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Note

Biological aspects of the Indo-Pacific sergeant *Abudefduf vaigiensis* (Quoy and Gaimard, 1825) from Gulf of Mannar, Tamil Nadu, India

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Abstract

Food and feeding habits of the commercially important marine ornamental fish *Abudefduf vaigiensis* from the Gulf of Mannar were evaluated. Analysis of gut contents indicated that *A. vaigiensis* is an omnivorous fish, feeding on any available food item in its environment, such as seaweeds, cladocerans, copepods and insects. Most of the sampled fishes had either quarter-full or half-full or three-fourth full stomachs. The index of preponderance indicated seaweeds as the preferred food item among majority of length classes except for those falling within the 80-89 mm and 100-109 mm length classes, in which a preference towards copepods was observed. On a monthly basis, seaweed *Spongomorpha* sp. emerged as the predominant food item. Gastro-somatic index (GaSI) for males recorded the highest value in July (1.20) and lowest (0.36) in November, while that of females recorded the highest value in July (0.95) and lowest value (0.47) in January. Hepato-somatic index (HSI) of females recorded the highest in December (2.01) and lowest in July (0.83), while that of males recorded the highest value in January (1.25) and lowest in September (0.81). Gonadosomatic index (GSI) in females recorded maximum in February (4.23) and lowest in June (1.32) while that of males recorded the highest value in February (0.85) and lowest value in July (0.35). The results of the study indicate that adopting seasonal regulatory measures is essential for sustainable exploitation of the species, since their trade relies on wild collection. The study also revealed a negative correlation between the feeding patterns of these fish and their reproductive development.

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Fishes belonging to the family Pomacentridae are banded marine fishes widely distributed along the Indo-west and Central Pacific tropical and warm temperate waters. They are primarily found in shallow coral reefs, with few species inhabiting depths of 80 m or more (Khalaf and Disi, 1997). The Indo-pacific sergeant major, *Abudefduf vaigiensis* (Quoy and Gaimard, 1825) is one of the important groups of marine ornamental fishes of this family, which contribute significantly to the total marine ornamental fish trade in India. It feeds mainly on macro-algae, benthic invertebrates and detritus (Sudhakar and Shameen, 2006). The study of food and feeding habits of fishes is essential to understand the species' life history, including its growth, breeding and migration (Bal and Rao, 1984). Information on the feeding habits of marine fish and their predatory relationship is helpful in assessing their role in the ecosystem (Bachok *et al.*, 2004). Knowledge of the influence of maturity stages, age and season on food and feeding preferences is important in assessing the trophic inter-relationship. Even though several studies on the diet composition in marine ornamental fishes are available (Mohan and Pillai, 1988; Pillai and Mohan, 1990; Pillai and Vijay Anand, 1995; Gandhi, 2002; Pillai *et al.*, 2002), specific studies on the seargent major group are limited. The present study analysed the food spectrum and dietary preferences of *A. vaigiensis* from Gulf of Mannar, south-east coast of India. It is also the first attempt to investigate these details in relation to gonadal development in *A. vaigiensis* and the results of this study will be of use in planning commercial aquaculture of the species.

Monthly samples of thirty individuals of *A. vaigiensis* were collected from October 2019 to September 2020 from Gulf of Mannar, south-east coast of India (Fig. 1). A total of 360 intact samples of *A. vaigiensis* caught by encircling nets were used for the study. The total length and standard length were measured to the nearest 0.1 cm and weight measurements (total body weight and gut weight) to the nearest 0.1 g using a measuring board and a sensitive weighing balance respectively. *A. vaigiensis* was identified following the description given by Allen (1991) and Randall (2007).

Each specimen was weighed to the nearest 1.0 g with the help of a single pan balance (Sartorius 'PT' 600) and then dissected to collect gut contents for analysis. Gut contents were preserved in 4% formalin solution and kept for further analysis. Qualitative analysis of gut contents was done in the Mariculture Laboratory of Mandapam Regional Centre of ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), Mandapam, Tamil Nadu, India with the help of a trinocular microscope (Olympus CH 20i) following the frequency of ooccurrence methods as per Hynes (1950) and Pillay (1952).

The data were segregated month-wise, sex-wise and size-wise. The gut contents were grouped into different categories such as zooplankton, phytoplankton, plant material, insects and decaying matter. The relative importance of all food contents was quantified by the index of preponderance and was calculated with the help of percentage composition (volume and occurrence) of food contents to follow the equation of Natrajan and Jhingran (1963):

$$I = (V1O1/ \sum V1\ O1)\ 100$$

where, I = Index of preponderance; V1= Percentage volume of particular food component; O1 = Occurrence of particular food component

The degree of fullness of stomach and the quantity of food contained in it were noted so as to ascertain the extent of feeding (feeding intensity). The degree of distension of stomachs was designated as gorged (50 points), full (40 points), ¾ full (30 points), ½ full (20 points), ¼ full (10 points) and empty (0 points) following the method by Hynes (1950). A stomach was considered 'gorged' when it was packed with food and stretched fully with thin, transparent walls, 'full' when filled with food and the walls thick and intact and ' ¾ full' when the stomach was partly collapsed with thick walls. Depending on the amount of food present and the appearance of the stomach wall, the stomach was further designated as '1/2 full', ¼ full' and 'empty'.

The samples collected were adequately cleaned in the laboratory, dissected and the stomachs were removed. The total weight of each stomach with its contents was measured to the nearest 0.01 g. The contents of each stomach and foregut were examined under a microscope and further identification of food content within each taxonomic group was made following appropriate taxonomic identification guides. GaSI based on monthly and seasonal calculations was obtained as described by Biswas (1993):

$$GaSI= (\text{Total weight of stomach/Bodyweight}) \times 100$$

Liver was removed and weight was recorded to the nearest 0.001 g. HSI was calculated following Sulistyo *et al.* (2000):

$$HSI = \frac{\text{Liver weight (g)}}{\text{Body weight (g)}} \times 100$$

The fishes were cut open and the morphology of the gonad was observed for sex determination. Gonads were then removed, weighed and macroscopically assessed to determine their maturation stage. Gonad weight was recorded to the nearest 0.001 g. Body weight and gonad weight were measured using a top-loading electronic balance with an accuracy of 0.001 g and the length was measured using a wooden scale with an accuracy of 1 mm.

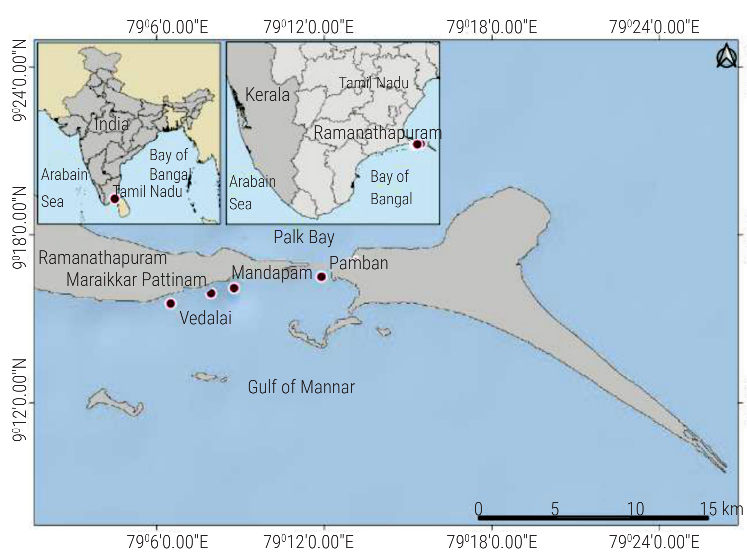

Fig.1. Location of sample collection for feeding studies of *A. vaigiensis*

To quantify the changes in gonad weight during the annual sexual cycle and to determine the spawning season, monthly GSI (Devlaming *et al*., 1982), was calculated using the formula:

$$GSI = \frac{\text{Gonad weight (g)}}{\text{Body weight (g)}} \times 100$$

Monthly analysis of the stomach contents of *A. vaigiensis* revealed that the diet consisted of seaweeds, polychaetes, copepods, shrimps, insect larvae, decapod larvae, mollusc, sagitta and organic debris. Index of preponderance of *A. vaigiensis* for various length classes and during various months is given in Table 1 and 2 respectively. Preferred food items for various length classes were: Copepods (80-89 mm), *Spongomorpha* sp. (90-99 mm), Copepods (100-109 mm), *Gracilaria* sp. (110-119 mm), *Spongomorpha* sp. (120-129 mm), *Chaetomorpha* sp. (130-139 mm), *Spongomorpha* sp. (140-149 mm) and *Chaetomorpha* sp. (150-159 mm).

On an average, for all months of the study period, the seaweed *Spongomorpha* sp. dominated with a percentage of 29% and the other food items in descending order were seaweed *Chaetomorpha* sp. (19.54%), copepods (17.96%), *Halobates* sp. (15.94%), *Gracilaria* sp. (7.92%), *Kappaphycus* sp. (3.33%), *Ulva* sp. (2.88%), *Caulerpa* sp. (1.03%), molluscs (0.63%) and shrimps (0.63%). The preference for food items were in the order: - *Spongomorpha* sp. (I), *Chaetomorpha* sp. (II), Copepods (III), *Halobates* sp. (IV), *Gracilaria* sp. (V), *Kappaphcus* sp. (VI), *Ulva* sp. (VII), *Caulerpa* sp. (VIII), molluscs (IX) and shrimps (X). The results of the present study indicated that *A. vaigiensis* is an omnivorous species feeding on any available food item in its environments such as seaweeds, cladocerans, copepods and insects.

Degree of fullness (%) of stomachs of *A. vaigiensis* observed in different months is given in Table 3. Out of the 360 specimens evaluated, the percentage of empty stomach was minimum (1.1 to 5.5%), the full stomach was comparatively less (2.2 to 56.3%) and

Table 1. Index of preponderance of *A. vaigiensis* for various length classes (mm)

Organism	80-89	90-99	100-109	110-119	120-129	130-139	140-149	150-159
Chaetomorpha sp.	0.2	29.5 (II)	31.5 (II)	22.3 (II)	25.2 (II)	35.2 (I)	18 (II)	26.3 (I)
Spongomorpha sp.	1.9 (II)	45.3 (I)	15.2 (III)	5.4	28.3 (I)	31.2 (II)	52 (I)	24.3 (II)
Ulva sp.	0.9	3.6	9.6	4.05	8.6	1.2	0.2	3.5
Caulerpa racemosa	0.12	0.5	1.1	1.38	1.2	1.5	4.5	5.2
Kappaphycus sp.	0.9	1.6	1.2	15.3(III)	5.2	5.6	9.15	12.5
Gracilaria sp.	0.95(III)	2.82	0.51	30.25 (I)	8.2	15.2 (III)	12.1 (III)	19.3 (III)
Polychaetes	0	0	0.15	1.3	0.25	0	0	0
Copepods	90.93 (I)	15.2 (III)	35 (I)	12.3	12.5 (III)	0.1	2.6	5.3
Shrimps	0	0.53	0.2	0.5	0	8.94	1.2	0
Halobates sp.	0	0	1.5	4.5	4.86	0	0	0
Molluscs	0	0.2	0.04	0	0	0.5	0	0
Sagitta sp.	0.52	0	0.8	0.5	0	0	0	0
Decapod larvae	0.26	0.25	0	0.02	0.02	0	0	0
Miscellaneous	3.32	0.5	3.2	2.2	5.67	0.56	0.25	3.6
Total	100	100	100	100	100	100	100	100

*Most preferred food item for each length class given in parenthesis

Table 2. Month-wise Index of preponderance of *A. vaigiensis*

Organism	Oct	Nov	Dec	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep
Chaetomorpha sp.	18.4 (II)	22.2 (III)	2.1	2.5	13.3 (II)	2.6	53.4 (I)	7.8 (II)	38.5 (II)	34.8 (II)	6.2 (III)	32.66 (II)
Spongomorpha sp.	1.0	3.4	0.6	1.2	65 (I)	54.2 (I)	28.5 (II)	70.2 (I)	48.5 (I)	51.2 (I)	23 (II)	1.2
Ulva sp.	1.8	0.6	0.3	0.24	0.32	2.6	1.5	4.4	3.2	3.1	1.1	15.4 (III)
Caulerpa racemosa	0.2	0.5	1	3.26 (III)	1.58	0	1.3	0.6	0.1	0.25	2.4	1.2
Kappaphycus sp.	2.1	1.2	2.9 (III)	0.5	5.2	9.4 (III)	7.1	5.6 (III)	0.8	0.1	2.5	2.5
Gracillaria sp.	3.6 (III)	36.2 (I)	1.2	15.2 (II)	8.5 (III)	5.5	7.6 (III)	4.9	8.5 (III)	0.9	2.1	0.8
Polycheates	0	0	0	0.2	0.1	0	0	0	0	0	0	0
Copepods	70.1 (I)	2.5	40.2 (II)	0	0	0	0	0	0	9.1 (III)	55.5 (I)	38.1 (I)
Shrimps	0	1.2	1.05	1.5	0.6	0	0	2.5	0	0	0	0.44
Halobates sp.	0	32.2(II)	50.4 (I)	75.2(I)	4.7	25.1(II)	0	1.9	0	0	0.3	1.5
Molluscs	0	0	0	0	0.2		0.5	0	0.4	0	5.5	0.9
Sagitta sp.	0	0	0	0.2	0	0	0.1	0	0	0	0.1	0.5
Decapod larvae	0.2	0	0	0	0	0.3	0	2.1	0	0	0.1	2.1
Miscellaneous	2.6	0	0.25	0	0.5	0.3	0	0	0	0.55	1.2	2.7
Total	100	100	100	100	100	100	100	100	100	100	100	100

*Most preferred food item for each length class given in parenthesis

Table 3. Degree of fullness (%) of stomachs of *A. vaigiensis* in different months

2019-20	N	Empty	¼ full	½ full	¾ full	Full	Gorged
Oct	30	1.1	27.5	39.3	31.2	0	0.8
Nov	30	0	20.2	59.4	20.1	0	0.2
Dec	30	1.2	38.9	30.3	20.1	9.4	0
Jan	30	0	25.7	52.7	11.7	9.8	0
Feb	30	2.1	30.6	36.2	31	0	0
Mar	30	0	38.5	30.2	23.1	8.1	0
Apl	30	0	32.5	28.1	39.2	0	0
May	30	5.1	13	30.8	42.5	8.5	0
Jun	30	0	12.3	18.1	12.1	56.3	1.1
Jul	30	3.1	27.5	8.8	40.54	18.1	2.05
Aug	30	8	0	37.7	50.2	2.2	1.8
Sep	30	5.5	16.4	35.4	37.8	3.8	1

most of the fishes had either 1/4 or 1/2 or 3/4-full stomachs. The highest percentage of empty stomachs was in September and the maximum percentage (56.3%) of full stomachs was in June.

GaSI (Fig. 2.) in male *A. vaigiensis* followed regular pattern with an increasing trend after February and reached the highest value (1.20) in July and lowest value (0.36) in November. GaSI in female *A. vaigiensis* followed an irregular pattern with an increasing trend followed by a decrease, with the highest value in July (0.95) and the lowest (0.47) in January.

HSI (Fig. 3.) in male *A. vaigiensis* increased from November (0.85) to January (1.25) and decreased from February to September, with a peak in December. HSI in females increased from August (0.85) to December (1.25) and then decreased up to July with a peak in December.

GSI in male *A. vaigiensis* (Fig. 4) sustained a maximum from September to March with a peak during February and was observed to be lower from April to July. GSI in female *A. vaigiensis* (Fig. 5) sustained maximum values from December to March with a peak during February and was observed to be lower from April to October.

Diet is a key factor that profoundly affects an organism's distribution, growth, reproduction, migration rate and behaviour (Priyadharsini *et al*., 2012). Feed quality and quantity directly impact fish growth and indirectly impact fish maturity and survival (Sourinejad *et al*., 2015). Information on the food and feeding habit of a species in its natural habitat provides cues for the selection of suitable cultivable

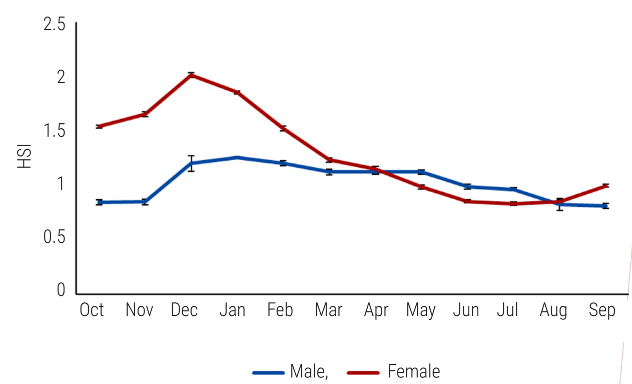

Fig. 3. Monthly hepato-somatic index in male and female *A. vaigiensis*

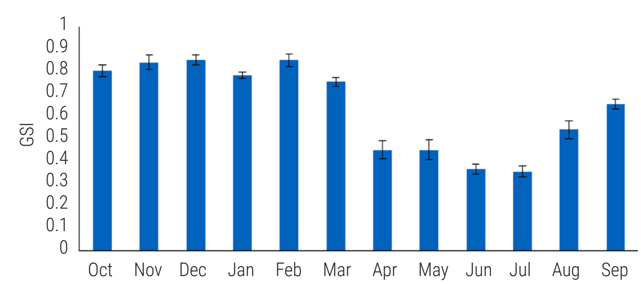

Fig. 4. Monthly gonado-somatic index in males of *A. vaigiensis*

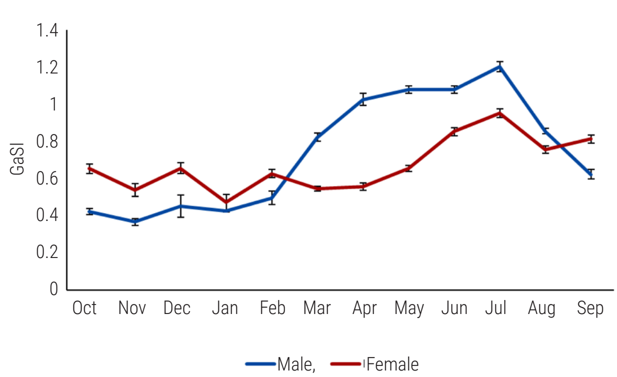

Fig. 2. Monthly gastro-somatic index in male and female *A. vaigiensis*

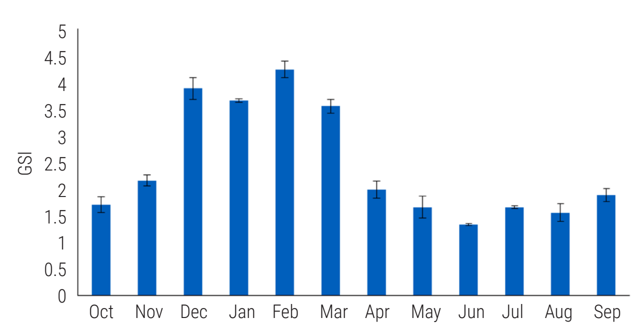

Fig. 5. Monthly gonado-somatic index in females of *A. vaigiensis*

species and for the development of successful farming practices (Manon and Hossain, 2011).

Research on the feeding habits and feeding ecology of fishes is the basis for understanding their roles in ecosystems (Hajisamaea *et al*., 2003). In addition, the knowledge of the feeding behaviour of marine fishes is essential to understand prey selection (Stergiou and Fourtouni, 1991), predator-prey size relationships (Mohanraj and Prabhu, 2012; Priyadharsini *et al.,* 2012), distribution of feeding habits with latitude (Pauly, 2000), and habitat selection (Labropoulou *et al*., 1999), which contribute to fish stock assessment and ecosystem modelling (Bachok *et al* 2004; Salavatian *et al*., 2011; Mohanraj and Prabhu, 2012).

In general, damselfishes living in coral reefs of the Indo-West Pacific region feed mainly on filamentous algae and small planktonic and benthic invertebrates (Allen, 1991; Kuo and Shao, 1991; Frédérich *et al*., 2009). The results of the present study were on par with other previous reports for the same species (Fishelson, 1970; Emery, 1973; Allen, 1991). *Abudefduf troschelii,* the pacific sergeant-major, was found to be omnivorous, foraging on benthic organisms (Hobson, 1965). Analysis of gut contents in the present study indicated that *A. vaigiensis* is an omnivorous species which agrees with the observations made on *A. vaigiensis* in the Mediterranean Sea (Allen, 1991). Fishelson (1970) noted that *A. vaigiensis* feeds on floating algae, whereas Emery (1973) reported that it feeds on benthic algae. Fishes often display environmentally induced morphological variations (Wimberger, 1992), reflecting different feeding biology (Sreekanth *et al.*, 2012).

The feeding intensity studies of *A. vaigiensis* samples collected from the Gulf of Mannar region revealed that most of the fishes had either 1/4th or 1/2th or 3/4th of the stomach. The highest percentage of empty stomachs was in September, which correlated with the GSI peak observed in this study. Percentage of empty stomachs and feeding intensity in fishes have been observed to be negatively related (Bowman and Bowman, 1980; Pallaoro *et al*., 2003) and often synchronised with the spawning seasons of the respective fishes (Manon and Hossain, 2011; Salavatian *et al.,* 2011; Sourinejad *et al*., 2015).

GaSI of male and female fishes followed an almost similar pattern and recorded low value during the period of high GSI in the present study. Perera and Cumaranatunga (2009) reported that GaSI peaked just before the breeding season in *A. vaigiensis* and reduced during reproductive activity as GSI increased. HSI followed a similar trend in both sexes and correlated with the trends of GSI in the present study. Higher liver activities are always associated with yolk development for vitellogenesis and gonadal development. HSI is used as an indicator of energy reserves in the liver (Cerda *et al*., 1996, Hismayasari *et al.*, 2015) and as an indicator of the reproductive period in fishes (Bolger and Connolly 1989; Jayasankar and Alagarswami, 1994; Barbieri *et al.*, 1996; Carvalho *et al*., 2009; De Giosa *et al.*, 2014).

The results of GSI in the present study revealed that April to August (pre-breeding season) is the preparatory season for the breeding season and the fishes feed voraciously during this phase leading to higher GaSI. During the breeding season (September to March), the gondal development is rigorous, leading to higher GSI. GSI has been used to improve accuracy in determining the maturity stage (McPherson *et al.*, 2011) and has also been widely used to determine reproduction timing (Lowerre-Barbieri *et al.*, 2011). During the high GSI, the alimentary canal will be thinner and the peritonial space will be occupied by the developing gonad. Keivany and Soofiani (2004) reported that the feeding intensity declines as the fish approaches the peak spawning season. The present study gives the first report on the food preferences and feeding indices of *A. vaigiensis* in the Gulf of Mannar and also give a clue to the breeding season of *A. vaigiensis* in this region, which can be used for regulatory measures on their capture in the wild and breeding of these species in controlled conditions.

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