Bombay Nat. Hist. Soc.*, 72(2): 357-367.
- Bhuyan, S. K. 2003. *Biology and stock assessment of some sciaenids off Paradeep Coast*. Dissertation, ICAR-Central Institute of Fisheries Education, Mumbai, India.
- Bhuyan, S. K., Jena, J. K., Pillai, B. R., Kumar, P. and Chakraborty, S. K. 2012. Studies on the growth of *Otolithes ruber* (Bloch and Schneider, 1801), *Johnius carutta* Bloch, 1793 and *Pennahia macrophthalmus* (Bleeker, 1850) from Paradeep coast, Orissa, India. *Indian J. Fish.*, 59(2): 89-93.
- Blaber, S. J. M. 2000. *Tropical estuarine fishes: Ecology, exploitation and conservation*. Blackwell Science, Queensland, Australia.
- Borah, N., Das, S. K. and Bhakta, D. 2020. Temporal changes in feeding and bio-indices of *Polynemus paradiseus* Linnaeus, 1758 occurring in Hooghly-Matlah Estuary, West Bengal. *Indian J. Mar. Sci.*, 49(01): 118-123.
- Chacko, P. I. 1949. Food and feeding habits of the fishes of the Gulf of Mannar. *Proc. Indian Acad. Sci.*, 29B: 83-97.

- Chakraborty, R., Das, S. K. and Bhakta, D. 2017. Length-weight relationship, relative condition factor and food and feeding habits of *Channa striata* from wetlands of Nadia district, West Bengal. *J. Inland Fish. Soc. India*, 49(2): 22-26.
- Chakraborty, R., Das, S. K., Bhakta, D. 2016. Food and feeding habits of *Channa punctatus* (Bloch, 1793) from water bodies of Nadia District, West Bengal. *J. Inland Fish. Soc. India*, 48(2): 88-92.
- Chakraborty, S. K. 1988. *Study on the sciaenids of Bombay waters*. Dissertation, University of Bombay, Mumbai, India.
- Chakraborty, S. K., Devadoss, P., Manojkumar, P. P., Khan, M. F., Jayasankar, P., Sivakami, S., Gandhi, V., Sastry, Y. A., Raju, A., Livingston, P., Hamsa, K. M. S. A., Badruddin, M., Ramalingam, P., Dhaireswar, V. M., Rao, C. V. S., Nandakumaran, K., Chavan, B. B. and Seetha, P. K. 2000. The fishery, biology and stock assessment of Jew fish resources of India. In: Pillai, V. N. and Menon, N. G. (Ed.), *Marine fisheries research and management*, ICAR-Central Marine Fisheries Research Institute, Kochi, India, pp. 604-616.
- Chao, L. N. and Musick, J. A. 1977. Life history, feeding habits, and functional morphology of juvenile sciaenid fishes in the York River Estuary, Virginia. *Fish. Bull.*, 75: 657-702.
- Chaturvedi, J. and Saksena, D. N. 2013. Diet composition, feeding intensity, gastro-somatic index and hepatosomatic index of a catfish, *Mystus cavasius* from Chambal River (near, Rajghat), Morena, Madhya Pradesh. *Int. J. Recent Sci. Res.*, 4(9): 1350-1356.
- CMFRI 2019. *Annual report 2018-19*. ICAR-Central Marine Fisheries Research Institute, Kochi, India, 320 p.
- Dukhande, S. 1991. *Feeding and reproductive biology of Johnnieops sina (Cuvier, 1830)*. Dissertation, University of Bombay, Mumbai, India.
- George, K. C., Dayanandan, M. G. and Nair, P. K. 1968. Food of some demersal fishes from the trawl grounds off Cochin. *Indian J. Fish.*, 15(1&2): 81-88.
- Ghosh, S. G., Mohanraj, G., Asokan, P. K., Dhokia, H. K., Zala, M. S. and Bhint, H. M. 2009. 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): 261-265.
- Gomathy, S. and Vivekanandan, E. 2017. Changes in the diet of predatory ribbonfish *Trichiurus lepturus* Linnaeus, 1758 with increasing body size along Chennai coast. *Indian J. Fish.*, 64(4): 34-43.
- Gulati, D. K. 1987. *Morphometry, biology and stock assessment of Otolithes cuvieri (Trewavas) off the Bombay coast*. Dissertation, University of Bombay, Mumbai, India.
- Jacob, P. K. 1948. Sciaenids of the west coast of Madras Province. *J. Bombay Nat. Hist. Soc.*, 48: 118-124.
- Jaiswar, A. K. and Chakraborty, S. K. 2005. *Acetes*, the preferred food of fishes along the northwest coast of India. *Indian J. Fish.*, 52(2): 215-219.
- Jayaprakash, A. A. 1974. Food and feeding habits of juveniles of koth *Otolithoides brunneus* (Day) in Bombay waters. *Indian J. Fish.*, 21(1): 127-140.
- Kapoor, B. B., Smit, H. and Verighina, I. A. 1975. The alimentary canal and digestion in teleosts. *Adv. Mar. Biol.*, 13: 109-239.
- Karandikar, K. R. and Thakur, S. S. 1951. *Sciaenoides brunneus* Day (anatomy with notes on distribution and bionomics). *Zool. Mem. Univ. Bombay*, 3: 1-89.
- Khongngain, O., Das, S. K. and Bhakta, D. 2017. Study on Food and feeding biology of *Trichogaster fasciata* Bloch & Schneider, 1801 from a wetland of Nadia District of West Bengal. *J. Inland Fish. Soc. India*, 49(2): 03-09.
- Kumar, M. S., Rajeswari, G. and Kishore, B. 2015. Food and feeding habits of *Johnius carutta* (Bloch, 1793) off Visakhapatnam, East-coast of India. *Fish. Technol.*, 52: 88-94.
- Kumar, T. 2012. *Biology and stock assessment of Johnnieops sina (Cuvier, 1830) from Ratnagiri waters*. Dissertation, ICAR-Central Institute of Fisheries Education, Mumbai, India.
- Kumar, T., Chakraborty, S. K., Jaiswar, A. K., Panda, D., Sandhya, K. M., Shah, T. H., Bhagabati, S. K., Alam, A. and Kumari, S. 2020. Diet composition and feeding strategy of *Johnius dussumieri* (Cuvier, 1830) from Ratnagiri coast of India. *Indian J. Geo. Mar. Sci.*, 49(07): 1242-1249.
- Kutty, M. N. 1967. A note on the biology of the 'Koth', *Otolithoides brunneus* (Day). *J. Mar. Biol. Ass. India*, 9(1): 197-198.
- Lal Mohan, R. S. 1985. Food and feeding habits of the sciaenid fish *Pennahia macrophthalmus* (Bleeker). *J. Mar. Biol. Assoc. India*, 27: 68-71.
- Manojkumar, P. P. 2003. Observations on the food and feeding habits of *Otolithes cuvieri* (Trewavas) off Veraval. *Indian J. Fish.*, 50: 379-385.
- Manojkumar, P. P. 2011. Fishery of sciaenids with some observations on the biology and stock assessment of *Johnnieops sina* (Cuvier, 1830) exploited along the Malabar coast. *J. Mar. Biol. Assoc. India*, 53(1): 68-74.
- Manojkumar, P. P. and Acharya, P. 1990. Morphometry, length-weight relationship and food and feeding habits of *Otolithoides blauritus* (Cantor, 1850) of Bombay waters. *J. Indian Fish. Assoc.*, 20: 31-36.
- Mathialagan, R. and Sivakumar, R. 2012. Few aspects of the reproductive biology of reba carp *Cirrhinus reba* (Hamilton) from Vadavar River Lower Anicut, Tamil Nadu. *E. J. Life Sci.*, 1(2): 61-67.
- Mehta, P., Mohite, S. A., Pawar, R. A., Nirmale, V. H. and Naik, S. D. 2023. Seasonal changes in feeding habit of *Johnius elongatus* (Mohan, 1976) sciaenid species from Ratnagiri coast, Maharashtra, India. *J. Exp. Zool. India*, 26(1): 707-711.
- Mohan Rajan, K. V. 1983. Some indigenous fishing gears and methods for squids and cuttle fishes along south-west coast of India. *Seafood Exp. J.*, 15(6): 19-30.
- Mohanraj, G., Batcha, H. and Gomathy, S. 2003. Sciaenids. In: *Status of exploited marine fishery resources of India*. ICAR-Central Marine Fisheries Research Institute, Kochi, India, pp 133-140.
- Mookerjee, H. K., Ganguly, D. N. and Mazumdar, T. C. 1946. On the food of estuarine fish of Bengal. *Sci. Cult.*, 10: 564-565.
- Morte, S., Redon, M. J. and Sanz-Brau, A. 2001. Diet of *Scorpaena porcus* and *Scorpaena notata* (Pisces: Scorpaenidae) in the Western Mediterranean. *Cah. Biol. Mar.*, 42(4): 333-344.
- Murty, V. S. 1979. Observation on some aspects of biology of croakers *Johnius (Johnnieops) dussumieri* (Cuvier) and *Johnius (Johnnius) carutta* Bloch from Kakinada. *J. Mar. Biol. Assoc. India*, 21(1&2): 77-85.
- Muthiah, C. 1982. Study on the biology of *Johnnieops vogleri* (Sleeker) of Bombay waters. *Indian J. Fish.*, 29(1&2): 118-133.
- Nair, K. V. S. 1979. Food and feeding habits of *O. ruber* (Schneider) at Calicut. *Indian J. Fish.*, 26(1&2): 24-34.
- Nair, K. V. S. 1980. Food and feeding habits of *Jolmieops sina* (Cuvier). *Indian J. Fish.*, 27(1 & 2): 24-34.
- Nelson, J. S. 1994. *Fishes of the world*, 3rd edn. Wiley, New York, USA.
- Odell, J., Adam, D. H., Boutin, B., Collier II, W., Deary, A., Havel, L. N., Johnson Jr, J. A., Midway, S. R., Murray, J., Smith, K., Wilke, K. M. and Yuen, M. W. 2017. Atlantic Sciaenids habitats: A review of utilisation, threats and recommendations for conservation, management and research. *Atlantic States Marine Fishery Commission Habitat Management Series, No. 14*, Arlington, Virginia, USA, 135 p.
- Pillai, P. K. M. 1983. Biometry, food and feeding and spawning habits of *Otolithes ruber* (Schneider) from Porto Novo, India. *Indian J. Fish.*, 30: 69-73.

- Pramanick, S., Das, S. K., Bhakta, D. and Johnson, C. 2019. Studies on the food and feeding habits of *Chelon planiceps* (Valenciennes, 1836) from Hooghly-Matlah Estuary, West Bengal. *J. Aqua. Trop.*, 34(3-4): 259-265.
- Qasim, S. Z. 1972. The dynamics of food and feeding habits of some marine fishes. *Indian J. Fish.*, 19(1&2): 11-28.
- Raje, S. G. 2000. Some aspects of the biology of *Otolithes cuvieri* (Trewavas) and *Johnius glaucus* (Day) from Veraval. *Indian J. Fish.*, 27: 1-6.
- Rao, S. K. 1964. Food and feeding habits of fishes from the trawl catches in the Bay of Bengal with observations on diurnal variation in the nature of the feed. *Indian J. Fish.*, 11: 277-314.
- Rao, S. V. 1968. Some aspects of the biology of 'Ghol' *Pseudosciaena diacanthus* (Lacepede). *Indian J. Fish.*, 10: 13-459.
- Rao, T. A. 1985. Observations on the some aspects of biology of *Otolithes cuvieri* from Veraval. *Indian J. Fish.*, 27(1&2): 186-188.
- Rao, T. A. 1980. Food and feeding habits of *Pennahia macrophthalmus* Bleeker at Visakhapatnam. *Indian J. Fish.*, 27(1&2): 61-65.
- Rao, V. K. 1963. Some aspects of the biology of 'Ghol' *Pseudosciaena diacanthus* (Lacepede). *Indian J. Fish.*, 10(2): 413-459.
- Sandhya, K. M., Chakraborty, S. K., Jaiswar, A. K. and Shah, T. H. 2014. Food and feeding habits of *Otolithes cuvieri* (Trewavas, 1974) from Ratnagiri, Maharashtra. *Indian J. Fish.*, 61(4): 99-102.
- Sarkar, S., Das, S. K. and Bhakta, D. 2017. Length weight relationship and relative condition factor of Indian shad, *Tenualosa ilisha* from Hooghly estuary system, West Bengal. *J. Inland Fish. Soc. India*, 49(1): 22-26.
- Suseelan, C. and Nair, K. V. S. 1969. Food and feeding habits of the demersal fishes off Bombay. *Indian J. Fish.*, 16(1 &2): 56-74.
- Talwar, P. K. 1995. *Pisces Perciformes: Sciaenidae* In: Ghosh A.K. (Ed.), *Fauna of India and the adjacent countries*. Zoological Survey of India, Kolkata, India, 145 p.
- Talwar, P. K. and Jhingran, A. G. 1991. *Inland fishes*, Vol 1. Oxford & IBH Publishing Co Pvt. Ltd., New Delhi, India, 541 p.
- Talwar, P. K. and Jhingran, A. G. 2001. *Inland fisheries*. Oxford and IBH Publishing Co. Pvt Ltd., New Delhi, India,
- Telvekar, P. A. 2002. *Studies on the food and feeding and reproductive biology of two sciaenid fishes from Mumbai waters*. Dissertation, ICAR-Central Institute of Fisheries Education, Mumbai, India,
- Telvekar, P. A., Chakraborty, S. K. and Jaiswar, A. K. 2006. Some aspects of the biology of *Johnius macrorhynchus* (Mohan, 1976) from Mumbai waters. *J. Mar. Biol. Assoc. India*, 48: 124-127.
- Thangavelu, R., Anbarasu, M., Zala, M. S., Koya, K. M., Sreenath, K. R., Mojjada, S. K. and Shiju, P. 2012. Food and feeding habits of commercially important demersal finfishes off Veraval coast. *Indian J. Fish.*, 59(4): 77-87.
- Vahneichong, E., Das, S. K. and Bhakta, D. 2017. Foraging and bio-indices of *Labeo calbasu* (Hamilton, 1822) from wetlands of South 24 Parganas District of West Bengal. *J. Aqua. Trop.*, 32(3-4): 353-360.
- Vaidya, S. V. M. 1960. A study on the biology of *Otolithes ruber* (Bl & Schn). Dissertation, University of Bombay, Mumbai, India.
- Venkataraman, G. 1960. Studies on the food and feeding relationships of the inshore fishes off Calicut on the Malabar Coast. *Indian J. Fish.*, 7(2): 275-306.
- Venugopal, N., Pillai, N. G. K. and Prakasan, D. 2014. Food and feeding habits of *Johnieops sina* (Cuvier, 1830) along Cochin coast of India. *Indian J. Fish.*, 61(1): 103-107.