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Research Article

Seasonal variation in the food and feeding habits of *Setipinna taty* (Valenciennes, 1848) inhabiting the Hooghly-Matlah estuary of West Bengal, India

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The food and feeding habits of *Setipinna taty* collected from the Hooghly-Matlah estuary, West Bengal, India, for a period of 12 months (February 2022 to January 2023) were studied. Zooplankton, crustaceans, insects, annelids, and molluscs have dominated the food items in the gut. Throughout the year, there were a very high percentage of empty stomachs. The Empty Stomach Ratio (ESR) value was highest in males during the pre-monsoon, and for females, it was higher in the post-monsoon. The mean Relative Length of Gut (RLG) value varied from 0.3147 to 0.389 in males and 0.323 to 0.425 in females. RLG values were found to be highest during the monsoon and lowest during the post-monsoon for both sexes. The species is a carnivorous fish and feeds mainly on zooplankton and crustaceans. The feeding intensity is higher in the adult stage, with crustaceans and insects dominating the gut contents, while zooplankton and annelids are preferred by the juveniles. Among the zooplankton, the main food items are copepods, rotifers, lichens, and crustaceans, mainly megalopa larvae, alima larvae, *Labidocera* sp., and unidentified shrimps. Among non-penaeid prawns, *Acetes* spp. was the most dominant food item. Bray-Curtis similarity shows 66 – 70 % similarity between the pre-monsoon season and both the monsoon and post-monsoon seasons. According to the Bray-Curtis similarity index, the seasonal diet variations of anchovy were alike each other by 66 – 70 %.

[**Keywords**: Feeding indices, Feeding intensity, Food composition, Relative length of gut, *Setipinna taty*]

Introduction

Making resource-related decisions benefits from knowledge of feeding habits and diet composition in fish ecology and fisheries resource management[1]. Examination of the fish's gut content provides details on the fish's diet and a quantitative assessment of their feeding habits, both of which are essential for managing fisheries. Conceptually, the first step in determining the trophic relationships of fish is to evaluate their food, feeding habits, and stomach content. Assessment of habitat preferences, prey preferences, ontogenetic effects, and the formulation of conservation strategies are then done using this information[2].

The FAO's commercial fisheries database lists up to 12 species of Engraulidae, which together account for 5 % of the total fish landings in India. The west coast in India is more productive contributing to 61 % of it. Kerala (28 %), followed by Gujarat (14.8 %) and Tamil Nadu (14.4 %), were the leading states contributing to the total landings of engraulids. The contribution of the different groups to the total engraulid landings varied with annual and seasonal fluctuations. Overall, the whitebaits dominated, contributing 45 % of the total engraulid landings, followed by *Thryssa* spp. (28 %), *Coilia* spp. (21 %) and *Setipinna* spp. (6 %)[3].

Fish's natural food is split into three categories: principal food, occasional food, and emergency food[4]. However, feeding behaviour and dietary composition in fish vary considerably seasonally. Therefore, it is necessary to conduct a study at regular intervals to develop an effective management strategy. Considerable work has been done in the past on the feeding of engraulids by several researchers[5,6].

The intensity of feeding varies with the seasons, the availability of preferred prey items, the stages of maturation, and the spawning season. The level of feeding is lower during the spawning season than it is during the non-spawning period[7,8]. By examining the gastro-somatic index of fish, it is possible to evaluate the degree of feeding as indicated by the stomach's relative fullness[6]. The amount that is consumed depends on an array of factors, including seasonal variations, fish development stages, spawning season, environmental conditions, etc. For determining

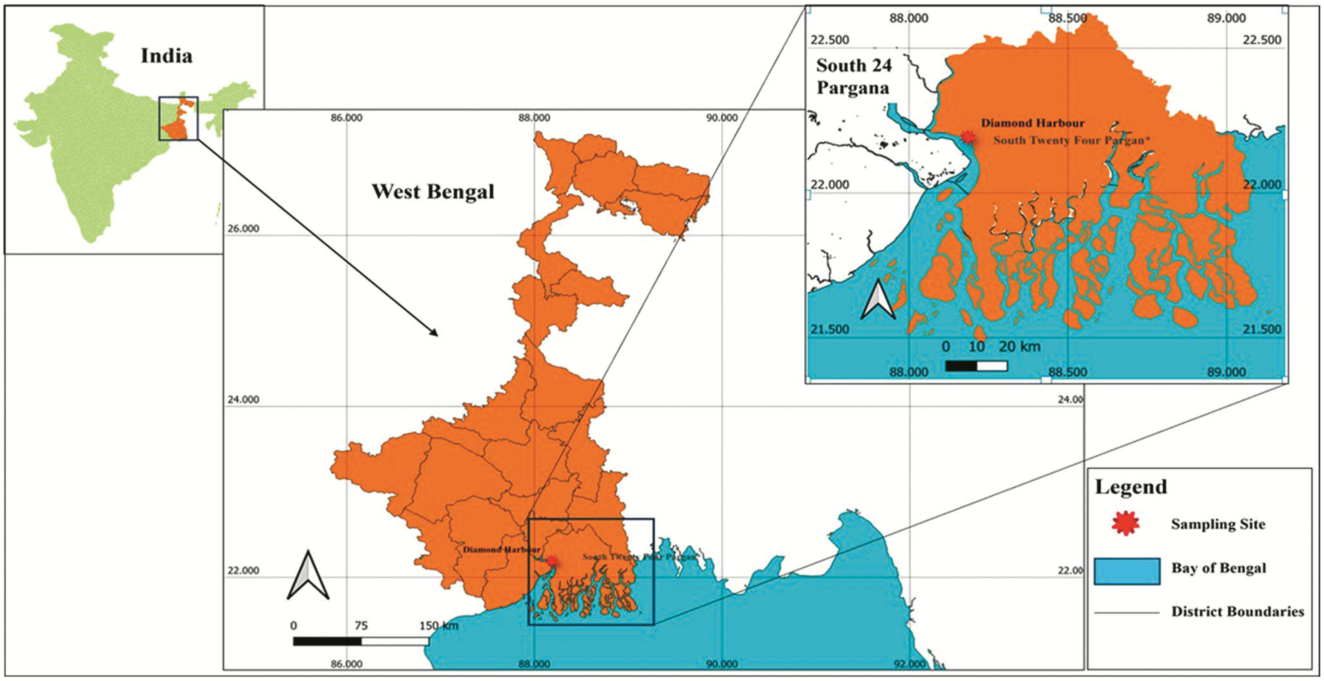

Fig. 1 — Location of the sampling site Hooghly-Matlah Estuary (Diamond Harbour) of West Bengal

whether a species is herbivorous, carnivorous, omnivorous, herbi-omnivorous, or carni-omnivorous, the relative length of the gut is frequently studied[9]. The calculation of fish RLG is crucial for understanding fish feeding habits. Several researchers[6,8,10-13] examined the association between preferred prey items and RLG in several fish species.

The scaly hair-fined anchovy is found all along the east coast of India, the Andaman and Nicobar Islands, West Bengal, Odisha, Sri Lanka, and the East Indies[14]. Two of the most common names for scaly-haired anchovies in India are "Phansa" and "Lalpata"[15]. In estuaries, scaly hair-finned anchovies are prevalent. Adequate studies on temporal variation in dietary composition of *Setipinna taty* are lacking in India. So, an attempt was made to address the gap.

Materials and Methods

This study is based on a total of 447 samples (154 males and 293 females) of *S. taty* that were collected throughout the examination, ranging in size from 105 to 180 mm in length and weighing from 11.6 to 43.47 g. Samples were collected from Diamond Harbour (from February 2022 to January 2023, a span of 12 months), the fish landing centre (22°11′34″ N, 88°11′22″ E), South 24 Parganas district of West Bengal, India (Fig. 1). They are often caught largely (90 %) by local fishermen using mechanized trawl nets, which are non-selective multispecies nets with mesh sizes of 10 – 60 mm. Month-wise sample size and length class are provided in Table 1. The fish samples were brought to the laboratory to study the different biometric indices in insulated and ice-packed iceboxes. Feeding indices were calculated after conducting a standard food and feeding habit study. Stomachs were stored in 5 – 10 % buffered formaldehyde for subsequent examination[16].

Table 1 — Month-wise sample and its length range

Month	Pooled	Male	Female	Length range (mm)
February	41	12	29	132-164
March	42	16	26	125-163
April	40	23	17	120-161
June	41	9	32	140-168
July	40	8	32	132-172
August	38	14	24	125-158
September	39	12	27	129-165
October	41	18	23	135-172
November	42	15	27	105-180
December	35	15	20	120-170
January	48	12	36	125-173

Studies on the Gastro-Somatic Index (GaSI) were used to examine the feeding intensity of fish. Monthly variations of GaSI reveal changes in feeding habits. It was also determined by gauging how full the stomach appeared. According to how much food was consumed, the status of the gut was classified as full, 3/4 full, 1/2 full, 1/4 full, trash, and empty[17].

Using a compound microscope, food items were identified up to the genus level and quantified appropriately. Both quantitative and qualitative methods were used to analyse the gut contents. The "points approach" was employed to estimate the amount of food in the fish's intestines[18]. The miscellaneous section includes the unidentified items.

The gut was removed and emptied in a petri dish with 10 ml of diluted water. A pipette was used to transfer 1 ml of the subsample from the diluted sample to a Sedgwick-Rafter (S-R) cell with 1000 no. 1 mm^2 areas. Then, using a compound microscope, food items were identified up to the genus level and quantified appropriately. There are mainly two methods followed: qualitative and quantitative methods. Quantitative analysis involved counting the total number of prey items present in each food group. While, the qualitative analysis involved identification of prey items in the gut contents. Planktonic organisms were identified using APHA (2005)[19] and Edmondson (1959)[20], CMFRI manual on phytoplankton identification/taxonomy, and other prey items were identified using standard literature[21,22]. The following formula was used to compute the relative length of the gut[23].

$$Relative\ length\ of\ gut = \frac{Length\ of\ gut}{Total\ length\ of\ the\ fish}$$

GaSI is a measurement of a fish's stomach weight and its entire body weight. It aids in figuring out the fish's eating situation during various months. The following method was used to determine the gastro-somatic index[24].

$$Gastro-somatic\ index = \frac{Weight\ of\ the\ stomach}{Weight\ of\ the\ body} \times 100$$

The Stomach Fullness Index (SFI) is a measurement of a fish's stomach food content in relation to its overall body weight. The fullness index is useful in the fields of biology, physiology, and fish ecology[25,26]. The stomach's fullness was measured after the whole digestive tract was removed, and it was categorized as empty, trace, 1/4 full, 1/2 full, 3/4 full, full, and gorged stomachs on a scale of 0 (empty) to 6 (totally distended with food)[27]:

$$Stomach\ fullness\ index = \frac{Weight\ of\ food\ in\ the\ stomach}{Weight\ of\ body - Weight\ of\ food\ in\ the\ stomach} \times 100$$

The Vacuity Index (VI) allows for the analysis of the intensity of feeding activity and corresponds to the percentage of Empty Stomachs (ES) compared to the Total Number of stomachs (TN) that were examined[28,29].

$$Vacuity\ index = \frac{Number\ of\ empty\ stomachs}{Total\ number\ of\ stomach} \times 100$$

Microsoft Excel was used to perform the ANOVA, followed by the post hoc analysis for finding significant differences in the mean values of feeding indices, including RLG, GaSI, SFI, and VI. PAST (version 4.0) software was used to perform cluster analysis. The correlation coefficients between the variables were identified, and their significance was evaluated using SPSS software.

Results and Discussion

Feeding intensity

Based on feeding intensity, fishes were further classified into 3 categories: actively fed fish (full and gorged), moderately fed fish (1/2 full and ¾ full), and poorly fed fish (1/4, and empty). Actively fed fish (stomach content greater than 1/2 full) were more commonly observed during the monsoon season for the pooled specimen (15.69 %), the pre-monsoon season for females (18.40 %), and the post-monsoon seasons for males (15.933 %). Low-fed fish (stomach content more than 1/2 full) were found during the post-monsoon season for pooled (61.85 %), monsoon for females (60.00 %), and pre-monsoon for males (66.00 %) (Fig. 2a – c).

Fish fed more voraciously because of a higher demand for food to build up the gonads and to cope with hunger[30]. The physiological reactions during reproduction in the spawning season led to poor feeding during the post-monsoon for both pooled fish (61.57 %) and females (61.23 %). In the case of males, the lowest feeding intensity was found during the pre-monsoon season (66.06 %), due to the fish becoming ripe and ready for spawning. The fish's feeding intensity appeared to have decreased due to an intrinsic factor termed stress that the fish's developing gonad brought to bear on its alimentary canal. Hence, the spawning season does not exactly correspond to the feeding intensity. It would be difficult to say for certain whether the decrease in feeding was driven by the fish's spawning activity[31].

Marichamy[32] reported high feeding intensity in *Thrissina baelama* during pre-monsoon and low during post-monsoon (34 %). He also observed a quite different trend in feeding intensity for the subsequent years, in which the active feeding was noticed during monsoon. The remaining period

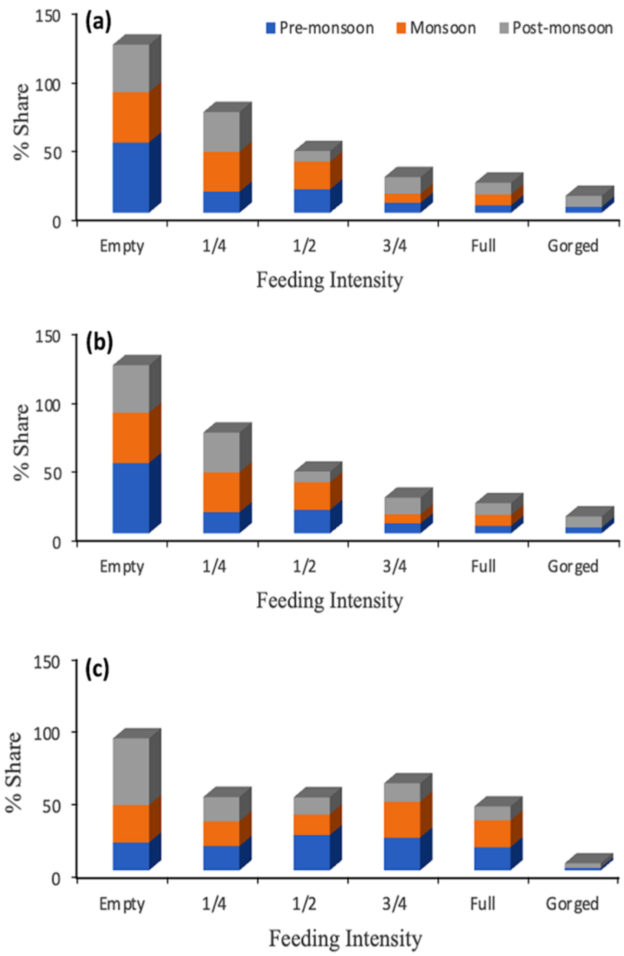

Fig. 2 — Season-wise estimated (%) feeding intensity of *S. taty*: (a) pooled, (b) male, and (c) female samples

showed poor feeding with a relatively high occurrence of empty stomachs. By measuring the actual volume of food in the stomachs, he further revealed that when the percentage of actively fed fish was high, the volume of food within the stomachs was also high. Thus, it was concluded that the feeding intensity varied considerably season-wise, and the fish appeared to feed actively at irregular intervals[32].

Food and feeding habits

The diet composition of *S. taty* is presented season-wise and month-wise. During the present study, animal matter was the major component present in gut content, followed by plant matter. The major preferred animal components were zooplankton, crustaceans, insects, annelids, and *Acetes* spp., and the highest percentage of these was noticed during October (19.91 %) and the lowest during February (6.47 %). The percentage of copepods ranged from 5.53 % (November) to 31.56 % (July). Rotifers are also important zooplankton prey for

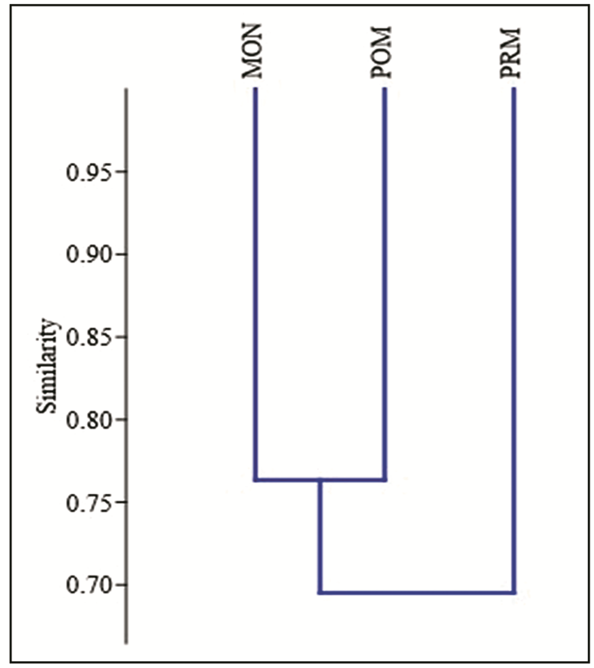

Fig. 3 — Dendrogram showing seasonal similarities of stomach contents for *S. taty* based on the Bray-Curtis index

S. taty, ranging from 5.97 % in February to 36.59 % in June. *Labidocera* sp. reached a maximum in September (11.98 %), while insects peaked in August (15.00 %). Both were at their lowest in November (2.00 %) and October (2.84 %), respectively. Unidentified shrimps were the second most predominant food item for this fish, with the highest amount found in February (30.85 %). Phytoplankton is also found in the stomach content in a lower amount (9.73 %). Algae and plant matter contributed minimally, *i.e.*, 3.5 % in November and a maximum of 12.74 % in August. During the investigation period, an average of 2.46 % of guts contained sand and mud items which night be due to accidental feeding. The semi-digested matter, like crustacean body parts and fish remains, reached its maximum in April (17.5 %) and its minimum in September (1.37 %).

According to the Bray-Curtis similarity index[33] values, prey composition exhibits 75 – 80 % similarity between monsoon and post-monsoon seasons, while it shows 65 – 70 % similarity for the combined composition of monsoon and post-monsoon with pre-monsoon prey composition (Fig. 3).

In the present study, unidentified shrimps (20.21 %), *Acetes* spp. (11.61 %), are the most predominant food items for *S. taty*. Copepods (9.15 %) and rotifers (9.37 %) were also predominant food items for young fishes. Insects (4.55 %), worms (2.34 %), megalopa larvae (3.22 %), alima larvae (3.14 %), *Labidocera* sp. (4.63 %), and gastropod larvae (2.04 %) are secondary food items. Bivalve larvae (1.56 %), phytoplankton, and plant origins (9.73 %) are accidental or occasional food items. The largest food groups were crustaceans (42.88 %), followed by zooplankton (18.52 %), debris (18.15 %), insects (4.55 %), molluscs (3.6 %), annelids (2.34 %), etc. (Fig. 4).

The food and feeding habits of *Setipinna taty* were found to be similar to those of planktivorous fishes[34]. The young fish fed mainly on copepods, while the adult fish fed mainly on mysidacea and *Acetes* spp. The food composition has a seasonal change; the main food is mysidacea in spring but *Acetes* spp. in summer. *Labidocera* spp. and *Acetes* spp. were the main food items in the half-fin anchovy's food composition collected from Bohai Sea areas[34].

In this study, the main types of food found in the stomachs of *S. taty* were copepods, rotifers, lichens, *Acetes* sp., megalopa larvae, alima larvae, *Labidocera* sp., non-penaeid shrimp, insects, worms, bivalve larvae, gastropod larvae, Oscillatoria sp., spirogyra, *Coscinodiscus* sp., algae, partially digested food, and shrimp parts. There were no significant differences in food items from month to month, showing that their diet didn't change over time. However, some seasonal variations are observed in their feeding habits. In the pre-monsoon season, the highest numbers of crustaceans (45.14 %), debris (33.09 %), and zooplankton (11.26 %) were present. During monsoon and post-monsoon seasons too, the highest numbers of crustaceans (33.82 % and 49.69 %) and zooplankton (27.75 % and 16.57 %) were present, but in varying percentages. Phytoplankton (13.82 %) is mainly found in the monsoon season. Insects, molluscs, and annelids were consumed throughout the season. During the monsoon and post-monsoon seasons, the variety of food intake is limited due to spawning, while it is abundant in the pre-monsoon season because of energy demand for gonadal development.

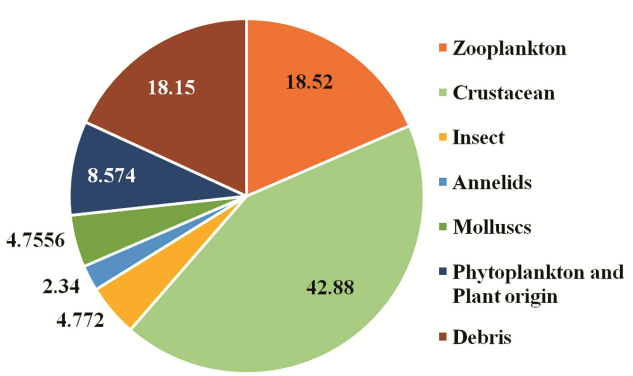

Fig. 4 — Average percentage composition of food groups in gut contents of *S. taty*

Setipinna taty exhibits two feeding habits, *i.e.*, either predation when visually identifying big prey or feeding via absorbing suspended matter in the water column, primarily during the day[35-38]. As a result, it is an opportunistic fish that may maximize its food intake by choosing between two feeding strategies depending on environmental factors such as the quantity or kind of prey and availability of the food items[39].

In *Setipinna phasa*, among the food of animal origin, insects dominated the diet throughout the year[40]. It fed on insects (30 %) and crustaceans (22 %) in the adults' stage, while annelids (24 %) and insects (26 %) during the juvenile stages. Adult individuals in the Hooghly estuary consume more food during the summer than during the rainy season. Fish in the ripening stage of gonads consume more food than fish during other maturity stages. It mainly fed on crustaceans (prawns, 29 %), teleost fish (*Puntius* sp., 6 %), and annelids (earthworms, 32 %) in the order of frequency of occurrence in the gut. The fish occasionally recorded molluscs in its gut, possibly accidentally swallowing them while consuming other preferred items. Aquatic vegetation was found at irregular intervals.

The present study confirmed that *S. taty* is a carnivorous fish based on observations of its food and feeding behaviour. It also indicated a constant and specialized feeding pattern, with crustaceans and zooplankton as the main food items with little variation in their abundance in gut contents. Young fishes mainly fed on zooplankton, while adult fishes fed mainly upon crustaceans[41]. It displayed two feeding modes and switched between filter feeding on smaller food particles and particulate or active feeding on larger food items[42]. These observations are in concurrence with the earlier food and feeding reports of the species[40,43,44]. A comparative table of the major food items of some anchovies is provided in Table 2.

Relative length of gut (RLG)

The highest values of the relative length of gut for males, females, and combined sexes were 0.389 (June), 0.42354 (July), and 0.414 (July), respectively. The lowest RLG values were 0.3207 (pooled), 0.3137 (male), and 0.3233 (female) in February. In the

Table 2 — Comparative analysis of major food items of anchovies

Species	Author	Diet composition	Location
Stolephorus purpureus	Hiatt[45]	Copepod, crab larvae, shrimps, Veliger larvae	Pearl Harbour
Thrissina baelama	Marichamy[46]	Veliger larvae, zoeae larvae, *Labidocera* sp., megalopa larvae, prawns	Andaman Sea
E. encrasicolus	Bulgakova *et al.*[47]	Rotifers, copepod, mysids	Black sea
Anchovia clupeoid	Duque & Acero[48]	Copepods, rotifers, megalopa larvae, diatoms, detritus	Colombian Caribbean
Engraulis japonicus	Islam & Tanaka[49]	Copepod, Calanus, *Labidocera* sp.	Ariake Bay, Japan
Cetengraulis edentulus	Gay *et al.*[50]	Copepod, phytoplankton, crustacean, filamentous algae, *Coscinodiscus* sp.	Rio De Janeiro
Engraulis encrasicolus	Costalago *et al.*[51]	Copepod, Cladocera, crustacean, diatoms	Gulf of Lion
E. encrasicolus	Muzlum *et al.*[52]	Cyanophyceae, Dinophyceae, copepod, Cladocera, rotifer, bivalve, gastropod larvae, decapod, semi-digested food	Southeast Black Sea
E. japonicus	Choi *et al.*[53]	Copepod, Cladocera, rotifer, Dinophyceae, semi-digested food	Korea
E. encrasicolus	Akalin *et al.*[54]	Crustacean, copepod, Cladocera, Decapoda larvae, gastropod, Bivalvia	Aegean Sea
Setipinna taty	Present study	Zooplankton, crustaceans, insects, annelids, debris	Diamond Harbour, West Bengal

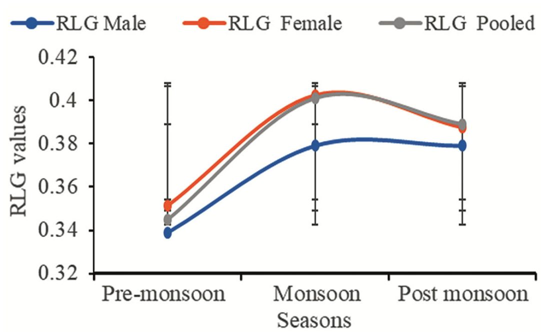

Fig. 5 — Season-wise estimated RLG values of *S. taty*

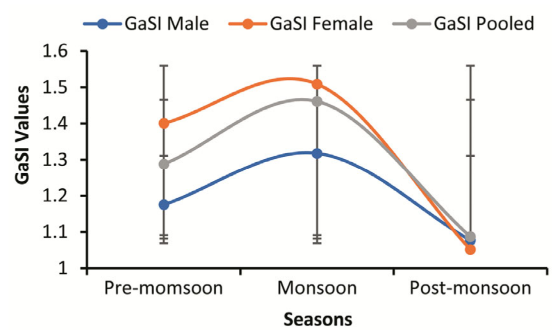

Fig. 6 — Season-wise estimated GaSI values of *S. taty*

present study, the RLG value varied from 0.3147 to 0.388 in males and 0.3233 to 0.4235 in females, indicating the carnivorous feeding habit of the fish (Fig. 5). The RLG value is highest in the monsoon season for both males (0.379±0.016) and females (0.402±0.026) and lowest in the pre-monsoon season for both males (0.339±0.0224) and females (0.352±0.024) due to changing the food and feeding habits of fish.

In the present study, the highest RLG value was found during the monsoon season and the lowest in the pre-monsoon season for both male and female specimens. There is a significant difference during different months and between both males and females ($P<0.05$). Post hoc analysis revealed a significant difference between the RLG values of the pre-monsoon and post-monsoon seasons. However, RLG exhibited a significant negative correlation with VI (r = -0.593) in males and a positive correlation with ESR (r = 0.058) in females.

RLG values differ with the food and feeding habits of fish[10]. The RLG values are reported to be 0.3 to 0.7 in carnivorous fishes, 4.77 in herbivorous fishes, 1.37 in omnivorous fishes, and 3.7 in planktivorous fishes[10]. Additionally, RLG value was found to have a close relationship with the amount of vegetable and animal matter in the gut content and stomach. The RLG values increased with the increase in plant matter and decreased with the increase in animal matter in the gut and stomach content[10].

Gastro-Somatic Index (GaSI)

The GaSI was highest in June (1.562) and lowest in October (1.051) for the pooled data. The GaSI was highest during the monsoon season for the combined specimens (1.461±0.153), for male specimens (1.318±0.104), for females (1.51±0.147), and lowest during the post-monsoon season for the combined specimens (1.086±0.031), male specimens (1.077±0.06) and female specimens (1.052±0.053) (Fig. 6).

A significant difference ($F_{2,1,0.05}$ = 23.97) was observed in GaSI values across the different seasons, indicating seasonal variations in feeding patterns, the occurrence of various size groups in the sample, and increased gonadal development. Post hoc analysis revealed a significant difference between the RLG values of the monsoon and post-monsoon seasons. GaSI showed a significant negative correlation with RLG (r = -0.068) in males and a positive correlation with SFI (r = 0.943) in females.

The GaSI values were highest during the monsoon season and lowest during the post-monsoon season for both sexes because the abdominal cavity is considerably occupied with gonads in the post-monsoon season. It results in the availability of less space in the stomach, leading to low feeding with trace food materials and empty stomachs. In Bohai Sea, Hong[34] reported highest GaSI from August to November (pre-spawning) and the lowest from April to July (spawning season). The interrelation between feeding and breeding is clear and close, which indicates low feeding intensity during the spawning period could be a physiological reaction like development of reproductive organs, production of gametes (eggs and sperm), spawning behaviour, and fertilization to reproduction[34].

In *Stolephorus commersonnii* the GaSI was found to be highest during the monsoon, indicating active feeding due to low spawning[43]. Mazlum *et al*.[52] also noticed that the females had a higher GaSI than the males. The GaSI showed a similar trend to the feeding intensity, with peaks during October in females and during the period from July to August in males. The lowest values of GaSI for both males and females were found between April and June.

Stomach Fullness Index (SFI)

The seasonal variations in the average values of the SFI of *S. taty* are presented in Figure 7. It was found that the SFI varied considerably month-wise and lengthwise as well. The SFI was highest in July for pooled (0.789) and males (0.514). In the case of females, SFI was highest during June (0.918). The lowest SFI values were observed for the pooled data (0.375) in October, for males (0.279) in March, and for females (0.385) in September.

There was no significant difference in the SFI of fish between the seasons or sexes. However, female SFI represents a significant negative correlation with VI (r = -0.762) and a positive correlation with GaSI (r = 0.943). In males, SFI is positively correlated with RLG (r = 0.129), GaSI (r = 0.497), and VI (r = 0.508).

SFI is a one-way analysis to evaluate the composition of fish with full stomach contents or fullness of the stomach between seasons and sexes[52]. SFI variation occurred seasonally in the current study. The highest SFI is found in the monsoon season for combined data (0.682±0.158) and males (0.433±0.075). In the case of females, SFI was highest in the pre-monsoon season (0.778±0.172) due to the high abundance of preferred food items in those months or because more energy is needed during the spawning season for gonadal maturation[55,56].

The lowest SFI values were found primarily in the post-monsoon season for pooled (0.414±0.042), male (0.416±0.0541), and female (0.416±0.055) due to the spawning season. Hong[34] also reported a similar kind of result with the highest SFI for *Setipinna taty* during April, June, and July because of the high consumption of food from the Bohai Sea, China.

Vacuity Index (VI)

Figure 8 presents the seasonal variations in the average values of the Empty Stomach Ratio (ESR) of *S. taty*. It was found that the ESR varied considerably month-wise and length-wise. The ESR was highest in August for pooled (50 %), males (57.14 %), and

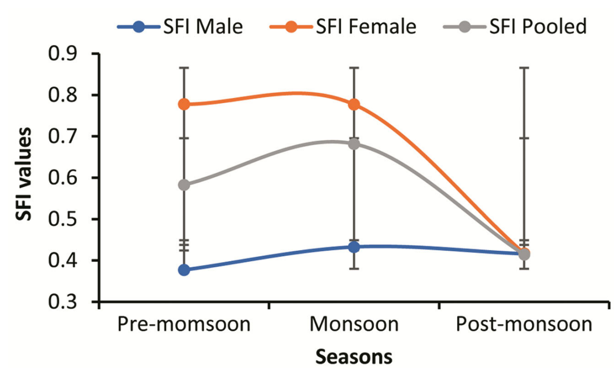

Fig. 7 — Season-wise estimated SFI values of *S. taty*

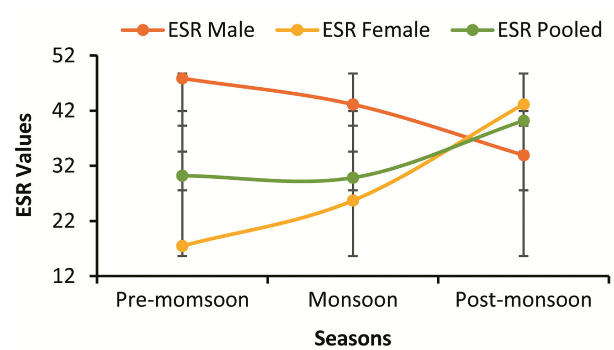

Fig. 8 — Season-wise estimated ESR values of *S. taty*

females (45.83 %). The lowest ESR values are found in June for pooled (19.52 %), male (22.22 %), and female (18.75 %) populations.

The highest ESR was observed in the post-monsoon season for the combined specimen (40.173±1.037), for males (47.887±10.415) in the pre-monsoon season, and for females (43.19±1.411) in the post-monsoon season. During the monsoon, the lowest ESR was found for pooled data (29.840±17.461) and female samples (25.693±17.717). Males have the lowest trophic activity during the post-monsoon season (33.950±6.502).

The ESR for the sexes and months did not differ significantly. However, female ESR represents a significant negative correlation with SFI (r = -0.763). In males, ESR is positively correlated with GaSI (r = 0.265) and SFI (r = 0.508) and negatively correlated with RLG (r = -0.593).

ESR is a useful indicator for determining the intensity of feeding activity along with SFI and VI[28,29]. The highest ESR was observed in the pre-monsoon season for the male samples and for the combined and female samples in the post-monsoon season due to the decreased feeding tendency, and the ingested food may impose pressure on the maturing gonads. The vacuity index assumes stomach fullness; hence, it should be used with caution. It can change depending on the digestion stage at the time of examination[57], the accessibility of prey in the study region, the kind of food item (soft prey is quickly digested), and the time of day the fish are caught[58]. The feeding intensity is not always reflected by the vacuity index[59]. The vacuity index for the combined samples in this study was 32.142 %. So, *Setipinna taty* is a relatively edacious species, with a range of $20 < VI < 40$[60,61].

Bacha and Amara[62] found that the vacuity index in *Engraulis encrasicolus* was lower in the summer (70 %) and autumn (20 %), which matched with more advanced gonadal development. Juveniles from the summer cohort demonstrated accelerated somatic and otolith growth relative to those from the autumn cohort. Research indicates that variations in water temperature primarily account for differences in development and condition. The vacuity coefficient attained a peak value of 38.46%, signifying a moderate degree of feeding activity at specific intervals[62].

The vacuity coefficient varied according to the study sites, with a maximum of 56.67 % in the Catalan Sea[59]. A value of 42.22 % was observed during the recession season and 15.03 % during the flood season. On the other side, low values (2.12 %) were found in the Kiel Bight and in the German Bight (2.85 %)[63].

There was no statistically significant difference found in the ESR of fishes between months or sexes. However, female ESR showed a significant negative correlation with SFI (r = -0.763). In males, ESR is positively correlated with GaSI (r = 0.265) and SFI (r = 0.508) and negatively correlated with RLG (r = -0.593) in *Setipinna taty*.

Conclusion

The current investigation on the food and feeding habits of *Setipinna taty* revealed that the species is a microphagous (juvenile), relatively edacious carnivorous (adult), and opportunistic feeder. The species primarily feed upon crustaceans and finfishes especially on zooplankton, penaeid shrimps, and *Acetes* spp. among crustaceans, and a variety of finfishes. The findings of this study not only fill a gap in *S. taty's* 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 Approval

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. All animals in this study were wild-caught and in accordance with the guidelines set out in the animal welfare laws of India. The study was undertaken with the approval of the statutory authorities of the WBUAFS, Kolkata, India.

Author Contribution

AM: Specimen collection & manuscript writing; GZ: Conceptualisation & editing; TSN: Manuscript editing; SKD: Manuscript editing; SJ: Specimen collection & data analysis; and DB: Data analysis & manuscript editing.

References

1 Kido M H, Morphological variation in feeding traits of native Hawaiian stream fishes, *Pac Sci*, 50 (2) (1996) 184-193.

2 Chipps S R & Garvey J E, Assessment of food habits and feeding patterns, In: *Analysis and interpretation of freshwater fisheries data*, edited by Guy C S & Brown M L, (American Fisheries Society, Bethesda, Maryland), 2007, pp. 473-514.

3 Rohit P, Abdussamad E M, Rathinam A M M, Ganga U, Ghosh S, *et al*., Pelagic fisheries of India – An overview, *Indian J Fish*, 71 (1) (2024) 12-28. https://doi.org/10.21077/ijf.2024.71.1.131154-02

4 Jhingran V G, *Fish and Fisheries of India*, Revised 2nd edn, (Hindustan Publishing Corporation, Delhi, India), 1983, pp. 666.

5 Manon M R & Hossain M D, Food and feeding habit of *Cyprinus carpio* var. *specularis*, *J Sci Found*,9 (1-2) (2011) 163-169. https://doi.org/10.3329/jsf.v9i1-2.14658

6 Bhakta D, Das S K, Das B K, Nagesh T & 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

7 Sarkar S, Das S K & Bhakta D, 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) (2017) 22-26.

8 Borah N, Das S K & Bhakta D, Temporal changes in feeding and bio-indices of *Polynemus paradiseus* Linnaeus, 1758 occurring in Hooghly-Matlah estuary, West Bengal, *Indian J Geo-Mar Sci*, 49 (01) (2020) 118-123.

9 De N K & Datta N C, Studies on certain aspects of the morpho-histology of Indian shad, hilsa, *Tenualosa ilisha* (Hamilton) in relation to food and feeding habits, *Indian J Fish*, 37 (3) (1990) 189-198.

10 Dasgupta M D, Relative length of the gut of some freshwater fishes of West Bengal in relation to food and feeding habits, *Indian J Fish*, 51 (2004) 381-384.

11 Mishra S P, Observation and analysis of the gut contents of some common edible fresh water cat fishes of river Gomti at district Sultanpur, *J Fr Lang Stud*, 5(2) (2020) 34-38.

12 Rao R K & Babu K R, Studies on food and feeding habits of *Mugil cephalus* (Linnaeus 1758) east coast off Andhra Pradesh India, *Can J Pure Appl Sci*, 7 (3) (2013) 2499-2504.

13 Chakraborty T, Yamamoto Y, Hanai S, Hirano M, Mohapatra S, *et al.*, Divulging the social sex change mechanism in a unique model system for studying the sexual plasticity of protogynous hermaphrodite fish, three bamboo leaf wrasse (*Pseudo labrussieboldi*), *Front Mar Sci*, 9 (2022) 104-506. https://doi.org/10.3389/fmars.2022.1048506

14 Day F, *The fishes of India: A natural history of the fishes known to inhabit the seas and fresh waters of India, Burma and Ceylon*, Vol 1, (William Dawson and Sons Ltd, London), 1958, pp. 800.

15 Talwar P K & A G Jhingran, *Inland Fishes of India and Adjacent Countries*, Vol 1, (Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi), 1991, pp. 1158.

16 Zacharia P U, Abdurahiman K P & Mohamed K, Methods of stomach content analysis of fishes, In: *Technical Notes of Winter School on Towards Ecosystem Based Management of Marine Fisheries - Building Mass Balance Trophic and Simulation Models*, (CMFRI, Kochi), 2004, pp. 148-158.

17 Kitsos M S, Tzomos T H, Anagnostopoulou L & Koukouras A, Diet composition of the seahorses, *Hippocampus guttulatus* Cuvier, 1829 and *Hippocampus hippocampus* (L., 1758) (Teleostei, Syngnathidae) in the Aegean Sea, *J Fish Biol*, 72 (6) (2008) 1259-1267.

18 Hynes H B N, The food of fresh-water sticklebacks (*Gasterosteus aculeatus* and *Pygosteu spungitius*), with a review of methods used in studies of the food of fishes, *J Anim Ecol*, (1950) 36-58.

19 APHA, *Standard Methods for the examination of water and waste water*, (American Public Health Association, New York), 21st edition, 2005, pp. 1288.

20 Edmondson W T, *Freshwater Biology*, 2nd edn, (John Wiley & Sons Inc., New York), 1959, pp. 1274.

21 CMFRI, *CMFRI Research Projects 1973*, Technical Report, CMFRI Kochi, Kochi, 1973, pp. 49.

22 Needham J G & Needham P R, *Guide to the study of freshwater biology*, 5th edn, (Holden Day Inc., San Francisco, USA), 1962, pp. 108.

23 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.

24 Desai V R, Studies on the fishery biology of *Tor tor* (Ham.) from river Narmada, Food and feeding habits, *J Inland Fish Soc India*, 2 (1970) 101-112.

25 Ouakka K, Yahyaoui A, Mesfioui A & El Ayoubi S, Stomach fullness index and condition factor of European sardine (*Sardina pilchardus*) in the south Moroccan Atlantic coast, *Aquacult Aquarium Conserv Legis*, 10 (1) (2017) 56-63.

26 Soe K K, Pradit S & Hajisamae S, feeding habits and seasonal trophic guilds structuring fish community in the bay mouth region of a tropical estuarine habitat, *J Fish Biol*, 99 (4) (2021) 1430-1445. https://doi.org/10.1111/jfb.14851

27 Vagh S, Kardani H K, Vase V K, Pal M, Mahavadiya D & Rathod V, Food and feeding habits of *Nemipterus japonicus* (Bloch, 1791) off Gujarat, north-west coast of India, *Indian J Geo-Mar Sci*, 50 (2) (2021) 473-479.

28 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

29 Bowen S H, *Quantitative description of the diet*, In: *Fisheries techniques*, 2nd edn, (American Fisheries Society, Bethesda, Maryland), 1996, pp. 513-532.

30 Serajuddin M & Ali R, Food and feeding habits of striped spiny eel, *Macrognathus pancalus* (Hamilton), *Indian J Fish*, 52 (1) (2005) 81-86.

31 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.

32 Marichamy R, Food and feeding habits of the short-jaw anchovy, *Thrissina baelama* (Forskal), of the Andaman Sea, *Indian J Fish*, 19 (1-2) (1972) 54-59.

33 Bray J R & Curtis J T, An ordination of the upland forest communities of southern Wisconsin, *Ecol Monogr*, 27 (4) (1957) 326-349. https://doi.org/10.2307/1942268

34 Hong G, Feeding habits and food composition of half-fin anchovy, *Setipinna taty* (C et V) in the Bohai Sea,

Chin J Oceanol Limnol, 8 (3) (1990) 280-288. https://doi.org/10.1007/BF02849668

35 Ganias K (Ed.), *Biology and ecology of sardines and anchovies*, 1st edn, (CRC Press, Boca Raton, Florida, USA), 2014, pp. 394.

36 Plounevez S & Champalbert G, Diet, feeding behaviour and trophic activity of the anchovy (*Engraulis encrasicolus* L.) in the Gulf of Lions (Mediterranean Sea), *Oceanol Acta*, 23 (2) (2000) 175-192. https://doi.org/10.1016/S0399-1784(00)00120-1

37 Palomera I, Olivar M P, Salat J, Sabates A, Coll M, *et al.*, Small pelagic fish in the NW Mediterranean Sea: an ecological review, *Prog Oceanogr*, 74 (2-3) (2007) 377-396. https://doi.org/10.1016/j.pocean.2007.04.012

38 El Qendouci, Amenzoui M, Baali A, El Qoraychy I & Yahyaoui A, Diet of anchovy *Engraulis encrasicolus* (Engraulidae) in Moroccan Atlantic coast, *Aquacult Aquarium Conserv Legis*, 11 (4) (2018) 1388-1398.

39 Van der Lingen C D, Hutchings L & Field J G, Comparative trophodynamics of anchovy *Engraulis encrasicolus* and sardine *Sardinops sagax* in the southern Benguela, *Afr J Mar Sci*, 28 (3-4) (2006) 465-477.

40 Serajuddin M & Chaubey B K, Food and feeding habits of the Gangetic hair-fin anchovy *Setipinna phasa* (Hamilton, 1822), *Indian J Fish*, 66 (4) (2019) 46-50.

41 James A G, Feeding ecology, diet and field-based studies on feeding selectivity of the Cape anchovy *Engraulis capensis* Gilchrist, *S Afr J Mar Sci*, 5 (1) (1987) 673-692. https://doi.org/10.2989/025776187784522784

42 Blaxter J H S & Hunter J R, The biology of the Clupeoid Fishes, *Adv Mar Biol*, 20 (1982) 1-223. https://doi.org/10.1016/S0065

43 Arun Kumar M, Padmavati G & Venu S, Food and feeding dynamics of *Stolephorus commersonnii* (Lacepede, 1803) (family: Engraulidae) from South Andaman, *J Mar Biol*, 2015 (1) (2015) p. 870919. https://doi.org/10.1155/2015/870919

44 Rajani Gopal V, Ramasubramanian V, Santhosh B & Mathew Abraham K, Food spectrum and dietary preferences of the Indian anchovy *Stolephorus indicus* (Van Hasselt, 1823) from Thiruvananthapuram coast, Kerala, *Indian J Fish*, 65 (1) (2018) 15-19.

45 Hiatt R W, Food and feeding habits of the nehu, *Stolephorus purpureus* Fowler, *Pac Sci*, 5 (4) (1951) 347-358.

46 Marichamy R, Food and feeding habits of the short-jaw anchovy, *Thrissina baelama* (Forskal), of the Andaman Sea, *Indian J Fish*, 19 (1-2) (1972) 54-59.

47 Budnichenko E V, Firulina A V & Bulgakova Y V, Feeding conditions of Azov anchovy *Engraulis encrasicolus* during summer-fall 1995-1996, *J Ichthyol*, 39 (3) (1999) 248-255.

48 Duque G & Acero P A, Feeding Selectivity of *Anchovia clupeoides* (Pisces: Engraulidae) in the Cienaga Grande de Santa Marta, Colombian Caribbean, *Gulf Caribb Res*, 15 (1) (2003) 21-26.

49 Islam M & Tanaka M, Diet and prey selection in larval and juvenile Japanese anchovy *Engraulis japonicus* in Ariake Bay, Japan, *Aquat Ecol*, 43 (2) (2009) 549-558.

50 Gay P, Rochat L, Billieux J, d'Acremont M, & Van der Linden M, Heterogeneous inhibition processes involved in different facets of self-reported impulsivity: Evidence from a community sample, *Acta Psychol*, 129 (3) (2008) 332-339.

51 Costalago D, Palomera I & Tirelli V, Seasonal comparison of the diets of juvenile European anchovy *Engraulis encrasicolus* and sardine *Sardina pilchardus* in the Gulf of Lions, *J Sea Res*, 89 (2014) 64-72.

52 Mazlum R E, Solak E & Bilgin S, Size and seasonal diet variation of European anchovy, *Engraulis encrasicolus* (Linnaeus, 1758) in the southeast Black Sea, *Cah Biol Mar*, 58 (3) (2017) 251-260.

53 Choi H C, Youn S H, Huh S H & Park J M, Diet composition and feeding habits of two engraulid fish larvae (*Engraulis japonicus* and *Coilia nasus*) in the Nakdong River estuary, Korea, *J Coast Res*, 85 (10085) (2018) 346-350.

54 Akalin S, Sever T M, Ilhan D & Unluoglu A, The Diet Composition of European Anchovy, *Engraulis encrasicolus* (Linnaeus, 1758) in İzmir Bay, Aegean Sea, *Turkish J Fish Aquat Sci*, 19 (5) (2018) 431-445.

55 Farrag M M S, *Fishery biology of Red Sea immigrant Etrumeus teres (Family: Clupeidae) in the Egyptian Mediterranean water, off Alexandria*, Master's thesis, Zoology Department, Faculty of Science, Al-Azhar University, Egypt, 2010.

56 Osman A G, Farrag M M, El Sayed H K & Moustafa M A, Feeding behavior of lessepsian fish, *Etrumeus teres* (Dekay, 1842) from the Mediterranean Waters, Egypt, *Egypt J Aquat Res*, 39 (4) (2013) 275-282. https://doi.org/10.1016/j.ejar.2013.12.004

57 Plounevez S & Champalbert G, Diet, feeding behaviour and trophic activity of the anchovy (*Engraulis encrasicolus* L.) in the Gulf of Lions (Mediterranean Sea), *Oceanol Acta*, 23 (2) (2000) 175-192.

58 Morote E, Olivar M P, Villate F & Uriarte I, A comparison of anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) larvae feeding in the Northwest Mediterranean: influence of prey availability and ontogeny, *ICES J Mar Sci*, 67 (5) (2010) 897-908. https://doi.org/10.1093/icesjms/fsp302

59 Jemaa S, Cuvilliers P, Bacha M, Khalaf G & Amara R, A study on the diet variation of European anchovy (*Engraulis encrasicolus*) in the Atlantique and Mediterranean water, *Leban Sci J*, 17 (1) (2016) 77-92.

60 Daan N, A quantitative analysis of the food intake of North Sea cod, *Gadus morhua*, *Neth J Sea Res*, 6 (4) (1973) 479-517. https://doi.org/10.1016/0077-7579(73)90002-1

61 Euzen O, Food habits and diet composition of some fish of Kuwait, *Kuwait Bull Mar Sci*, 9 (9-10) (1987) 65–85.

62 Bacha M & Amara R, Inter-cohort differences in growth, condition and feeding of juvenile anchovy (*Engraulis encrasicolus*) in the Gulf of Bejaia (Algerian coast, SW Mediterranean): Implications for recruitment success, *Fish Res*, 129 (2012) 73-81. https://doi.org/10.1016/j.fishres.2012.06.012

63 Schaber M, Petereit C & Paulsen M, Diet composition and feeding of European anchovy *Engraulis encrasicolus* in Kiel Bight, western Baltic Sea, *J Fish Biol*, 76 (7) (2010) 1856-1862.