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Nutritional Characteristics and Feeding of Rabbitfish (*Siganus guttatus*) in Tam Giang-Cau Hai Lagoon Systems

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Abstract: The research aimed to investigate for lagoon foodweb and dietary composition for rabbitfish in different stages (larvae, fingerlings and grower). Data were collected from two experiments using basic methods in field and laboratory. Experiments were structured on 2,000 larval head, 500 each tanks for nursery and 90 heads of three groups were collected in different seasons to laboratories for analysis of feeding intake and food compositions. Results showed that the number of omnivorous species, including animals, plants and organics, have been identified and grouped in 39 genera, 30 families, 23 sets, eight classes and six branches. Animal groups have been identified as 18 breeds, 18 families, 13 lines, three classes and three animal species of industry animal. Plant foodweb, mainly Bacillariophyta, have accounted for 27 genera and 67.5% of total expenditure vegetation eaten by the rabbitfish. For the animal feed industry joint foot, Arthropoda have the highest number of 15 varieties, accounting for 83.3% of the animal's nutritional ratio. Organic residues as food for species have the highest prevalence in digestive tract (94.4%). The dominant food groups were determined as 15 genera and five animal breeds, particularly those large groups of algae.

Key words: Rabbitfish, nutrition, foodweb, characteristics, lagoon.

1. Introduction

Tam Giang-Cau Hai lagoon systems, a largest lagoon in Asian region, has more than 200,000 ha water covering areas, and there is a biodiversity of aquatic species and one of economic and potential food species, as rabbitfish (*Siganus guttatus*). There were studies and researches have done on this species to produce larvae, but not successful for the stage of nursery periods, and larvae are all dead after 7 d [1-3]. So, farmers often collect the fingerlings from sea into lagoon through two inlets—Thuan An and Tu Hien, and numbers of the fingerlings are reducing in lagoon gradually [2-4]. For the problems for larvae death after 7 d of hatching by no food and starvation, Puvaneswari et al. [5] conducted a study to test problem of no food in digestion systems and thus dead. The questions were reminded which kinds and types of feedstuffs and foodweb that can be adapted for them in early growing stages. The hypothesis of the study can be pointed out and conducted to practice for microalgae or zooplankton supplied. In the discussion of hatchery the larval nauplii diets of *Brachionus*, *Artemia* and artificial food are also concentrated [6]. At larval stage, the fish grow very quickly within 24 h, the mouth of this species opens at 36 h after hatching, and learns to eat at 60 h after hatching [7, 8]. The larvae of *S. guttatus* starts to consume the yolk common and nutritious on day 2, and mortality happens very high in the 3rd and 4th day due to the lack of appropriate foods [9]. The diets required for larvae are less than 90 μm as size of *Brachionus*, 10-20 individuals/mL can be combined with other ingredients. The algae *Chlorella*, *Isochrysisla* and

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Tetraselmis are larval food source, but not used at the 4th day of *S. guttatus* larvae when exposes photophilic and flow properties as they reach full body length 2.6-2.7 mm, but photophobic properties disappear afterward at 9.2 mm size. Larvae size in the tank bottom runs stable in 19.6 mm size [9]. The eggs *of S. guttatus* hatched from the wild were often subjected to changes in salinity 24‰ and the lowest at 8‰. Tests for salinity tolerance on the different ages of *Discus* showed 0-day-old larvae resistant to low and high salinity concentration at 8‰ and 37‰, respectively, for a better larval age at day 14. From 21 to 35 old days, larvae can withstand sudden changes in salinity at 35‰ [4]. According to Ref. [9], there was not any significant difference observed in the survival rate of larvae reared at 20‰-32‰ salinity. The survival rate of larvae was enhanced at the temperature of around 22-26 °C.

There are more difficulties that the authors study the nutritional features and characteristics as a basis for producing artificial breeding discussion. The inherent natural food in the brackish lagoon with different salinity change creates diverse plankton and microalgae. The goals of study are to find suitable nutritional characteristics and feeding regime for different growth stages of rabbitfish, and identify the possibilities of using different types of food and foodweb. The alga *Chlorella*, *Isochrysis* and *Tetraselmis* are good sources of feedstuffs and foodweb to use for larvae on the starting four days period of feeding [4, 9]. The authors prefer to use zooplankton feed synthesis or *Isochrysis* or in combination with *Chlorella* and *Brachionus*. Crustacean nauplii larvae of copepod is suitable for the first stage of nutrition than *Brachionus*, but their biomass remains a problem which should be studied furthermore in the study and experiment practices.

2. Materials and Methods

2.1 Fish Samples

The fingerlings were collected from wildlife, started nursery at enclosed nets for 7 d for adapting period and designed into two experiments. Besides, these fish samples also were collected from wild condition for determination of the nutritional characteristics. All fish were cultured at Loc Binh and Hai Duong communes, Tam Giang-Cau Hai lagoon systems.

2.2 Experimental Design

2.2.1 Experiment 1

Collecting a total of 2,000 wildlife rabbitfish larvae with 1-2 cm length and allocated into the 16 composite tanks, then divided into four groups of 500 individuals per tank and observed the ability to catch food under the different food groups. Larvae were reared in composite tanks and maintained in the water temperature from 23 °C to 30 °C. Then they were allocated into four groups and larvae were fed Polychaeta for group 1, *Artemia* for group 2, Rotifers (*Brachionus plicatilis* and *Brachionus rotundiformis*) for group 3, and *Chlorella*, *Tetraselmis* and *Isochrysis* for group 4, respectively.

2.2.2 Experiment 2

Different sizes of rabbitfish are collected in the wild and then undergo surgery to remove the food from the gut to analysis of nutritional composition. There are three groups of fish were analyzed with feed ingredients in the gastrointestinal tract. The three groups were allocated as: group 1 with size of 4-12 cm (30 heads), group 2 with size of 12-20 cm (30 heads) and group 3 with size > 20 cm (30 heads), and they all were fed by commercial feedstuffs.

2.3 Methods

Fishes in every tank were fed after 1 h, and 24 individuals were randomly collected to test the ability to catch prey and not catch the food, then 3 h to continue catching 24 samples were randomly collected again for test in each nusery tank. Data were calculated according to the proportion of saturation and description of the ability that fish can catch baits. The first of full “0” means without food in the

gastrointestinal tract, the second level of full "1" means food appeared in the food pipe, the third level of full "2" means in the gastrointestinal tract have some food, but still many blanks gas, the fourth level of full "3" means in tube full of food digestion medium (no space to accommodate gas), but not tense, and the last level of full "4" means in tube filled with food digestion and swollen than normal.

Samples were surgical and laboratory analysis was done at the Center and Institute of Biotechnology, Hue University. The nutritional characteristics and functional characteristics of gastrointestinal tract were tested, and the ratio of the intestinal length compared to body length was observed. Gut and body lengths of the fish are observed and meanwhile the shape and structure are described to determine the length. Through that, we can be aware of its feeding habitat in the wild. Based on the research results in fish bone on the relationship between gut length (Li) with length (L) to known the spectrum as well as the food eaten of the whole disk [3]. Fresh fish samples were collected and put into a plastic box containing 10% formalin for conservation up to labs, and sampling was in May and September. The composition and species of flora and fauna, which they ate and were contained in the digestive tract, were determined by comparing morphological method. Group of plant material used by the authors in report of Ref. [10]; and zooplankton, the group of animals and bottom materials were used as reported in Refs. [11, 12].

2.4 Analysis and Determination

Identify the frequency of one type of food and record the number of times encountered such feed in the first paragraph and the gastrointestinal tract associated with the observed morphological anatomy of the digestive tube of *Discus* [13, 14]. Determination of full eating is based on the amount of food contained in the stomach and intestines of the fish ladder five steps, and the indexs are observed and evaluated by eye and microphoto. All of the samples were analyzed immediately or dying fish to avoid mistakes with 5-tier scales from 0 to 4. The first of full "0" means without food in the gastrointestinal tract, the second level of full "1" means food appeared in the food pipe, the third level of full "2" means in the gastrointestinal tract have some food, but still many blanks gas, the fourth level of full "3" means in tube full of food digestion medium (no space to accommodate gas), but not tense, and the last level of full "4" means in tube filled with food digestion and swollen than normal.

3. Results

3.1 The Ability to Catch Prey and not Catch the Baits

Table 1 showed that rabbitfish can get foods from feeding systems from nursering day 1, 2, 4 and 7. The results showed all group have no feed intake at day 1, and increase at day 2, day 4 and up to day 7 with 37.5%, 87.5% and 100% for group 1, and at day 7 eat at grade 1 of 33.3%, grade 2 of 25.0%, grade 3 of 25.0% and grade 4 of 16.7%, respectively. While for group 2, they have feed intake with 0, 54.2%, 91.7% and 100% at day 1, 2, 4, 7, respectively, and at day 7 they have different eating full grades, at grade 1 of 8.3%, grade 2 of 37.5%, grade 3 of 29.2% and grade 4 of 25%. For group 3 at day 1, 2, 4, 7, they have feed intake with 0, 66.7%, 95.8% and 100%, and at day 7 have different eating full grades with 4.2% for grade 1, 41.7% for grade 2, 29.2% for grade 3 and 25% for grade 4. For group 4 at day 1, 2, 4, 7, the number of having feed intake is 8.3%, 87.5%, 100% and 100% grades, respectively, and the number of at different eating grades levels at day 7 is 4.2%, 41.7%, 29.2% and 25%, respectively.

3.2 Nutritional Ecosystems

The rate of bowel length and body length is an important indicator to determine the spectrum of an object feed in any fish bone that biologists and aquaculturists expected. The ratio of intestine length and body length is shown in Table 2, and it shows that the percentage of intestinal length compared to body

Table 1 The eating full of larvae under four grades at nursering days.

Group	Days	Eating grades at different levels										Total	
		0		1		2		3		4			
		n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
I	1	24	100.0	-	-	-	-	-	-	-	-	-	0.0
	2	15	62.5	3	12.5	3	12.5	2	8.3	1	4.2	9	37.5
	4	3	12.5	8	33.3	6	25.0	4	16.7	3	12.5	21	87.5
	7	0	0.0	8	33.3	6	25.0	6	25.0	4	16.7	24	100.0
Total		42		19		15		12		8			
II	1	24	100.0	-	-	-	-	-	-	-	-	-	0.0
	2	11	45.8	6	25.0	4	16.7	2	8.3	1	4.2	13	54.2
	4	2	8.3	5	20.8	5	20.8	7	29.2	5	20.8	22	91.7
	7	0	0.0	2	8.3	9	37.5	7	29.2	6	25.0	24	100.0
Total		35		13		18		14		12			
III	1	24	100.0	-	-	-	-	-	-	-	-	-	0.0
	2	8	33.3	6	25.0	6	25.0	2	8.3	2	8.3	16	66.7
	4	1	4.2	8	33.3	7	29.2	4	16.7	4	16.7	23	95.8
	7	0		1	4.2	10	41.7	7	29.2	6	25.0	24	100.0
Total		35		15		23		13		12			
IV	1	22	91.7	2	8.3	-	-	-	-	-	-	2	8.3
	2	3	12.5	7	29.2	8	33.3	3	12.5	3	12.5	21	87.5
	4	0	0.0	6	25.0	10	41.7	5	20.8	3	12.5	24	100.0
	7	0	0.0	1	4.2	10	41.7	7	29.2	6	25.0	24	100.0
Total		25		16		28		15		12			

Table 2 Percentage of intestinal length compared to body length.

Groups	1	2	3
	Mean ± SD	Mean ± SD	Mean ± SD
Body length (L) (cm)	9.2 ± 1.7	16.1 ± 1.7	22.6 ± 1.4
Intestine length (Li) (cm)	20.5 ± 4.3	42.5 ± 9.4	56.4 ± 3.1
Rate (Li/L)	2.2	2.6	2.5

length varies according to individual group from 2.2 to 2.6. In different fish size groups, the rates that individuals catch sizes of feed are different, the smaller sizes, they can get more diversity ingredients than greater groups; this indicates that the individual groups have different sizes with different food spectrum.

Table 3 confirms once again the characteristics of *Discus* food, including surface layer (zooplankton) and bottom benthics. However, the number of bottom animals breed is only four varieties which account for 22.2% of spending zoobenthos, the rest are 14 varieties of zooplankton which accounting for 77.8% of spending zoobenthos. Of the three identified animal, branch leg joints (Arthropoda) have spent the most amounts, with 15 genera, accounting for 83.3% of total expenditure natural resources for *Discus*. Meanwhile, there is only 11.1% and 5.6% of total zoobenthics and zooplankton for this species on the lagoon systems. It was found that organics are divided between three ecoregions of the lagoon (Tam Giang, Thuy Tu and Cau Hai) [15] (Table 4). And there is also plant genus expressed with a high frequency in all three regions, i.e., *Achnanthes* and *Nitzschia*. Meanwhile, there is the genus which dominates only in one ecoregion, for example, *Amphora*, *Licmophora* and *Polysiphonia* in the Tam Giang; *Merismopedia* in Thuy Tu; *Chaetomorpha*, *Diatoma*, *Lyngbya*, *Oscillatoria*

Table 3 Composition of zooplankton and bottom fauna in the gastrointestinal tract.

Zooplankton	Distribution areas and allocations of Tam Giang-Cau Hai		
	Tam Giang	Thuy Tu	Cau Hai
Arthropoda			
Crustacea			
Copepoda			
Calanoida			
Cartiidae family			
Acartia branch	x	x	x
Calanoida			
Calanidae family			
Canthocalanus branch			x
Centropagidae			
Centropages branch	x	x	x
Harpacticoida			
Clytemnestridae family			
Clytemnestra branch	x		
Cyclopoida			
Corycaeidae family			
Corycaeus branch	x	x	x
Ostracacoda			
Cypridinidae family			
Cypridina branch	x		x
Harpacticoida			
Tachidiidae family			
Euterpina genus			
Ectinosomidae family			
Microsetella branch	x	x	x
Cyclopida			
Oithonidae family			
Oithona branch		x	x
Oncaeidae family			
Oncaea branch	x		x
Calanoida			
Pontellidae family			
Pontellina branch			x
Psediodiaptomus family			
Chi *Pseudodiaptomus*		x	x
Branchiopoda			
Ostracoda			
Halocypridae			
Conchoecia branch		x	x
Cladocera			
Polyhemidae			
Evadne branch	x		
Zoobenthos			
Amphipoda			
Corophiidae family			
Corophium branch	x	x	x

(Table 3 continued)

Zooplankton	Distribution areas and allocations of Tam Giang-Cau Hai		
	Tam Giang	Thuy Tu	Cau Hai
Annelida			
Polychaeta			
Nepthydida			
Nephthydidae grube family			
Nephthys branch	x	x	x
Nereidae Johnston family			
Ceratonereis branch			x
Mollusca			
Bivalvia			
Corbiculida			
Corbiculidae family			
Corbicula branch	x		
Total of branches	11	9	14

X means presented in the Tam Giang-Cau Hai lagoon as food for *Siganus guattatus*.

Table 4 Composition of plants and organics in the gastrointestinal tract.

Classification system	Length and sizes (cm)		
	4-12	13-20	> 20
Cyanophyta			
Chrooccocus branch	x	x	
Merismopedia branch		x	x
Pseudanabaena branch			x
Spirulina branch			x
Oscillatoriaceae family			
Oscillatoria branch	x	x	x
Lyngbya branch			x
Silic-Bacillariophyta			
Melosira branch	x	x	x
Biddulphia branch			x
Chaetoceros branch			x
Diatoma branch	x		x
Synedra branch			x
Rhaphoneis branch			x
Licmophora branch	x	x	x
Grammatophora branch	x	x	x
Ardissonea branch			x
Petroneis branch			x
Cocconeis branch	x	x	x
Achnanthes branch	x	x	x
Pinnularia branch		x	
Diploneis branch	x	x	x
Navicula branch		x	x
Climaconeis branch			x
Pleurosigma branch	x	x	x
Gyrosigma branch	x		x
Amphora branch	x	x	x

(Table 4 continued)

Classification system	Length and sizes (cm)		
	4-12	13-20	> 20
Pseudonitzschia branch			x
Nitzschia branch	x	x	x
Cylindrotheca branch		x	
Tryblionella branch	x	x	x
Rhopalodia branch	x	x	x
Campylodiscus branch			x
Surirella branch			x
Psammodictyon branch	x		
Dinophyta			
Prorocentrum branch	x		x
Chlorophyta			
Enteromorpha branch		x	x
Cladophorales			
Cladophoraceae family			
Chaetomorpha branch		x	x
Gracilaria branch	x	x	
Ceramiales			
Rhodomelaceae family			
Chi *Polysiphonia* branch	x	x	x
Higher plants			
Organics	x	x	x
Total of branches	19	21	34

Table 5 Occurrence frequency of some dominant plant.

Plant branches (seaweed)	Thuan An	Thuy Tu	Cau Hai	Total	%
Achnanthes	60	47	52	159	58.9
Amphora	51	14	42	107	39.6
Chaetomorpha		6	51	57	21.1
Cocconeis	60	69	21	150	55.6
Diatoma	27		52	79	29.3
Gammatophora	46	56	35	137	50.7
Gracilaria	50	64		114	42.2
Licmophora	61	29	27	117	43.3
Lyngbya			45	45	16.7
Merismopedia		67	34	101	37.4
Nitzschia	60	72	63	195	72.2
Oscillatoria	21	24	52	97	35.9
Pleurosigma	12	27	57	96	35.6
Polysiphonia	61	11	39	111	41.1
Organics	82	86	87	255	94.4

and *Pleurosigma* in Cau Hai. The identification that the genus of zooplanton and phytoplanton are popular food items is significant for *Discus* on production practices. On that basis, we can choose the type of natural plant feedstuffs suitable for the production the fingerlings and open the prospect of the future to actively feed biomass to make food for *Discus*. Also, we could choose the ecoregions which have the distribution of this species to the fish, especially local feed resources from plants and seaweed.

3.3 Organic Residues in the Gastrointestinal Tract

Table 5 shows that the organic humus is foods with the highest frequency of appearance in the *Discus* gastrointestinal tract (94.4%). Also *Discus* also uses a variety of macroalgae (seaweed), as *Gracilaria* (42.2%), *Polysiphonia* (41.1%), weed membrane, seaweed fiber, seaweed and algae. Feed intake contained in the digestive tract of fish was the highest *Nitzschia* (72.2%), followed by *Achnanthes* (58.9%) and *Cocconeis* (55.6%).

4. Discussions

Feeding system and feed intake for larval individuals of rabbitfish at conditional composite tanks showed that for the earlier stage of larvae, they can not eat anything from artificial conditional feeding and had no intake at day 1 to day 7; this was also adapted with report from Ref. [16], while in this study, the authors had got larvae from artificial reproduction of center and started feeding at day 1 up to day 7. At day 1, due to change from natural habitat to a composite tank condition and artificial feeding by water in tanks, the eating behaviours of the larvae appeared around the pool and explored the bottom. At day 2, the fish began to catch prey and the zooplankton is seen as their hobby, and larvae in group 4 can catch more food compared to other groups. Thus, the proportion ranged from group 1 to group 3, showing the larvae are omnivores (animals, plants and organics). Analytical results show that plant foods and organic humus in the gastrointestinal tract are 270 samples and have been identified with 39 genera, 30 families, 23 sets, eight classes and six Dinophyta and organics in Table 4. Results obtained from Tables 3 and 4 show that dietary components in the gastrointestinal tract are very diverse plant and animal species, as reported by Refs. [17, 18] that the young and adults in the wild eat any algae that they can catch and digest. Analytical results from Table 5 also show the different levels and numbers of ingredients between three ecoregions (Tam Giang, Thuy Tu and Cau Hai). Among the 39 genera (72.2%) identified, there is only 15 genera (27.8%) have their frequency quite common, and the residual limb with a very low frequency of appearance and there were more common plant species (Table 4). The detailedly identified methods of plants in life cycle are quite diversified for different forms and living layers. Thereby, they are found that the fish likely eat the genus at both surface and bottom. Of the six species of algae identified, Bacillariophyta of *Diatoms* branches appeared in almost ecoregions, with 27 genera and accounting for 67.5% of total expenditure vegetation eaten by rabbitfish. The mostly ecological environment is saltwater and brackish, *Diatoms* have abundant life and they are distributed from the surface layer as live plankton, middle layer (epiphytic species of seaweed) and the mud floor (organics). Due to characteristics of *Diatoms*, they are commonly encountered in the gastrointestinal tract [19]. In particular, *Diatoms* dominate 20 genera regarding the volume of vegetation predominated, and there are also a few animals vertebrate. However, in this case the analytical results show plant foods and organics in the gastrointestinal tract of rabbitfish occupied 270, which has been identified with 18 genera, 18 families, 13 orders, three classes and three sectors as shown in Table 4.

5. Conclusions

Omnivorous species, including animals, plants and organics, have been identified with 39 genera, 30 families, 23 sets, eight classes and six branches; animal groups have been identified with 18 breeds, 18 families, 13 lines, three classes and three species. Plant foodweb (Bacillariophyta) have occupied the most of 27 genera (67.5%) of total expenditure vegetation for rabbitfish and animal as joint foot (Arthropoda) have a highest number with 15 varieties (83.3%) of the animal species and feed. Humus is mainly organic residues with a highest prevalence of digestive tract of rabbitfish (94.4%). In the analysis,

there are 15 genera and five species, which are the dominant food groups as natural plants, particularly those large groups of algae. Rabbitfish of group size < 20 cm of body length can catch baits better than other groups, and most of fish can eat with grade "3" and "4" as mentioned in early parts.

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