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Prey Selection by African Catfish *Clarias gariepinus* (Burchell, 1822) Larvae Fed Different Feeding Regimes

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Abstract: Live prey selection by African catfish, *Clarias gariepinus*, larvae was examined under laboratory conditions. Larvae were offered plankton, plankton + trout starter (TS) and plankton + betaine supplemented trout diet (BTS) for 7 days after exogenous feeding. Five larvae were sampled to determine their gut contents and selectivity index for each treatment 15 min after the feeding. It was observed that dry diets (TS and BTS) improved the growth ($P < 0.05$), but did not significantly influence the prey selection of the larvae. It was determined that African catfish larvae preferred *Copepods* and *Rotaria* sp. to other zooplankton species for all feeding regimes.

Key Words: *Clarias gariepinus*, prey, selectivity, rotifer, copepod, betaine.

Farklı Yemleme Rejimleri ile Beslenen Karabalık *Clarias gariepinus* (Burchell, 1822) Larvalarında Canlı Yem Seçimi

Özet: Mevcut çalışmada karabalık, *Clarias gariepinus*, larvalarının canlı yem seçimi laboratuar koşullarında incelenmiştir. Dış beslenmeye geçen larvalara 7 gün boyunca plankton, plankton + alabalık başlangıç yemi ve plankton + betain ilaveli alabalık başlangıç yemi verildi. Yemlemeden 15 dakika sonra her muameleden 5 larva mide içeriklerini ve seçicilik indekslerini tespit etmek için örneklendi. Kuru yemlerin larvaların canlı yem seçimlerini etkilememesine rağmen, büyümelerini önemli derecede iyileştirdiği gözlendi ($P < 0,05$). Tüm yemleme rejimlerinde de karabalık larvalarının diğer zooplankton türlerinden çok Kopepod ve Rotaria türlerini tercih ettiği belirlenmiştir.

Anahtar Sözcükler: *Clarias gariepinus*, canlı yem, seçicilik, rotifer, kopepod, betain.

Introduction

The most important live food organisms used today are micro-algae, rotifers (*Brachionus plicatilis*) and the brine shrimp (*Artemia* spp.). In larvi-culture, the use of *artemia* nauplii has increased production costs. For this reason, attempts have continued to find new food sources alternative to *artemia* and good results have been reported for some cultured fish species. The genus *Moina* from the *Cladocerans* is known to be an appropriate live starter food for *Chanos chanos* and *Clarias macrocephalus* (Villegas, 1990). Dry diets are the other alternative food sources for larvi-culture. Although dry feeds have met the nutritional requirements of fish larvae and have been prepared in appropriate sizes with today's technology, the attractiveness and digestibility of these feeds for the larvae have not been improved completely (Kowen et al., 2001). Moreover, in the early larval stage, this low success of dry diets has been attributed to insufficient feed intake, digestion and absorption due to the absence of a functional digestive system. Verreth et al. (1992) indicated that a functional digestive system is complete in 5 days after the starting of exogenous feeding in *Clarias gariepinus* larvae.

Many factors are known to influence larval prey selection within the restrictions imposed by ontogenetic development (Ghan and Sprules, 1993). These include prey characteristics such as size, density and motion (Moore and Moore, 1976; O'Brien, 1979; Reiriz et al., 1998), and also larval characteristics such as sensory capabilities, prior experience, motor ability, mouth dimensions (mouth gape) and body size (Godin, 1978; Werner et al., 1981; Cox and Pankhurst, 2000). Most first-feeding fish larvae are dependent upon vision for prey detection (Blaxter, 1986), although non-visual senses have also been implicated in prey detection by selective planktivorous fish larvae (Batty and Hoyt, 1995; Salgado and Hoyt, 1996). Many studies concentrate on the relationship between prey size and mouth size as the primary determinant of prey selection (Shirota, 1978; Hyatt, 1979; Dabrowski and Bardega, 1984; Cunha and Planas, 1999). In addition, some water-soluble chemical compounds, i.e. L-amino acids and betaine, have influenced the food intake of the larvae as an attractant by stimulating non-visual senses (Atema, 1977). Therefore, the present study aimed to investigate the effects of dry diets with or without betaine on prey selection of *Clarias gariepinus* larvae and the alternative live food organisms could be substituted for artemia for the first feeding period.

Materials and Methods

The current study was carried out at the aquarium unit of the Fisheries and Aquaculture Faculty of Mustafa Kemal University, Hatay, Turkey. Larvae of *Clarias gariepinus* were obtained through artificial reproduction (Hogendoorn and Vismans, 1980). On the final day of yolk absorption, 150 larvae were bulk weighed and stocked in three 30-l aquaria randomly. Three different feeding regimes, i.e. plankton (live food), plankton + trout starter (350-500 µm) and plankton + betaine supplemented trout starter respectively, were implemented to feed the larvae for 7 days.

Betaine supplemented diet was prepared by spraying 3 g of betaine in 50 ml of distilled water on 100 g of trout starter diet. Plankton was collected from a hypereutrophic reservoir daily and offered to the larvae the same day. Each diet was provided twice (9:00 and 18:00) a day and 5 larvae were removed from each aquarium 15 min after the morning meals. Furthermore, water samples (200 cc) were taken from the reservoir to determine the zooplankton compositions daily. Larvae and water samples were fixed in 4% neutral formalin solution and their zooplankton counts were determined using an inverted microscope.

The selectivity index (E_i) of larvae for each prey was calculated according to the formula (Ivlev, 1961): $E_i = (R_i - P_i) / (R_i + P_i)$, where Ri is the mean percentage of species i in the diet and P_i is the mean percentage of species i in the reservoir over 7 days. Ivlev's selectivity index assumes values between -1.0 and +1.0, negative values indicating avoidance of a certain prey item and positive values indicating selective preference for a prey item. Values around zero is related with prey that are present in reservoir water but ingested non-selectively.

Weight and length comparisons of the larvae were carried out by one-way analysis of variance (ANOVA) and the differences between treatments were detected by Duncan's multiple range tests. Differences were considered significant at $P < 0.05$ and SPSS was used for the statistical analysis (SPSS, 10.01).

Results

Larvae fed plankton + trout starter and betaine supplemented trout starter attained higher growth and survival when compared to larvae fed only plankton ($P < 0.05$) (Table 1). Although *copepod* nauplii had the highest percentage in gut contents for all feeding regimes, only larvae fed with plankton preferred this species positively. The selectivity index (E_i) of *Megacyclops viridis* increased with the use of both dry diets (TS and BTS). Some species (*Leydigia acanthocercoides, Anuraeopsis fissa, Euchlanis dilatata, Lecane lunaris, Polyarthra dolichoptera, Brachionus budapestinensis, B. quadridentatus*, and *Scaridium longicaudum*) were detected in the aquaria medium (Table 2), but they were not found in the gut contents of the larvae for all feeding regimes (E_i = -1).

While the rotifer *Hexarthra fennica* had the higher percentages followed by the copepod nauplii, it was selected negatively by the larvae for all feeding regimes. Although *Rotaria* sp. was selected positively by the larvae for only the plankton and trout starter feeding regime, it was preferred by larvae fed the betaine supplemented diet negatively (Tables 3-5).

Table 1. Mean total length, weight and survival rates of the larvae for the different feeding regimes at the end of the experiment.

Feeding regime	Length (mm)	Weight (mg)	Survival (%)
Initial	7.28±0.09	2.75±0.16	
Only plankton	8.77±0.19[a]	4.50±0.42[a]	31.20
Plankton+TS	14.70±0.59[b]	24.90±1.96[b]	66.40
Plankton+BTS	15.00±0.42[b]	23.40±1.68[b]	40.80

TS: trout starter, BTS: betaine supplemented trout starter, a and b refer to differences between treatments

Table 2. Mean zooplankton counts given to the aquaria medium during the experiment.

Species	Day							Length (µm)
	1.	2.	3.	4.	5.	6.	7.	
<u>Copepods</u>								
Megacyclops viridis	150	220	600	1.050	980	1.950	2.050	2000
Copepod nauplii	12.975	11.460	17.289	23.400	10.500	15.450	14.250	750
<u>Cladocers</u>								
Simocephalus vetulus	225		280	360			240	1500
Leydigia acanthocercoides			114	225	90	150		1500
Chydorus sphaericus	900	360	864	2.325	950	1.350	1.290	650
<u>Rotifers</u>								
Hexarthra fennica	2.100	2.050	2.064	2.625	980	3.600	1.650	270
Testudinella patina	675	650	714	1.500	135	900		150
Anuraeopsis fissa	1.725	2.550	75	525	445	375		100
Lepadella patella	375		264	225	125	175	150	200
Euchlanis dilatata			39					350
Lecane bulla		45	189	225	175	150	230	280
L. lunaris			150	225	55	150	210	250
L. clasterocerca	170	140		70	75			200
L. luna	650		39	440	95	78	80	200
Polyarthra dolichoptera	1.125		189	225		1.650		150
Brachionus angularis	75	75	114	450		525	145	200
B. budapestinensis	75			75				150
B. quadridentatus	75		75					300
Scaridium longicaudum				150				400
Dicranophorus epicharis	250		375	75		75	255	300
Asplanchna sieboldi				75	110			600
Eosphora najas	225		190	150	225	300	130	600
Trichocerca stylata	225		375	300	450	675		250
Rotaria sp.	2.000	740	600	375	390	675	650	325
Colurella sp.	600		225	75		75		90
Ostracod	480	440	714	525	540	750	780	675

Table 3. Mean proportions (%) of the zooplankton in the gut contents and average selectivity index (E_i) of *Clarias gariepinus* larvae fed only plankton for each prey.

Species	Day							E_i
	1	2	3	4	5	6	7	
Copepods								
Megacyclops viridis	6.38	4.17	4.16	1.09	2.94		10.53	-0.01
Copepod nauplii	59.57	25	82.5	84.62	85.29	89.20	68.42	0.04
Cladocers								
Simocephalus vetulus				2.19			2.11	-0.33
Leydigia acanthocercoides[b]								-1
Chydorus sphaericus	10.64		1.67	5.50	2.94	2.70	2.10	-0.28
Rotifers								
Hexarthra fennica	8.51	16.67	1.67	2.20			2.11	-0.51
Testudinella patina	2.13	4.16	0.83					-0.59
Anuraeopsis fissa[b]								-1
Lepadella patella[b]								-1
Euchlanis dilatata[b]								-1
Lecane bulla		4.17	2.5	2.21				-0.20
L. lunaris[b]								-1
L. clasterocerca	4.26	4.17						-0.15
L. luna[b]								-1
Polyarthra dolichoptera[b]								-1
Brachionus angularis		4.16					2.11	-0.44
B. budapestinensis[b]								-1
B. quadridentatus[b]								-1
Scaridium longicaudum[b]								-1
Dicranophorus epicharis			0.83				2.10	-0.60
Asplanchna sieboldi						2.70		-1
Eosphora najas							2.11	-0.74
Trichocerca stylata			1.67			2.70		-0.57
Rotaria sp.	8.51	33.33	3.33	1.09	5.88	2.70	4.21	0.24
Colurella sp.[b]								-1
Ostracod		4.17	0.84	1.10	2.95		4.20	-0.34
Total	100	100	100	100	100	100	100	

[b] Not found in the gut contents.

Table 4. Mean proportions (%) of the zooplankton in the gut contents and average selectivity index (E_i) of *Clarias gariepinus* larvae fed plankton and trout starter diet for each prey.

Species	Day							E_i
	1	2	3	4	5	6	7	
Copepods								
Megacyclops viridis		20		6.67	25.81	14.29	20.83	0.10
Copepod nauplii	20	45.67	56.76	43.33	51.62	52.38	12.50	-0.24
Cladocers								
Simocephalus vetulus							20.83	-0.40
Leydigia acanthocercoides[b]								-1
Chydorus sphaericus		12.33	16.22	26.67	3.23	4.76	8.33	0.13
Rotifers								
Hexarthra fennica	50	5.57		3.33	3.22		12.50	-0.33
Testudinella patina		4.10	2.70					-0.80
Anuraeopsis fissa[b]								-1
Lepadella patella							4.17	-0.66
Euchlanis dilatata[b]								-1
Lecane bulla				6.67	3.22		8.33	-0.17
L. lunaris[b]								-1
L. clasterocerca	5							-0.41
L. luna[b]						4.76	4.17	-0.25
Polyarthra dolichoptera[b]								-1
Brachionus angularis[b]								-1
B. budapestinensis[b]								-1
B. quadridentatus[b]								-1
Scaridium longicaudum								A
Dicranophorus epicharis[b]								-1
Asplanchna sieboldi[b]								-1
Eosphora najas			2.70			9.52		-0.32
Trichocerca stylata[b]								-1
Rotaria sp.	25	12.33	21.62	13.33	12.90	4.76	8.34	0.60
Colurella sp.[b]								-1
Ostracod						9.53		-0.82
Total	100	100	100	100	100	100	100	

[a] Not found in the sample of the reservoir, [b] Not found in the gut contents.

Table 5. Mean proportions (%) of the zooplankton in the gut contents and average selectivity index (E_i) of *Clarias gariepinus* larvae fed plankton and betaine supplemented trout starter for each prey

Species	Day							E_i
	1	2	3	4	5	6	7	
Copepods								
Megacyclops viridis	0.96	29.03	5.88	13.04	22.50	44.12	46	0.60
Copepod nauplii	40.38	58.06	74.51	39.13	66.25	29.41	32	-0.14
Cladocers								
Simocephalus vetulus			1.96					-0.68
Leydigia acanthocercoides[b]								-1
Chydorus sphaericus		3.23	5.88	17.39	2.50		4	-0.23
Rotifers								
Hexarthra fennica	47.12	3.23	3.92				2	-0.54
Testudinella patina[b]								-1
Anuraeopsis fissa[b]								-1
Lepadella patella					1.25	17.65	4	-0.19
Euchlanis dilatata[b]								-1
Lecane bulla				8.69	1.25		2	-0.29
L. lunaris[b]			1.96	4.37			2	-0.07
L. clasterocerca[b]								-1
L. luna	0.96			4.36			6	-0.40
Polyarthra dolichoptera[b]								-1
Brachionus angularis[b]								-1
B. budapestinensis[b]								-1
B. quadridentatus[b]								-1
Scaridium longicaudum[b]								-1
Dicranophorus epicharis	0.96			4.33			2	-0.17
Asplanchna sieboldi[b]								-1
Eosphora najas	0.96				3.75			-0.58
Trichocerca stylata	1.92							-0.73
Rotaria sp.	4.81	3.22	5.89	8.70		8.82		-0.08
Colurella sp.	0.96							-0.85
Ostracod	0.97	3.23			2.50			-0.62
Total	100	100	100	100	100	100	100	

[b] Not found in the gut contents.

Discussion

The use of the betaine supplemented dry diet did not change the prey selection by the larvae significantly due to their underdeveloped sensory organs at the first feeding. African catfish larvae could not intake the dry diets until the fifth day of the experiment effectively because they did not have a functional digestive system, and thus they mainly feed on zooplankton (Verreth et al., 1992). Although dry diets did not influence the live prey selection as expected, they improved the growth and survival compared to the larvae fed only plankton for the first 7 days feeding. This also indicated that *Clarias gariepinus* larvae could digest the micro-particulate diets 5 days after the exogenous feeding (Verreth et al., 1992). It was observed that betaine supplementation had no attractive role on feed intake and growth compared to the non-supplemented group for the first 7 days.

Most fish larvae of commercial importance usually have a mouth size smaller than 200 µm (Lubzens, 1987), and thus have a restricted spectrum of prey sizes. For example, 1-week-old common carp larvae failed to consume even the smaller *Cladocers* such as *Moina* and *Ceriodaphnia*, but consumed a high number of rotifers (Khadka and Rao, 1986). In contrast, African catfish larvae have a partially bigger mouth than most cyprinid larvae and ingested the bigger *Cladocers* such as *Chydorus sphaericus* at the first feeding. This trend is evident in the present work, where newly born larval *C. gariepinus* could also consume rotifers (size > 200 µm) easily, but larvae preferred the copepods and cladocers to the rotifers. In spite of the high swimming activity of the cladocers and copepods (Woynarowich and Horvath, 1980), their preference could be attributed to the high swimming activity and predation of the larvae as well. This situation might also result from lower percentages or absence of the rotifers in the medium compared to other zooplanktonic groups except *Rotaria* sp. Small rotifers such as *Testudinella patina* and *Colurella* sp. were detected in the medium, but they were neither preferred positively nor found in the gut contents of the larvae. This indicates that the bigger rotifers such as *Rotaria* sp. are preferentially selected by the larvae in spite of their partially low percentages in the medium for some feeding regimes. It was, however, observed that bigger rotifers like *Asplanchna sieboldi* and *Eosphora najas* were not found in the gut contents as expected due to their low density compared to others in the medium.

Although *Hexarthra fennica* was more plentiful than *Rotaria* sp. throughout the experiment, *Rotaria* sp. had a high percentage in the gut contents of the larvae showed that the body shape of live prey may be another factor influencing the live prey ingestion by the larvae. *Hexarthra fennica* has 6 arms with many skins attached to its body, while *Rotaria* sp. can minimise its body when danger occurs. This ability of *Rotaria* sp. has facilitated their ingestion by the larvae and resulted in a higher preference than *Hexarthra fennica*. It is, therefore, possible that the different movement and activity patterns observed between live prey species in this study may have had an effect on prey selection. Moreover, species-specific prey characteristics such as colour, availability to the predator and escape mechanisms are also known to affect prey selection by larval fishes (Houde and Schekter, 1980; Reiriz et al., 1998) and may have influenced the selectivity of the live prey. The sequential increase in prey size selection with age is common for many larval fish species (Meeren, 1991; Fernandez-Diaz et al., 1994; Dou et al., 2000; Shaw et al., 2003) developing concurrently with an increase in mouth gape, improved locomotor ability and increased sensory function (Hairston, 1982), with the result that larvae in the wild can initially feed on only a fraction of the available prey (Galbraith, 1967). It is difficult to conclude from the present study that live prey size of the African catfish larvae was affected by increased age.

In conclusion, trout starter with or without betaine did not influence the live prey selection by the larvae, but they improved the growth and survival compared to the larvae fed only plankton. Moreover, it was well documented that the shape or geometry of the live prey was an important factor as well as the size for their ingestion by the larvae. Finally, *Megacyclops viridis*, *Copepod nauplii* and *Rotaria* sp. could be recommended for feeding the African catfish larvae as the first live food organisms due to their high preference compared to others.

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