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Feeding Dynamics and Diet Composition of Black-Banded Trevally [*Seriolina nigrofasciata* (1829)] from the South-East Arabian Sea

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A study on feeding habits of Black-banded trevally, *Seriolina nigrofasciata*, collected off southwest coast of India, examined stomach contents of 627 specimens from August 2017 to May 2018. The analysis showed that their diet consists mainly of teleost fishes, which were the most significant

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food item, as reflected by an Index of Relative Importance (IRI) of 49.73. Cephalopods were the next most prevalent prey, with an IRI of 44.54, while crustaceans encompassing shrimp and crabs were seen in small quantities, with an IRI of 5.73. The contents found in the stomachs confirm that *S. nigrofasciata* is a carnivorous species. Feeding activity was observed to be highest before gonadal maturation and after spawning, but decreased when the majority of individuals were fully mature.

Keywords: Index of relative importance; Seriolina nigrofasciata; feeding intensity; gastro-somatic index; vacuity index.

1. INTRODUCTION

Feeding plays a vital role in the daily life of fish, as they spend a significant portion of their time searching for food (Hajisamaea *et al*., 2003). Different species exhibit considerable variation in their dietary preferences, which directly influence their growth and biochemical composition. Changes in the type, quality, or availability of food can significantly affect fish health and overall condition. The feeding patterns of many species also fluctuate throughout the year, largely in response to seasonal changes in the biological composition and abundance of potential food sources (Anam & Mostarda, 2012). Seasonal and spatial fluctuations in prey communities lead to corresponding changes in fish biological activities such as growth, condition, shoaling behavior, and migration. It has been found that there is a correlation between the availability of the preferred food for a particular fish and the availability and abundance of that species' fishery (James, 1987; Van de Lingen *et al*., 2008). Studies on natural feeding habits are essential for identifying trophic interactions within aquatic ecosystems, as they provide insight into feeding composition, food web structure, and ecosystem stability (Adeyemi, 2009; Otieno *et al*., 2014). Understanding the relationship between fish species and their food resources is crucial for predicting population trends, determining distribution patterns, and ensuring effective fisheries management (Rao & Durga, 2002). While the quantity and quality of consumed food have a direct impact on fish development, factors such as maturation and survival are regulated indirectly (Sourinejad *et al*., 2015). The type of food consumed and the feeding habits of fish are commonly assessed through gut content analysis, which has become a standard method in fisheries research (Hyslop, 1980; Al-Khayat & Al-Ansi, 2007). Examining feeding dynamics plays a crucial role in fisheries biology and contributes to the effective management of fish stocks (Chakraborty *et al*., 2016).

The family Carangidae represents one of the most diverse groups of marine fishes, comprising 146 recognized species across 30 genera (Eschmeyer & Fong, 2017). *Seriolina nigrofasciata*, commonly known as the black-banded trevally, is the sole representative of the genus *Seriolina*. This species is distributed in the Indian Ocean, the western Pacific Ocean, and along the Atlantic coast of South Africa, and is locally referred to as "Neyyimeenu" in Karnataka. It is a solitary fish occurring at depths of 20–150 m, typically inhabiting offshore reefs on rocky substrates over the continental shelf. Along the Karnataka coast, it is captured using trawl nets, multi-day gillnets, outboard gillnets, and hook-and-line gears (Sommer *et al*., 1996). Despite its occurrence in regional fisheries, information on the diet and feeding ecology of *S. nigrofasciata* in Indian and other waters is lacking. To bridge this knowledge gap, the present study investigates the food and feeding habits of *S. nigrofasciata* from the Arabian Sea off Karnataka during the 2017–2018 fishing season.

2. MATERIALS AND METHODS

A total of 627 specimens of *S. nigrofasciata*, ranging in size from 15 cm to 63.5 cm, were collected fortnightly from Mangaluru fishing harbour between August 2017 and May 2018 using a multi-stage stratified random sampling approach. Sampling was carried out throughout the study period to understand the assessment of seasonal variations in feeding habits; however, no samples were obtained during the annual trawl ban in Karnataka, which occurs in June and July. For each specimen, total length and weight were recorded prior to dissection. The intestines were carefully removed, and the stomachs were weighed to the nearest 0.1 g. Each stomach was then opened to assess degree of fullness, which had been classified according to the amount of ingested material present: (i) full, (ii) three-quarters full, (iii) half full, (iv) quarter full, (v) trace amounts of food, and (vi) empty. Fishes with a full stomach, 3/4 full, and 1/2 full have been measured as 'actively feeding'. Similarly, the stomach was considered 'poorly fed' with only 1/4 full and little content (Hylop, 1980)

2.1 Index of Relative Importance (IRI)

After contents of intestines were taken out and put in a Petri dish, the organisms found inside were recognized at the species or genus level. Food composition of *S. nigrofasciata* had been studied by tabulating % occurrence of each food item. *S. nigrofasciata* is carnivorous, the IRI method had been utilized, as it is considered appropriate for evaluating diet of carnivorous fish. (Pinkas *et al*., 1971)

Following equation has been utilized to calculate index.

$$IRIi = (\%Ni + \%Wi)\%Oi)$$

Where, Ni is percentage of number of food items, Wi alongside Oi implies % of weight and % occurrence indices of each food item, respectively, moreover, I is index.

2.2 Food Preference Index (FP)

To quantify prey selection patterns, stomach contents had been assessed utilizing frequency of occurrence method adapted from Chrisfi *et al*. (2007). This method involves examining the stomach contents to determine the proportion of fish containing each prey item and calculating a food preference index based on these frequencies.

$$FP = \left(\frac{Number\ of\ stomachs\ with\ a\ specific\ food\ item}{Numberof\ non-empty\ stomachs}\right) \times 100$$

Based on the calculated Food Preference index values, prey items were categorized into three levels of trophic significance:

If FP >50%, the species is a main diet item
If 50%> FP > 10%, species is a minor diet item
If FP < 10, the species is negligible in the diet

2.3 Gastro-Somatic Index (GaSI)

The GaSI had been estimated employing formula proposed by Desai (1970).

$$GaSI = \left(\frac{Weight\ of\ gut}{Total\ weight\ of\ fish}\right) \times 100$$

2.4 Vacuity Index (VI)

The Vacuum Index (VI), also known as the stomach emptiness index, is used to evaluate the appetite of fish by measuring proportion of empty stomachs in a sample. Following the methodological framework of Euzen (1987), the Vacuum Index is calculated as:

$$VI = \left(\frac{Number\ of\ empty\ stomachs}{Total\ number\ of\ stomachs\ evaluated}\right) \times 100$$

The Vacuum Index (VI) values were classified according to the criteria proposed by Euzen (1987), as follows:

If, 0≤VI<20, fish is Edacious
20≤VI<40, fish is relatively edacious
40≤VI<60, fish is Moderate feeder
60≤VI<80, the fish is comparatively abstemious
80≤VI<100, fish is abstemious

3. RESULT AND DISCUSSION

Carangids are fast-swimming carnivorous predators that actively chase their prey. Based on dietary habits, Randall (1967) classified the carangid family into two groups: fish-eaters and plankton-feeders. Species such as *Atule, Decapterus*, and *Selar* fall into the plankton-feeding category. Gosline & Brock (1960) described these fish as "voracious plankton feeders" that consume small fish and crustaceans during the daytime. According to Shiota (1986), *Decapterus tabl* feeds on copepods, mysid crustaceans, and small fishes within the water column, whereas horse mackerel feed on hyperiid amphipods, crab larvae (*Megalopa*), and fish larvae.

3.1 Diet composition and IRI

IRI of *S. nigrofasciata* reveals that fish is the main dietary element of *S. nigrofasciata* and can be observed throughout the year. Average annual composition of all fishes had an IRI value of 49.73. IRI values for fishes have been highest during September (86.73) and the lowest in October (19.98). *Nemipterus* spp. has been dominant food item observed in stomach of *S. nigrofasciata,* with IRI value that varies from 58.23 (February) to 2.68 (November), with mean IRI of 27.69. Second dominant fish food item was *D. russelli* with an annual IRI value of 12.99 and a monthly IRI value varied among 1.21 (December) and 34.06 (January). Other fish prey were *Saurida* spp., with mean IRI value of 2.45, *Rastrelliger kanagurta* (IRI = 2.44), followed by *Alectes* spp. (IRI = 1.6), *Platycephalus* spp. (IRI = 1.42), *Leiognathus* spp. (IRI = 0.92), *Trachinocephalus myops* (IRI = 0.14), and *Lactarius lactarius* (IRI = 0.09). Cephalopods, primarily squids and cuttlefishes, constituted 2nd most crucial prey category with an average IRI of 44.54. Highest IRI value has been demonstrated in October (78.18), and the minimum in May (14.79). IRI values for squids and cuttlefishes were 37.22 and 7.32, respectively. Crustaceans such as shrimps and crabs were less frequently consumed, with a combined IRI of 5.73; shrimp IRI was 5.039 and crab IRI was 0.687, showing the highest crustacean intake in August (37.03) and the least in May (1.84) (Table 1).

Despite the variety of prey, *S. nigrofasciata* showed clear preferences: among fish, *Nemipterus* and *Decapterus* species were most frequently consumed; among cephalopods, squids belonging to the genus *Loligo* predominated; and among crustaceans, prawns were the preferred choice. The lack of sand, detritus, and benthic organisms in its stomach contents suggests that this species does not usually feed at the seabed. Rajesh *et al*. (2019) from south southwest coast of India reported that *Seriolina nigrofasciata* feed on Teleosts (*Nemipterus* spp., *Decapterus russelli, Trachinocephalus myops*, *L. lactarius*, *Saurida* spp., *Rastrelliger kanagurta*, *Upeneus* spp., *Trichiurus* spp., *Platycephalus* spp., and *Alectis* sp.), cephalopods, and crustaceans. For *Alepes djedaba* from Cochin coast, Sajana *et al*. (2019) documented diet largely consisting of *Stolephorus* spp., ostracods, shrimps, shrimp larvae, as well as partially digested material. In comparison, along Ratnagiri coast, Bandkar *et al*. (2022) observed that its diet was dominated by fish scales, small crustaceans, *Acetes* spp., copepods, small fishes, shrimp larvae, fish eggs, moreover polychaetes. For *Atropus atropus* from Ratnagiri, Rakhunde *et al*. (2023) recorded *Acetes* spp., small teleosts, cephalopods, squilla, fish scales, as well as semi-digested matter as the main dietary components.

3.2 Food Preference Index (FP)

The Food Preference Index (FPI) further confirms that fish are the main food item that has an FP index of 80.67 percent (i.e.,>50 percent) and is considered a main diet item in all seasons. Squid and shrimp, with FPIs of 19.88% and 14.52% respectively, are minor foods, whereas crab and cuttlefish, with FP<10, are considered random foods (Table 2). The current study on the dietary composition of *Seriolina nigrofasciata* shows that this species is carnivorous, primarily consuming teleost fishes and molluscs, with occasional ingestion of crustaceans such as crabs and shrimps. This finding aligns with Randall (1995), who also reported that *S. nigrofasciata* feeds on demersal fishes, cephalopods, and prawns. Similarly, Jadhav & Mohilic (2013) noted that *Megalaspis cordyla* prefers fish, cephalopods, crustaceans as its main food sources.

3.3 Food in Relation to the Size

Length-group-wise analysis of food composition revealed that teleost fishes were the most preferred prey across all size groups of *Seriolina nigrofasciata*. The highest consumption of teleosts was observed in the 60–65 cm length group, followed by 45–60 cm group. Lowest intake has been recorded in 40–45 cm and 35–40 cm groups. Cephalopods have been available in diets of nearly all size groups except the 50–55 cm and 60–65 cm groups. Their highest occurrence was found in the 30–45 cm size range, while the lowest was in the 25–30 cm and 55–60 cm groups. Crustaceans appeared only in certain size categories, specifically 20–30 cm and 35–50 cm, with the greatest occurrence in the 45–50 cm group and the least in the 20–25 cm group (Fig. 1). Several studies reported that young carangids generally feed on crustaceans, especially shrimps but tend to become more piscivorous as they mature. This ontogenetic change in feeding behavior has been reported in *Alepes djedaba* (Bandkar *et al*., 2022), *Decapterus dayi* (Manojkumar, 2007), along *Atule mate* (Sasidharan *et al*., 2018). Similarly, Poojary *et al*. (2015) have seen that young *Decapterus russelli* feed mainly on *Acetes indicus* as well as occasionally on plankton, whereas adults consume *A. indicus* as well as other teleost fishes. Abdussamad *et al*. (2008) found that the diet of *Caranx ignobilis* showed no major variation across different size groups, although larger individuals consumed a higher proportion of teleosts. Similarly, Rakhunde *et al*. (2023) reported that juvenile *Atropus atropos* primarily feed on *Acetes* spp., fish scales, and cephalopods, while adults prefer small teleost fishes moreover, Squilla.

Table 1. IRI of different food items in *S. nigrofasciata*

Finfishes	Jan	Feb	Mar	Apr	May	Aug	Sept	Oct	Nov	Dec	Annual
Decapterus russelli	34.06	4.72	17.3	15.07	12.61	7.61	14.73	11.15	11.45	1.21	12.99
Nemipterus spp	19.04	58.23	11.59	18.98	58.12	4.35	57.76	3.85	2.68	42.26	27.69
Platycephalus spp	0.37	-	3.18	0	2.05	3.28	0.58	0	0	4.7	1.42
Saurida spp	0.19	0	0.73	0	2.69	0	11.29	4.98	0	4.65	2.45
Trachinocephalus myops	0	0	0	0	0	0.85	0.53	0	0	0	0.14
Leiognathus spp	0.25	2.81	0	0	0	0	0	0	3.1	3	0.92
Rostrelliger kanagurta	0.28	3.13	0	15.46	0	5.57	0	0	0	0	2.44
Alectes spp	0	0	0.67	0	6.59	0	1.83	0	6.92	0	1.6
Lactarius lactarius	0	0	0	0	0	0.87	0	0	0	0	0.09
Fishes total	54.19	68.89	33.47	49.51	82.06	22.53	86.73	19.98	24.15	55.82	49.73
Molluscs											
Squid	41.35	18.21	42.43	50.49	14.79	37.93	13.27	78.18	31.34	44.18	37.22
Cuttlefish	4.46	10.61	11.16	0	0	2.5	0	0	44.51	0	7.32
Molluscs total	45.81	28.83	53.58	50.49	14.79	40.43	13.27	78.18	75.85	44.18	44.54
Crustaceans											
Shrimp	0	2.29	7.92	0	3.15	37.03	0	0	0	0	5.039
Crab	0	0	5.03	0	0	0	0	1.84	0	0	0.687
Crustaceans total	0	2.29	12.94	0	3.15	37.03	0	1.84	0	0	5.73

Table 2. The average Food Preference Index (FPI) examined in *S. nigrofasciata* from August 2017-January-2018

Prey	Monsoon FPI	Winter FPI	Summer FPI	Annual FPI (%)
Fish	82.05	46.06	69.73	80.67
Squid	25.29	24.63	14.79	19.88
Cuttlefish	3.57	4.99	3.8	3.79
Shrimp	39.28	-	7.98	14.52
Crab	-	1.26	2.02	1.01

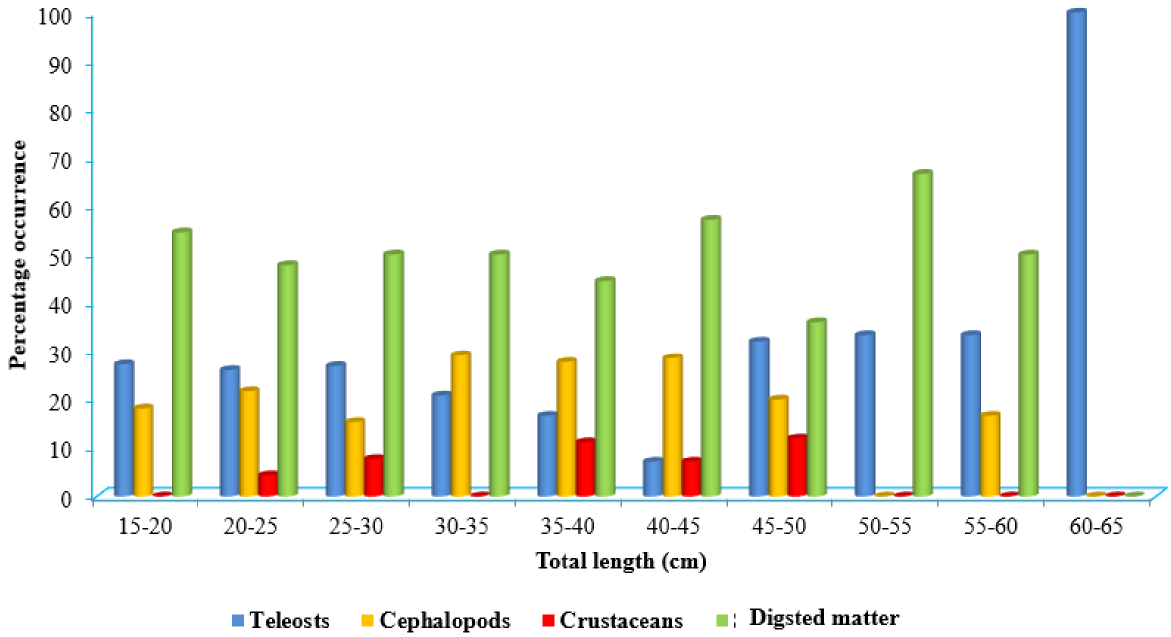

Fig. 1. Percentage occurrence of food items in different size groups of *S. nigrofasciata*

3.4 Feeding Intensity

Stomach contents of 627 *S. nigrofasciata* were examined. Of these, 40.97% contained food, while 59.01% were empty. Feeding activity varied considerably with the seasons. The percentage of empty and full stomachs is a key indicator for evaluating feeding intensity in fish. Observations showed that high feeding intensity has been determined during the month of April, with 68.43% followed by May (65.00%) and August (52.37%). Poor feeding had been seen in December (66.65%), followed by November (57.13%) and September (52.19%). Elevated percentage of empty stomachs had been seen in January (40.00%), followed by April (26.31%) and November (21.45%). Rest of the months showed a decrease in empty stomach (Table 3). These results indicate that the fish reduce their feeding throughout breeding season as well as feed more actively after spawning. Decline in feeding observed throughout peak spawning season is often attributed to the space occupied by fully developed gonads in the abdominal cavity, which limits the stomach's capacity. This condition is generally more prevalent in females than in males (Sajana *et al*., 2019; Raje, 1993; Sreenivasan, 1974; Kingston *et al*., 1999). The results are consistent with Sajana *et al*. (2019), reported that *A. djedaba* from the Cochin coast showed decreased feeding activity during the spawning period. Similarly, Bandkar *et al*. (2022) noted that empty stomachs were frequently found in *A. djedaba* during spawning. Equivalent trend had been noticed in *A. atropos* by Rakhunde *et al*. (2023), who reported lower feeding intensity in spawning fish, although feeding measures were elevated in maturing moreover spent specimens.

3.5 Feeding Intensity in Relation to the Size

Fig. 2 illustrates percentage occurance of stomach in different levels of fullness for each size group of fish. It shows that percentage of actively fed fish were highest in the size groups 60-65 cm (100%), followed by 55-60 cm (49.99%) and 30-35 cm (44.44%). Poor feeding had been noticed in size groups 35-40 cm (72.23%), 50-55 cm (66.66%), and 45-50 cm (63.63%). The empty stomach was recorded at the highest percentage only in the lower size groups, 15-20 cm (41.66%), followed by 20-25 cm (27.27%), 25-30 cm (13.79%), and then decreased gradually as the size group increased. Feeding intensity was higher in medium and large-sized fish (30–65 cm) compared to smaller individuals (15–30 cm), as smaller fish tend to feed at a slower rate. Additionally, larger, reproductively mature fish reduce their feeding during the spawning season, but resume active feeding after spawning. There is no clear pattern linking feeding intensity to fish size; variations in available food resources between habitats can lead to differences in diet and feeding behavior

Table 3. Season and feeding activity of *S. nigrofasciata* (based on percentage of fullness and emptiness)

Months	No. of fish examined	Full	¾ full	½ full	¼ full	Little	Empty	% of fullness*	% of emptiness*
Aug.17	61	-	9.52	42.85	33.32	9.52	4.76	52.37	47.6
Sep.	62	8.69	8.69	13.04	43.47	8.72	17.39	30.42	69.58
Oct.	72	10.00	15.00	15.00	35.00	15.00	10.00	40	60
Nov.	64	7.14	14.28	-	21.42	35.71	21.45	21.42	78.58
Dec.	61	-	3.70	11.14	29.62	37.03	18.51	14.84	85.16
Jan.18	60	5.00	15.00	15.00	-	25.00	40.00	35	65
Feb.	62	12.50	12.50	12.50	25.00	25.00	12.50	37.5	62.5
Mar.	61	13.79	6.89	24.13	31.03	17.24	6.92	44.81	55.19
Apr.	61	31.57	21.08	15.78	5.26	-	26.31	68.43	31.57
May	63	15.00	10.00	40.00	30.00	5.00	-	65	35
Average								40.97	59.018

** Fullness includes full, ¾ full and ½ full stomachs. Emptiness includes ¼ full and empty stomachs*

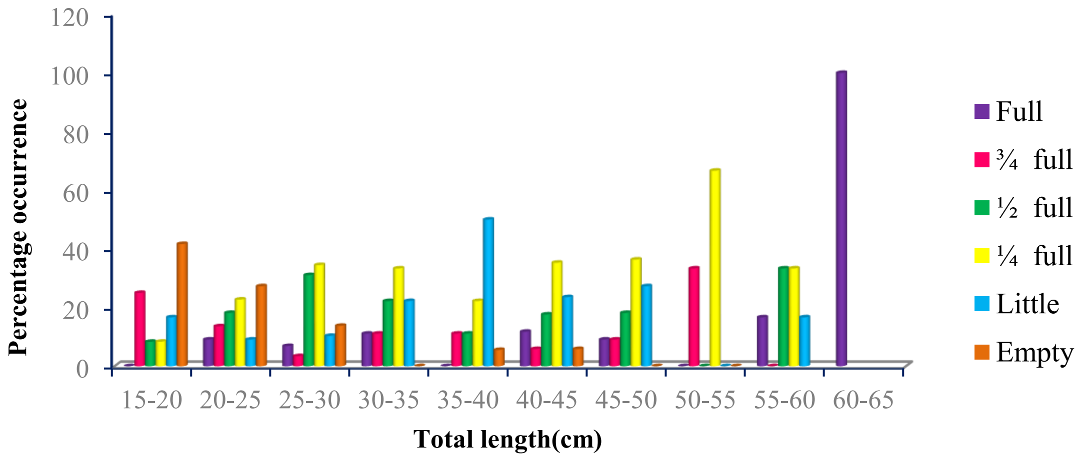

Fig. 2. Percentage occurrence of feeding intensity in different size groups of *S. nigrofasciata*

across geographic regions. Frequent occurrence of empty stomachs might be rapid digestion rate in carnivorous fish, which is facilitated by strong gastric juices (Qasim, 1972).

3.6 Gastro-Somatic Index

GaSI and VI were recorded each month, and the results are summarised in Table 4. Highest GaSI value was recorded in April (4.30), and the lowest in December (2.07). Seasonally, GaSI peaked in summer (3.49 ± 0.42) and reached its minimum in winter (2.15 ± 0.13). This seasonal trend is in line along the results of Sajana *et al*. (2019), who documented low GaSI during the spawning season in *A. djedaba* from Cochin waters, and with Rengarajan's (1971) observation that feeding activity declines

Table 4. Average Gastro-somatic Index and Vacuity index examined in *S. nigrofasciata*

Months	Aug.17	Sep.	Oct.	Nov.	Dec.	Jan.18	Feb.	Mar.	Apr.	May
Season	Monsoon			Winter				Summer		
GaSI	3.35 ± 0.23			2.15 ± 0.13				3.49 ± 0.42		
	3.70	3.45	2.91	2.10	2.07	2.09	2.34	2.86	4.30	3.28
VI	21.80 ± 3.45			53.30 ± 5.52				18.49 ± 6.18		
	14.28	26.11	25.00	57.16	65	55.54	37.50	24.16	26.31	5.00

**(Empty & little are considered as EMPTY Stomach)* during spawning and increases afterward. The GaSI variation observed in the present study appears closely related to gonadal maturation.

The mean annual vacuity index was 33.51 ± 6.25, indicating that *Seriolina nigrofasciata* is relatively voracious. December, the peak spawning month for this species, recorded the highest VI. Seasonally, VI was highest in winter (53.30 ± 5.52) and lowest in summer (18.49 ± 6.18). This pattern may be due to the enlarged gonads during spawning, which occupy much of abdominal cavity, narrowing stomach, thereby reducing feeding activity and limiting food intake (Dadzie *et al*., 2000; Sourinejad *et al*., 2015).

4. CONCLUSION

The diet ingredients along with feeding habits of *Seriolina nigrofasciata* from Arabian Sea off Karnataka, reveal its predominantly carnivorous feeding habit with a marked preference for teleost fishes, particularly *Nemipterus* spp. and *Decapterus* spp., followed by cephalopods, mainly squids, and to a lesser extent, crustaceans such as shrimps and crabs. Ontogenetic shifts in diet were observed, with smaller individuals consuming a greater proportion of crustaceans, while larger specimens exhibited a stronger tendency toward piscivory. Lower GaSI values and higher VI pattern were observed during the spawning season. The absence of benthic organisms and detritus in the stomach contents indicates that *S. nigrofasciata* primarily forages in midwater habitats rather than along the seabed. Overall, these findings contribute valuable baseline data on the trophic ecology of *S. nigrofasciata,* which can aid in understanding its role in the marine food web. However, further research is necessary to support fisheries management and to clarify the species' trophic interactions within the ecosystem**.**

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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