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Food, Feeding Habits and Biochemical Composition of *Scatophagus argus*

Gisha Sivan[1,*], C.K.Radhakrishnan[2]

[1] Cochin University of Science and Technology, Dept. of Marine Biology, Microbiology and Biochemistry, 682016, Kerala, India.
[2] Cochin University of Science and Technology, Dept of Marine Biology, Microbiology and Biochemistry, Kerala, India.

* Corresponding Author: Tel.: +91.984 6375610; Fax: ;
E-mail: gishasivan@rediffmail.com

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Abstract

The spotted scat (*Scatophagus argus*) is widely distributed throughout Indo Pacific basin. This species is valuable brackish water aquarium fish and an important food fish in parts of its range. A study on the feeding habits, condition factor and muscle biochemical composition was carried out. The present study on the food and feeding revealed that algae and detritus dominated the gut contents of the fish. Spotted scat showed flexibility in their feeding ecology and food selection was based on relative abundance of prey. The gut contents showed an ontogenetic shift in diet with an increase in length. The results showed that the relative length of gut is 3.1 (ranging from 2.14 to 3.96) which is commonly considered normal for an omnivorous fish. The muscle biochemical composition of the fish, *S. argus* was studied. It showed variation with season in its proximal composition.

Keywords: *Scatophagus*, condition factor, spotted scat, omnivorous.

***Scatophagus argus*'un Yem, Beslenme Alışkanlıkları ve Biyokimyasal Kompozisyonu**

Özet

Scatophagus argus, benekli argus balığı, Pasifik havzası boyunca geniş bir alana dağılmıştır. Bu tür, acı su akvaryum balığı olarak değerlidir ve kendi doğal ortamında önemli bir yem balığıdır. Çalışmada bu türün beslenme alışkanlıkları, kondüsyon faktörü ve kas biyokimyasal kompozisyonu değerlendirilmiştir. Balığın yem tercihi ve beslenmesi konusunda alglerin ve taş döküntülerinin balığın bağırsak içeriğinde baskınlık oluşturduğu belirlenmiştir. Benekli argus, avının bolluğuna bağlı olarak beslenme ekolojisinde ve yem seçiciliğinde esneklik göstermektedir. Bağırsak içeriği, boyda artış ile birlikte diyette ontogenetik değişim göstermektedir. Sonuçlar, bağırsak bağıl boyunun omnivor bir balık için normal sayılabilecek ortak bir görüş olan 3,1 (2,14 ile 3,96 arasında dağılım göstermektedir) olduğunu göstermiştir. *S. argus*'un kasının biyokimyasal kompozisyonu çalışılmıştır. Mevsimlere bağlı olarak proksimal kompozisyonda çeşitlilikler tespit edilmiştir.

Anahtar Kelimeler: Kondüsyon faktörü, Benekli argus, omnivor.

Introduction

Scatophagus argus also known as spotted scat (Bardach *et al*., 1972) butterfish, Argus fish, spade fish, spotted spade fish (Barry and Fast, 1988) is widely distributed in the mudflats, mangrove swamps, harbors, upstream swamps, estuaries and marine habitats of Indo Pacific, the Malay Archipelago, the Philippines, Australia and South and South East Asia especially India. The habits inhabited by scats are characterized by fluctuations in salinity, temperature, dissolved oxygen, tidal movements, river run off, turbidity and turbulence. These adaptations to live in such ever changing environments endow them with many biological attributes highly desired in cultured finfish (Barry and Fast, 1988). The quality and taste of the fish ranks it as an edible fish and the spotted rhombic body ranks it as a fascinating aquarium fish. Large size fish are transported to inland markets where they fetch price just like any other table fish (Gandhi, 2002, Barry and Fast, 1988). Because of their favorable biological characteristics and economic importance, considerable interest exists in developing propagation and culture techniques for the spotted scat. This species is very potential for brackish water aquaculture in this region.

There is little information about the biology of spotted scat despite its palatability and consumer appeal. Studies on the food and feeding habits of *S. argus* in estuaries of Bengal by Mookerji *et al*.

(1949), in brackish and fresh water by Datta *et al*. (1984), the mangrove areas of Thailand by Monkolprasit *et al*. (1994) and the marine environment in and around Mandapam by Gandhi (2002) have all studied the qualitative aspects. Keeping in mind the paucity of information on the biology of spotted scat the aim of this present study is to provide some basic biological information concerning the food and feeding habits as well as the feeding indices of *S. argus*. The changes in muscle biochemical composition of spotted scat with regard to season are examined to evaluate its paramount importance in regard to nutrient value and physiological condition.

Material and Methods

Specimen Collection

The specimens for the study of food and feeding habits were collected from the fish landing centers in and around Cochin Estuary, fortnightly for a period of one year from January, 2007 to December, 2007. Gut contents of a total of 764 specimens were dissected out weighed and preserved in 5% formalin. The gut contents were analysed through quantitative and qualitative methods (Hynes, 1950; Natarajan and Jhingran, 1961). The volume (displacement method) and occurrence of various food items in each stomach were recorded. Monthly variations in feeding index were obtained on the basis of fullness of stomach as suggested by Kow (1950) to assess the feeding intensity. Depending on the relative fullness and the space occupied by the food contents fish were classified as gorged, full, ¾ full and ½ full as actively fed whereas those with ¼ full, trace and empty as poorly fed. For analysis of gut content fish were sized into two different size groups (<70 mm length and >70 mm length). Spotted Scat sexes could be differentiated by head shape. In females, the head profile ascends at a constant slope, whereas males have a concave curvature of the head above the eye. Females are often a lighter olive green color compared to the darker males.

Specimens were collected using Chinese net from Cochin estuary from January, 2007 to December, 2007. Fish were transported to the laboratory in ice cold condition, where their body weight and length (Standard Length) were recorded to the nearest 0.01g and cm respectively and stored in liquid nitrogen at -80°C until analysis. Their fins and spines were removed and flesh pooled together, weighed to the nearest mg and biochemical analysis carried out. Triplicate set of experiments were carried out (n=6).

Relativegut Index (RGI)

The values of relative gut indices of *S. argus* in the size range of <70 mm (juvenile) and >70 mm (adult) were studied by the method of Hynes, (1950) using the formula,

$$R.G.I. = \frac{\text{Length of gut (mm)}}{\text{Total length (mm)}} \times 100$$

Condition Factor

The relative condition factor (Kn) was computed using LeCren's (1951) modified formula,

$$Kn = W/aL^n$$

Muscle Biochemical Analysis

Protein content was determined by Lowry's (1951) method using BSA (Bovine serum albumin) as standard. To determine the moisture content known amount of fish sample was dried in an oven at 50–60°C for 8–10 hours. Finally the moisture content was calculated and reported in percentage (AOAC, 1988). The percentage composition of fat and carbohydrates of collected samples were analyzed according to AOAC (1988) methods.

Statistical Analysis

The SPSS® statistical software for windows, version 13.0 (SPSS Inc., Chicago, USA) was used in all data analysis. Analysis of variance method was employed to determine the statistical significance of the changes in muscle biochemical composition and the variations were compared using Duncan's Multiple Range Test. In all cases statistical significance is indicated by $P<0.05$

Result

The diet pattern at various length group showed that there was a gradual shift in diet from smaller sized(<70 mm) to larger sized fish(>70 mm). Stomach is enlarged and U shaped with high consumption of food. The main food of the smaller specimens consisted of different species of unicellular algae and detritus. The components of detritus were mud, sand, minute broken shells of molluscs and other inorganic matter. Fish scales, diatoms, copepods and fish eggs were also found. The percentage occurrence of algae (58.2–88.1%) and detritus (12.3–32.4%) were higher than diatoms (7.2–19.3%), copepods (0.8–28.3%), fish scales (1.2–9.1%) and fish eggs (0.7–5.3%) were also observed (Figure 1a).

Larger sized fish have the most diversified food items in their diet. Multicellular algae were the predominant food of the adult fish (>70 mm) throughout the period of observation. Algae (48.4–86.3%), detritus (12.4–46.9%), diatoms (8.9–28.3%), fish scales (2.8–15.9%), crustaceans (1.2–13.6%), fish eggs (0.2–11.3%), bivalves (1.1–8.2), copepods (0.7–16.3%), rotifers (0.4–5.2%) sea anemones (0.2–

4.9%), sponges (0.4–3.1%) and polychaetes (0.2–2.9%) were found in the gut contents (Figure 1b). Maximum occurrence of algae in the stomach contents were found during post monsoon months. There were two occurrences of crustaceans throughout the year, first during February and March and the second during September and November. Among crustacean larva zoea was common and found in maximum during January–March and September–October. Prawn larvae were present in dominance during March–May. Fish eggs were also found in maximum occurrence in November and December.

It was observed that the diet of scats depended largely on the availability of the food. A special preference was observed for filamentous algae in the case of larger fish otherwise the study clearly shows that the scats take in food which they happened to encounter. The fish were sometimes seen to have swallowed whole organisms depending on the size of the prey. Small prawns, copepods, sponges were eaten as whole organisms. Undigested chitinous remains and molluscan shells were observed. Lengthy filamentous algae have been nibbled or browsed by larger fish. Detritus, fish scales, bivalves, anemones and fish egg have been swallowed. Since detritus was also observed scats are bottom feeders.

The feeding intensity of scats did not follow a regular pattern. During the months of January–April majority of the fishes had actively fed. May showed decreased feeding. July–August active feeding was observed, followed by decrease in feeding during September. October–December again the number of actively fed was more (Figure 1).

The values of relative gut indices ranged from 2.14 to 3.96 for fish >70 mm. The average RGI was 3.1. There existed a significant correlation between gut length and total body length ($r = 0.7427$, $p<0.05$) (Figure 2).The values of relative condition factor (Kn), (LeCren, 1951) ranged from 0.91 to 1.3 (Figure 3).

Muscle Biochemical Composition

The profile of proximate composition of *S. argus* muscle was assessed from January 2007–December 2007. The moisture content, protein, fat and ash content were evaluated. Moisture content in the fish ranged from 72.89–76.03%. One way analysis of variation showed significant variation ($P<0.05$) (Figure 4a). The protein content showed a minimum of 15.13% during November while a maximum of 17.47% was recorded during August. Significant

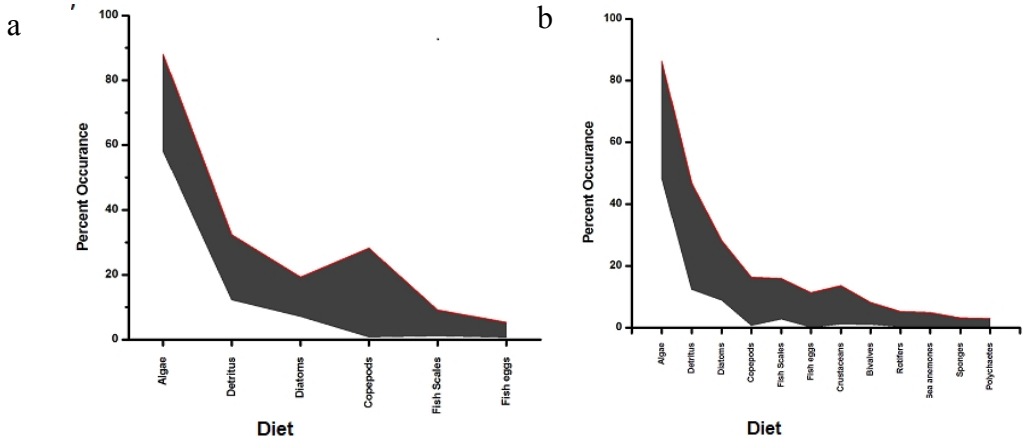

Figure 1. a and b shows thedifferent diet pattern in fish between the length group of <70 mm and >70 mm respectively.

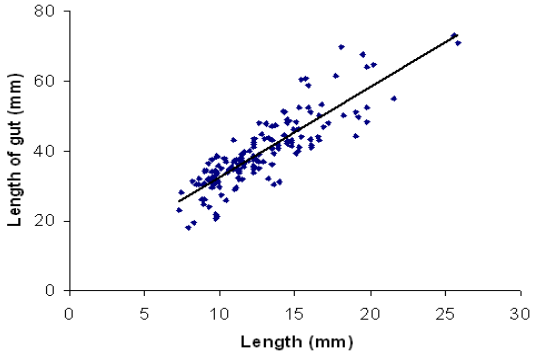

Figure 2. Changes in gut length with total length. r^2 is =0.7427.

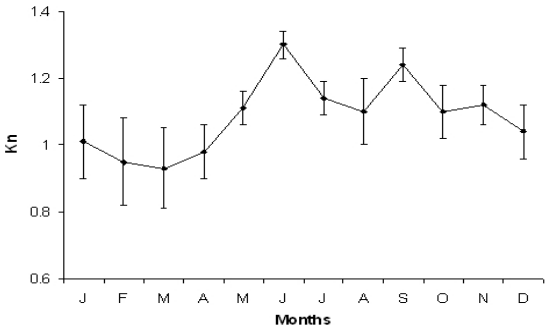

Figure 3. Monthly variations in relative condition factor of *S.argus*. Data are represented as mean ±SD.

monthly variation was observed (P<0.05) (Figure 4b). The fat content evaluated showed significant variation (Figure 4c) ranging from 5.16 to 7.92%. One way ANOVA showed significant variation (P<0.05). The ash content ranged from 2.15 to 2.86%. One way ANOVA did not show any significant variation in ash content with season (Figure 4d).

Discussion

Knowledge on the food and feeding habits is essential to have knowledge on growth, distribution and general ecology of the fish. Changes in the food spectrum during different seasons help us to study the migratory patterns of the fish.

Studies on the *S. argus* from different places in the estuaries of Bengal by Mookerji *et al.* (1949) reported the presence of unicellular algae, higher plants, protozoa, sponges, crustaceans, fish scales, sand and mud in the gut. Datta *et al*. (1984) studied the food of scats inhabiting both fresh and brackish water ponds and reported that the food comprised of aquatic macrophytes, phytoplankons, zooplanktons and macrobenthos. Gandhi (2002) studied the food and feeding of scats from the marine environment in and around Mandapam and reported that in addition to those observed by Mookerji *et al*. (1949) coral polyps, bivalves, *Lepas*, prawns, sea anemones and alphaeids were present. The present findings were also in agreement with their findings. The food items included algae, diatoms, sponges, crustaceans, fish scales, fish eggs, sea anemones, rotifers, polycheates, copepods, bivalves and detritus. The present study clearly indicated that the spotted scat feeding was related to diet availability. It was found that detritus in the gut contents of scats were always associated with algae leading us to conclude that the scats preferred algae and the fish actually consume detritus while feeding on algae attached with detritus. In estuaries, detritivory: herbivory ratios are often high compared to other waters (Lin *et al*., 2001), with the high efficiency of fish yields leading to the assumption that most estuarine fishes are detritivores, including the spotted scat in Taiwan (Lin *et al*., 2007).

Monkolprasit (1994) studied the composition and food habits of fish collected from the mangrove forests of Phanang and Ban Don Bay of Thailand. He indicated that *S. argus* feeds on diatoms, nematodes, rotifers, polycheates, insects and protozoa. During the present study also diatoms, rotifers and polychaetes were observed. It was also observed that adult fed on detritus, unicellular algae, copepods and protozoa which were consistent with the findings of Mookerji *et al*. (1949) and Gandhi (2002).Adult fish preferred multicellular algae, diatoms and detritus. Spotted scats showed reasonable flexibility in their feeding ecology. The feeding selectivity was based on the availability of the food items. Maximum occurrence of algae in the stomach contents were found during post monsoon months. Prawn larvae were present in dominance during March–May. Fish eggs were also found in maximum occurrence in November and December.

The presence of different species of multicellular filamentous algae in the gut contents during the course of this study indicated that the scats nibbled/ browsed and swallowed them. Attached organisms such as sea anemones, sponges and bivalves were

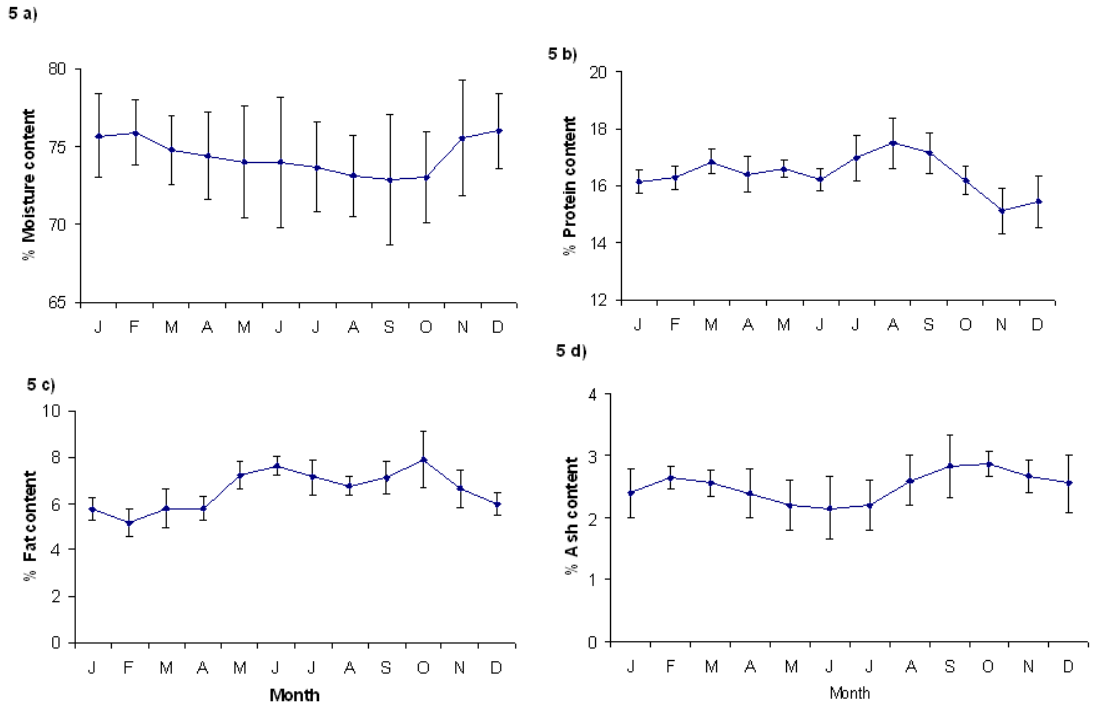

Figure 4. Changes in muscle biochemical composition of *S. Argus* in different months. A) Moisture b) Protein c) Fat d) Ash. Data are represented as mean ±SD

scrapped by the fish and swallowed. The presence of detritus and fish scales showed that the scats are bottom feeders. Planktons present in the gut content of young fish indicated that the scats are pelagic feeders at their juvenile stage. The development of rows of small rasp like teeth and elongated intestines are well suited for scrapping and shredding and digestion of plant materials. Both animal and plant food items were recorded in the gut content, though a preference for algae could be observed indicating that the fish is omnivorous. The omnivorous nature of the fish has been revealed by Mookerji *et al*. (1949), Datta *et al*. (1984), Gandhi (2002) and Phuong *et al*. (2004). The present study also confirms scats to be omnivorous. However Barry and Fast (1988) have reported that adult spotted scats are primarily herbivorous in nature.

The diverse food items with feeding preference supported that spotted scats showed a likely ontogenic niche shift. The smaller fish predominantly consume unicellular algae present in the water column. The prey diversity consumed by fish broadens as the length increases. Larger fish feed on substrata taking the whole prey items including the multicellular algae, benthos and detritus. Although unicellular algae remained the dominant food of smaller fish, the larger fish shifted to multicellular algae. Percent detritus content increased from 12.3-32.4% in juvenile to 12.4-46.9% in adult group. Likewise diatoms were 7.2-19.3% in juveniles increasing to 8.9-28.3% in adults. The fish scale increased from 1.2-9.1% in juveniles to 2.8-15.9% in adults.

The feeding intensity monitored monthly showed active feeding during January–April. Peak feeding intensity was observed during June-August. The female fish that fed actively during this period had shed their eggs and after spawning the fish needed to feed actively for revitalizing and rematuring of ova to spawn (Barry and Fast, 1988) during October-November (data not shown). It was noted that during the final stages of maturity of egg the fish had fed poorly. Wongchinawit and Paphavasit (2009) reports that scats have the ability to take advantage of the most profitable food source at a particular time and select food items that maximize fitness and energy gain.

The values of relative gut indices ranged from 2.14 to 3.96 for fish >70 mm (adult). The average RGI was 3.1 which are normal for an omnivorous fish. Based upon the relative intestine lengths of 0.5-2.4 for carnivores, 2-21 for herbivores 0.8-5 for omnivores (Rust, 2002) this ratio for spotted scats suggest the omnivorous nature of the fish. The RGI which is within the observed average of 3.1 is well in conformity with the average of 2.88 (range 2.59–2.93) in detritus feeding scats found in Vietnam (Phuang *et al*., 2004) and 3.0 for herbivorous adult scat in the Philippines (Barry and Fast, 1998). The absence of appreciable differences in this index in juveniles and adult fish indicated that growth does not involve any major shift in the basically omnivorous habits of this fish. There existed a significant correlation between gut length and total body length ($r = 0.7427$, $P<0.05$).

The values of relative condition factor (Kn), reflects through its variations, information on the physiological state of the fish in relation to its welfare (LeCren, 1951) ranged in this study from 0.91 to 1.3. The Kn value depends on the physiological factors like maturity and spawning as well as food availability. The Kn values did not show marked variations except peaks in June and September corresponding to the periods of maturity and spawning. These peaks are not prominent probably due to the close breeding period and releasing of eggs in batches.

As fish exhibit a wide array of diversity in their shapes, modes of life, habitat etc it is to be expected that they will also show diversity in their composition. Variations in the monthly proximate composition of *S. argus* was observed. The moisture content was high during the winter season (November–February) and low during the summer (February–May) and spawning season. With the onset of spawning season fat content was found to be high. Fat content was low during the refractory period of the fish from December–April and high during spawning season. Ash content did not show much variation except for the spawning season when it was low. Protein content of the fish was high during the spawning season and the minimum values were recorded in the post spawning period. High fat and protein content during spawning season has been reported for other fishes (Bhuyan, 2003; Shamsan and Ansari, 2010).

In conclusion, in the present study though the scats show a preference for algae the omnivorous nature of *S. argus* is well documented. Studies on the proximate composition of the fish shows the potent nutrient value of *S. argus*. Monthly variations in the muscle biochemical composition were observed.

Even though there exists a huge demand for this fish, culture of spotted scats is largely in its primary stages. Virtually all scat for the food market and aquaria trades are captured from the wild. The scope for the culture of the spotted scat is promising field. The present study would definitely add some basic information on the food and feeding habits as well as the nutrient value of the fish opening new vistas for brackish water culture of the spotted scat.

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