www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 16: 321-326 (2016) DOI: 10.4194/1303-2712-v16_2_12

RESEARCH PAPER

Development of a Feeding Program for Early Larval Stage of Goldfish (*Carassius auratus*)

Orhan Demir[1], Süleyman Sarigöz[2,*]

[1] Süleyman Demirel University The Faculty of Fisheries, Aquaculture Department, Isparta, Turkey.
[2] Mediterranean Fisheries Research Production and Training Institute, Kepez Unit, Döşemealtı, Antalya, Turkey.

* Corresponding Author: Tel.: +90246.211 8649; Fax: +90246.211 8697;
E-mail: orhandemir@sdu.edu.tr

Received 17 December 2015
Accepted 28 March 2016

Abstract

The aim of this study was to develop a feeding program for early larval stage of goldfish (*Carassius auratus*) with an initial weight of 0.97-1.13 mg and total length of 5.77 - 6.05 mm. The study was conducted with totally 2340 larvae during 15 days, and included 13 groups with three replications. Four different feeding times (T_{1-4}), three different dry (D_{1-3} "one commercial feed and two test") diets plus continuous live food were the treatments. Larval growth were checked on 8th day and at the end of the experiment. Dry diets were fed to larvae continuously (T_1) or after 3 (T_2), 5 (T_3) and 7 (T_4) days of rotifer feeding. Also, in the control group only rotifer (R) was fed for 15 days. Results were analyzed with the factorial analysis design (feeding times × diets) and compared using the Tukey multiple comparison test. A comparison of the control group R with subgroups were also made using the Dunnett's test. The present results indicate that various combinations of "live and dry foods" administered at different durations significantly effected growth and survival rates of goldfish larvae ($P<0.05$). Briefly, continuous feeding with all dry diets were not as successful as the others. As the duration of rotifer feeding as first food increased, larval growth and survival also increased even if still worse than the control (15 days rotifer). The best practice for early larval feeding of goldfish could be T_4D_{1-2-3} (7 days rotifer, 3 days rotifer + dry diet and 5 days dry diet) during the first 15 after hatching.

Keywords: Goldfish, early larval feeding, rotifer, dry diet.

Japon Balıklarının (*Carassius auratus*) Erken Larva Dönemi Besleme Programının Geliştirilmesi

Özet

Bu çalışmada, Japon balıklarının (*Carassius auratus*) erken larva dönemi besleme programının geliştirilmesi için canlı ağırlıkları 0,97-1,13 mg ve total boyu 5,77-6,05 mm olan 2340 adet besin kesesi çekilmiş larva kullanılmıştır. Larvalar farklı yemleme zamanı (T_{1-4}) ve farklı yemlerle (Y_{1-3}; biri ticari karma yem, diğer ikisi deneme yemi) on beş gün süresince beslenmiştir. Kontrol gurubu (KY) da dahil olmak üzere 13 farklı muamele 3 tekerrürlü olarak denenmiştir. Denemede 8. ve 15. günlerde periyodik ölçümler yapılmıştır. Veriler faktöriyel (T_{1-4} X Y_{1-3}) düzende analiz edilerek grup ortalamaları Tukey yöntemiyle, kontrol ve alt gruplar ise Dunnett testiyle karşılaştırılmıştır. Elde edilen yaşama ve büyüme oranları, farklı yemleme zamanı ile canlı ve kuru yem kombinasyonlarından önemli derecede etkilenmiştir. Kısaca, sürekli olarak kuru yemlerle besleme, rotifer ve kuru yem kombinasyonları kadar başarılı olmamıştır. Beslenmeye rotiferle başlanan gruplarda canlı yemle besleme süresi arttıkça, büyüme ve yaşama oranları da artmıştır. Buna göre 15 günlük toplam besleme sürecinde ilk 7 gün canlı yem (rotifer) sonra 3 gün süreyle canlı yem+kuru yem ve daha sonra 5 gün süreyle de tamamen kuru yemle beslenen grupların (T_4Y_{1-2-3}) daha başarılı olduğu görülmüştür. Böyle bir program Japon balığı erken larva dönemi besleme programı olarak önerilebilir.

Anahtar Kelimeler: Japon balığı, erken larva dönem, canlı yem, besleme programı.

Introduction

Aquariums can be both a living environment for maintaining beautiful fish and a place that reduces the impact of daily stress due to their visual beauty (Hekimoğlu, 2006; Savaş *et al*., 2006). While there were only 30 countries involved in this sector in 1976, the number increased to 146 in 2004 (Ploeg, 2007). While the number of exotic and cultured aquarium fish species was 410 and 40 in 1955 respectively, today thousands of species are available (Fossa, 2003). Turkey, like many other countries, has recently witnessed a drastic development of ornamental fish

culture (Alpbaz, 1993; Hekimoğlu, 1997; Tlusty, 2002; FAO, 2011).

With their ability to adapt to Mediterranean climate conditions, gold fish are the most widely cultured species both in the world and Turkey (Türkmen and Çelik, 2014; Gümüş *et al*., 2014). However, goldfish larval survival under culture conditions is low due to inappropriate feeding practices (Watson *et al*., 2004; Korkmaz, 2008). Although artemia (*Artemia nauplii*), daphnia (*Daphnia magna*) and tubifex (*Tubifex tubifex*) worms are used during goldfish larval rearing in Turkey (Gümüş *et al*., 2014), it has been reported that freshwater rotifer (*Brachionus calyciflorus)* is the most suitable live food for goldfish larvae because of their size, slow movement, capability of remaining suspended in the water and high reproduction capacity (Lim and Wong, 1997; Harzevili *et al*., 2003; Arimoro, 2006).

Present study was aimed to determine the optimal weaning time, live and dry feed requirements of early larvae of goldfish.

Materials and Methods

The experiment was conducted in aquarium section of the Kepez Unit of Mediterranean Fisheries Research Production and Training Institute, Antalya, Turkey in 2014. Post yolk sac larvae used in the study was produced from Oranda variety of goldfish (4 female and 6 male).

A total of 2340 larvae early larval stage of goldfish (initial weight of 0.97-1.13 mg and total length of 5.77 - 6.05 mm.) were used. Thirteen experimental treatments including the control were triplicated and tried in 39 10 L glass tanks connected in a recirculation system. Each tank was stocked with 60 larvae (6 larvae/L). Each aquarium was given 100 mL/min water flow and provided with aeration using air stones. Water renewal rate and frequency of the recirculation system was 30% and twice a week. Water temperature was kept at an optimum of 27.0°C acceding to Kestemont (1995) using a thermostat, and changed between 26.0 and 27.4°C over the experiment. Photoperiod was set on 12 hours darkness and 12 hours lightness with a timer.

Feeding schedules, diet compositions and formulation are shown in Table 1-3. In the experiment, 4 feeding times "T_{1-4}" and 3 different diets "D_{1-3}" (4×3=12) were used. Feeds were offered at 07:30, 10:00, 12:30, 15:30 and 17:30. Rotifers were given at a rate of at least 10 ind./mL whereas dry diets were given *ad libitum*.

Experimental dry diets (D2 and D3) were formulated according to Castell and Tiews (1980). Freshwater rotifer used in the present study was produced in a 12 ton pond (3×4×1) within a greenhouse.

Length specific growth rate (SGR_L, % / day) = [(lnLt- lnLt0)/ day] × 100

Weight specific growth rate (SGR_W, % / day) = [(lnWt- lnWt0)/ day] × 100

Survival rate = (Nt/Nt0) × 100

Condition factor (CF) = (W / L^3) × 100

Where Lt is larvae length at day t, L_{t0} is length at day 0, W_t is the weight at day t, W_{t0} weight of larvae at day 0, N_t and N_{t0} are the number of larvae at day t and 0.

Variation coefficient (VC) of individual larval lengths at 8th day and at the end of the experiment was also calculated using the formula below to determine the effects of the feeding treatments on size homogeneity of goldfish larvae.

VC (%) = (Standard deviation / arithmetic mean) × 100

Twenty larvae were used in periodical measurements. They were weighed using a balance with a precision of 0.0001 g. Lengths of larvae was determined with a software (ImageJ 1.44p, National Institutes of Health, Bethesda, MD) after photographing. Temperature and dissolved oxygen of water were measured with a portable device (YSI 55 12 FT, Yellow Springs Instrument CO., Inc., Yellow Spring, Ohio) whereas pH, salinity and conductivity were recoded using a pH meter (YSI 63-10 FT, Yellow Springs Instrument CO., Inc., Yellow Spring, Ohio). The parameters were checked three times a week.

Statistical analysis of data was performed with JMP v8 software. Effects of treatments on variables were analyzed by a factorial design (4 feeding times and 3 different diets), and the treatments were discriminated with the Tukey multiple comparison test. On the other hand, comparison of the control with other diets was made with the Dunnett's test (Özdamar, 2001; Yıldız *et al*; 2011).

Results

There were no significant differences among the treatments in terms of initial total length and body weights (P>0.05), (Table 4).

Although length and SGR_L on day 8 were comparable among the diets (P>0.05), these variables were significantly altered by various feeding times (P<0.01). In feeding regimen of T_1, length and SGR_L of larvae on day 8 fed dry diets were significantly lower than the control (P<0.05). At the end of the experiment, there was no significant interaction between feeding times and diet types in terms of larvae length, but feeding times (P<0.01) and diets (P<0.05) significantly affected the size of fish (Table 4). Accordingly, SGR_L values of the treatments displayed a similar pattern, with significant effects of feeding times (P<0.01), i.e. T_2 and T_3 were similar to each other, but significantly higher than T_1 and significantly lower than T_4. All the experimental groups, except T_4D_1, significantly differed from the control in terms of SGR_L.

Final weights of larvae were significantly

Table 1. Larval feeding program used in the experiment*

Experimental groups		Feeding times "T" (days)		Diets'D'
1	T_1D_1			D_1
2	T_1D_2	T_1	15	D_2
3	T_1D_3			D_3
4	T_2D_1			3R+(3R+ D_1)+9 D_1
5	T_2D_2	T_2	3+3+9	3R+(3R+D_2)+9 D_2
6	T_2D_3			3R+(3R+D_3)+9 D_3
7	T_3D_1			5R+(3R+ D_1)+7 D_1
8	T_3D_2	T_3	5 +3 +7	5R+(3R+ D_2)+7 D_2
9	T_3D_3			5R+(3R+D_3)+7 D_3
10	T_4D_1			7R+(3R+ D_1)+5 D_1
11	T_4D_2	T_4	7 + 3 +5	7R+(3R+ D_2)+5 D_2
12	T_4D_3			7R+(3R+ D_3)+5 D_3
13	C		15	15R

*Different feeding times (T_{1-4}), dry diets (D_{1-3}), a commercial rainbow trout diet (D_1), casein based dry diet (D_2), egg protein based dry diet (D_3), live food "rotifer" (R) as the control group (C).The figures before the diets in the latest column refer to the number of days that a particular diet was offered.

Table 2. Proximate compositions of experimental diets (%)

Experiment diets	Moisture	Dry matter	Crude ash	Crude oil	Crude protein
Commercial diet (D_1)	6,07	93,93	11,91	11,28	60,84
Casein based diet (D_2)	13,18	86,82	3,86	10,81	59,85
Egg protein based diet (D_3)	10,65	89,35	4,26	9,39	59,55
Live food (R)	92,21	7,79	10,11	10,03	65,83

Table 3. Formulation of experimental diets (D_2 and D_3) used in the study

Ingredients	D_2 (%)	D_3 (%)
Casein	45	33
Gelatin	6,7	7
Salmon oil	10,5	10,2
Dextrin	16,5	16,5
Egg protein	9,8	21,8
Vitamin C	0,5	0,5
Vitamin premix[1]	2	2
Mineral premix[2]	1	1
Methionine	1,8	1,8
Lisin	1,7	1,7
Carboxymethyl cellulose	3	3
Carofil-red	1	1
Choli chloride (%96)	0,5	0,5
Nutrient compositions (%)		
Crude protein	56,69	56,19
Crude oil	10	10

[1]Vitamin premix: 12.000.000 IU A, 2.500.000 IU D3, 200.000 mg E, 10.000 mg K_3, 20.000 mg B_1, 24.000 mg B_2, 100.000 mg B_5 (Ca D-pantothenate), 20.000 mg B_6, 200 mg B_{12}, 150.000 mg B_3 (niacin), 10.000 mg B_9 (folic acid), 1.000 mg B_7 (biotin), 200.000 mg C, 200.000 mg inositol, 1.000.000 mg choline.
[2]Mineral premix: 5.000 mg Cu, 20.000 mg Mn, 2.000 mg Co, 2.500 mg I, 30.000 mg Zn, 250 mg Se.

affected by feeding times and diet types and their interactions were a significant factor ($P<0.01$). Larvae fed rotifer were significantly heavier than those fed dry diets. However, dry diets did not significantly affect SGR_W at the end of the study, and there was no a significant interaction term with feeding times. Weaning larvae at different times significantly changed SGR_W values, with lower values in T_1 compared with the others. Feeding with only rotifer over the study period resulted in significantly higher SGR_W values than dry diets ($P<0.01$).

Feeding times and their interactions with diet types were significant factors for survival rates of larvae were significantly affected by at end of the experiment ($P<0.01$). Control larvae showed significantly higher survival than those on T_1D_2 and T_1D_3 ($P<0.05$), but they were comparable to others ($P>0.05$).

Table 4. Weight and length growth of gold fish larvae (with an initial weight of 0.97-1.13 mg and total length of 5.77 - 6.05 mm) maintained on various feeding schedules and diets

Variable	Feeding time	Diets			
		D_1	D_2	D_3	R
Length on day 8 (mm)	T_1	^{b}7,74±0,13*	^{b}7,65±0,26*	^{b}7,65±0,25*	9.53±0.14*
	T_2	^{a}9,26±0,28	^{a}9,32±0,42	^{a}9,37±0,27	
	T_3	^{a}9,91±0,01	^{a}9,67±0,27	^{a}9,95±0,33	
	T_4	^{a}10,13±0,22	^{a}9,80±0,04	^{a}9,59±0,21	
Final length (mm)	T_1	^{d}9,38±0,34*	^{dh}9,67±0,19*	^{h}9,70±0,22*	14.68±0.92*
	T_2	^{c}11,55±0,18*	^{cg}11,47±0,16*	^{g}11,08±0,22*	
	T_3	^{b}12,63±0,32*	^{bf}11,96±0,24*	^{f}11,59±0,29*	
	T_4	^{a}13,30±0,34^{A}	^{ae}12,88±0,04^{AB}*	^{e}12,42±0,04^{AB}*	
SGR_L on day 8	T_1	^{b}3,07±0,42*	^{b}3,13±0,55*	^{b}3,45±0,48*	6.15±0.48*
	T_2	^{a}5,41±0,53	^{a} 5,84±0,51	^{a} 5,89±0,50	
	T_3	^{a}6,28±0,17	^{a} 5,90±0,30	^{a} 6,57±0,51	
	T_4	^{a}6,99±0,33	^{a} 6,29±0,35	^{a} 6,37±0,15	
SGR_L at the final	T_1	^{c}2,91±0,14*	^{c}3,24±0,05*	^{c}3,43±0,13*	6.13±0.27*
	T_2	^{b}4,36±0,19*	^{b}4,51±0,18*	^{b}4,26±0,21*	
	T_3	^{b}4,96±0,17*	^{b}4,57±0,09 *	^{b}4,53±0,22*	
	T_4	^{a} 5,54±0,19	^{a}5,18±0,20 *	^{a}5,18±0,20*	
Final weight (mg)	T_1	^{a}9,29±0,78*	^{ae}9,74±0,42*	^{l}10,05±0,39*	63.43±0.59*
	T_2	^{b}20,03±0,88*	^{bf}19,08±0,50*	^{k}18,58±0,87*	
	T_3	^{c}27,04±0,78*	^{cg}25,03±0,66*	^{k}j25,08±0,34*	
	T_4	^{d}37,35±0,89*	^{dh}32,47±0,97*	^{i}29,47±1,73 *	
SGR_W at the final	T_1	^{c}14,73±1,46*	^{c}15,22±0,92*	^{c}15,03±0,53*	27,81*
	T_2	^{b}19,88±1,23*	^{b}19,54±0,65*	^{b}19,61±0,81*	
	T_3	^{ab}21,46±0,73*	^{ab}21,79±0,82*	^{ab}21,36±0,76*	
	T_4	^{a}23,38±0,77*	^{a}23,03±0,68*	^{a}22,45±0,87*	
Survival	T_1	^{b}75,56±8,62	^{d}37,20±0,40*	^{df}30,60±10,30*	93,89*
	T_2	^{a} 90,00±3,47	^{c} 97,22±1,47	^{ce} 95,56±2,94	
	T_3	^{a} 95,56±2,94	^{c} 96,11±1,47	^{ce} 97,78±1,47	
	T_4	^{a} 95,56±1,11	^{c} 97,22±2,00	^{ce} 98,89±1,11	
VC on day 8	T_1	^{a} 9.96±2.13	^{a}8.37±0.25	^{a}10.62±1.69*	7,22±0,24*
	T_2	^{ab} 9.47±1.47	^{ab}8.48±0.62	^{ab}7.84±1.32	
	T_3	^{b}6.63±0.42	^{b}7.98±0.06	^{b}6.90±0.79	
	T_4	^{a}7.53±0.59	^{a}7.10±1.48	^{a}7.38±0.28	
VC at the final	T_1	^{a}10,95±1,82*	^{a}10,48±0,65*	^{a}11,04±0,81*	7,52±1,12*
	T_2	^{b} 8,23±0,54	^{b} 7,32±1,71	^{b} 7,50±0,69	
	T_3	^{b} 7,26±0,14	^{b} 7,20±0,27	^{b} 8,51±0,30	
	T_4	^{b} 8,86±1,05	^{b} 7,88±0,58	^{b} 7,49±1,13	
CF	T_1	^{a}1,13±0,21*	^{a}1,07±0,06*	^{a}1,11±0,17*	2,10±0,41*
	T_2	^{b}1,31±0,20*	^{b}1,26±0,13*	^{b}1,36±0,06*	
	T_3	^{bc}1,35±0,14*	^{bc}1,47±0,09*	^{bc}1,61±0,17*	
	T_4	^{c}1,59±0,16*	^{c}1,51±0,08*	^{c}1,54±0,15*	

Values sharing common superscripts in the same rows or column are not significantly different (based on Tukey multiple comparison test) (P< 0,01; P<0,05), * indicates that these values are significantly different from the control (Dunnett's test) (P<0,05)

There was no an interaction term of feeding times and diet types in terms of VC on day 8 and at end of the experiment. However, final VC values were altered by feeding times (P<0.05), with significantly higher values in T_1 than the others. Average VCs of the control were similar to other treatments, except T_1D_3 on day 8, T_1D_1 and T_1D_3 at the final.

Larval CFs were not affected by diet types and their interactions with feeding times, whereas the later significantly changed, with lowest and highest values in T_1 and T_4 respectively (P<0.05). Rotifer-fed larvae were significantly higher in terms of CF compared with the others (P<0.05).

Discussion

In many previous studies during larval rearing of goldfish, *Artemia*, *Daphnia* spp. and compounded feeds (micro-particle diets etc.) were used as first feed but little attention has been paid to the use of freshwater rotifers (Janakiraman and Altaff, 2015). Single use of dry diets was reported to lower the success of larval rearing when compared to the live foods but their combined use with live foods increased the survival and growth rates (Sales and Janssens, 2003; Demeny *et al*., 2012). In a 12 day-study with goldfish larvae, best growth and survival were observed with the use of artemia cyst, and when artemia were given, larvae showed cannibalism on

day 5 since the mouth size of these larvae were bigger than other treatments probably due to the cannibalism (Paulet, 2003). However, in the present study, continuous use of dry diets resulted in length differences without any observation of cannibalism.

Kaiser *et al*. (2003) observed the best length growth in goldfish larvae fed with artemia 15.8 mm size followed by those on artemia + a commercial diet with 14.8 mm and those on only the commercial diet with 10.8 mm. These researchers recorded a lower survival in larvae fed only dry diet (61.9%) than those fed only either artemia (96.4%) or artemia + dry diet (94.7%). In the present study, we observed the best survival in larvae fed T_4D_3 with 98.89% and although there were no differences among feeding times, continuously feeding with dry diets resulted in low survival rates (75.56% in T_1D_1, 37.20% in T_1D_2 and 30.60% in T_1D_3), which are consistent with the findings of Sales and Janssens (2003). In the present study, low survival of larvae on dry diets could be resulted from undeveloped digestive system and enzyme activities and incomplete digestion of dry foods, which was previously verified by Abi-ayada and Kestemont (1994). However, when rotifer was used as first feed in the current experiment, even only for 3 days (T_3), survival rate increased up to over 90%. The study indicated that a further increase in the duration of rotifer usage resulted in a concomitant elevation of survival and the highest survival was recorded in T_4D_3. Kaiser *et al*. (1994) found that a decrease of weaning day from 24 to 6 did not affect survival rate, which complies with the data of $T_1D_{1\text{-}3}$ treatment of the present study that included a 3 day only rotifer followed by another 3 day co-feeding with dry diets. Therefore, we can suggest a 6-7 day live food feeding in goldfish larval rearing.

In a 21 day study with goldfish larvae, Abi-ayad and Kestemont (1994) investigated the effects of *Artemia nauplii* (D1), Artemia nauplii+50% dry food (D2) and only dry food (D3) on survival and growth rates and proteolytic enzyme activities. They found that survival rates in D1 and D2 were higher than D3. The highest trypsin activity and SGR values were in D2 where as the lowest was in D3. In the present experiment, the best length and SGR_L was in rotifer-fed treatment, which was followed by $T_{2\text{-}4}D_{1\text{-}3}$ treatments. SGR_L values of T_1 on day 8 were significantly lower than T_1, T_3 and T_4 with the highest value 6.99% in T_4D_1. At the end of the experiment, the highest SGR_L was observed in rotifer-fed larvae with 6.13%. Although continuous feeding of three diets resulted in poor length growth and SGR_L, rotifer administration as first feed with these diets at T_2, T_3 and T_4 remarkably ameliorated growth rates. On the other hand, the fact that only rotifer feeding over the experiment showed the highest growth rates reveals the importance of live feeds in early goldfish larval rearing. In this study, when the same diet was given at different times, responses of larval growth were also significantly different. A similar tendency was also the case in SGR_W values. Our larval length, SGR_L and CF values are similar to the growth rate reported by Abi-ayad and Kestemont (1994). CF of larvae in T_1D_2 treatment was the lowest (1.07). But the increase in duration of rotifer feeding elevated CF values and it reached the highest in larvae fed only rotifer with 2.10. These values are within the range of literature data (Kashani *et al*. (2010).

One interesting finding in the present study is that using only dry diets resulted in significantly higher VC compared to the other treatments, suggesting that rotifer feeding prior to dry diets would increase the homogeneity of larval individuals or reduce the inter-individual size variation.

Briefly, in this experiment a combination trial of freshwater rotifer and dry diets during early larval feeding of goldfish was evaluated in terms of growth and survival rates. We can suggest that only dry diet should not be applied in goldfish larval rearing and should be fed after rotifer feeding for at least 3 days. Moreover, a transition period from rotifer to dry diets should be performed by co-feeding for at least 3 days. In light of the present findings, one appropriate protocol can be that 7 days rotifer followed by a 3 day co-feeding with dry diets and then a complete weaning.

Acknowledgements

This study was funded by Scientific Research Projects Coordination Department of Süleyman Demirel University with a grant no: 3534-YL2-13. The authors would like to thank Assistant Assoc. Prof. Dr. Özgür Koşkan, Assoc. Prof. Dr. Yılmaz EMRE, Dr. Banu YALIM, Ramazan UYSAL, Faruk PAK, Hatice GÜNDÜZ, Assoc. Prof. Dr Hüseyin Sevgili, Soner SEZEN, Serkan ERKAN, İsmail DAL, Fevzi KARDEŞ for their help during the study, laboratory analysis, statistical evaluation and manuscript writing.

References

Abi-Ayad, A. and Kestemont, P. 1994. Comparison of the nutritional status of goldfish (*Carassius auratus*) larvae fed with live, mixed or dry diet. Aquaculture, 128: (1-2), 163-176. doi:10.1016/0044-8486(94)90111-2.

Alpbaz, A. 1993. Akvaryum Tekniği ve Balıkları. MAS Ambalaj Sanayi ve Ticaret A.Ş., İzmir, 403 pp.

Apha, Awwa and Wef. 1998. Standart Methods for Examination of Water and Waste Water. American Public Health Assosiciation, 20th edition, Washington, 1176 pp.

Arimoro, F.O. 2006. Culture of the fresh water rotifer, *Brachionus calyciflorus*, and its application in fish larviculture technology. African Journal of Biotechnology, 5: 536-541.

Castell, J.D. and Tiews, K. 1980. Report of the EIFAC, IUNS and ICES working groups on the standardization of methodology in fish nutrition research. EIFAC Technical Paper.

FAO, 2011. Ornamentalfish.

http://www.fao.org/fishery/topic/ 13611/en (accessed October 12, 2011).

Fossa, S.A. 2003. Man-Made Fish: Domesticated fishes and their place in the aquatic trade and hobby. OFI Journal, 44: 1, 3-4, 6-10, 12-16.

Demeny, F., Trenovszki, M.M., Sokoray-Vargal, S., Hegyi, A., Urbanyi, B., Zarski, D., Acs, B., Miljanovic, B., Specziar, A. and Müller, T. 2012. Relative efficiencies of artemia nauplii, dry food and mixed food diets in intensive rearing of larval crucian carp (*Carassius carassius* L.). Turkish Journal of Fisheries and Aquatic Sciences 12, 691-698. DOI: 10.4194/1303-2712-v12_3_18.

Gümüş, E., Kanyılmaz M., Gülle İ. and Sevgili H. 2014. Antalya bölgesindeki süs balığı üreten işletmelerin yapısal ve teknik analizi: II. teknik özellik ve pazarlama durumları. Biyoloji Bilimleri Araştırma Dergisi, 6: 32-38.

Harzevili, A.S., Charleroy, D.D., Auwerx, J., Vught, I., Slycken, J.V., Dhert, P. and Sorgeloos, P. 2003. Larval rearing of burbot (*Lota lota L.*) using *Brachionus calyciflorus* rotifer as starter food. Journal Applied Ichthyologia, 19: 84–87.

Hekimoğlu, M.A. 1997. Türkiye'de pazarlanan lepistes varyeteleri (*Poecilia reticulata*) üzerine araştırmalar. Ph.D. Thesis, İzmir: Ege Üniversitesi Su Ürünleri Fakültesi.

Hekimoğlu, M.A. 2006. Akvaryum sektörünün dünyadaki ve Türkiye'deki genel durumu. Ege Üniversitesi Su Ürünleri Dergisi, 23: 237-241.

Janakiraman, A. and Altaff, K. 2015. Hatchery rearing of goldfish (*Carassius auratus*) larvae using different zooplankton live foods. International Journal of Research in Fisheries and Aquaculture, 5: 84-88.

Kaiser, H., Endemann F. and Paulet, T.G. 2003. A comparison of artificial and natural foods and their combinations in the rearing of goldfish, *Carassius auratus* (L.). Aquaculture Research, 34: 943-950. DOI: 10.1046/j.1365-2109.2003.00948.x.

Kashani, Z.H., Imanpoor, M.R., Shabani, A. and Gorgin, S. 2010. Effect of dietary vitamin C, E and highly unsaturated fatty acid on growth and survival of goldfish (*Carassius auratus*). Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society, 3: 281-288.

Kestemont, P. 1995. Influence of feed supply, temperature and body size on the growth of goldfish *Carassius auratus* larvae. Aquaculture Research, 136: 341-349. DOI: 10.1016/0044-8486(95)00060-7.

Korkmaz, A.Ş. 2008. Sazan biyolojisi ve yetiştirme teknikleri. http://traglor.cu.edu.tr/objects/objectFile/sazan_yetistirme.html (accessed May 15, 2012).

Lim, L.C. and Wong, C.C. 1997. Use of the rotifer, *Brachionus calyciflorus* Pallas, in fresh water ornamental fish larviculture. Hydrobiologia, 358: 269–273.

Ploeg, A. 2007. The volume of the ornamental fish trade, International transport of live fish in the ornamental aquatic industry. Ornamental Fish International. 2: 48–61.

Özdamar, K. 2001. SPSS ile Biyoistatistik. Kaan Kitabevi, Eskişehir, 452 pp.

Paulet, T.G. 2003. The effect of diet type and feeding rate on growth, morphological development and behaviour of larval and juvenile goldfish C*arassius auratus* (L.). MSc thesis. Grahamstown: Rhodes University.

Sales, J. and Janssens, G.P.J. 2003. Nutrient requirements of ornamental fish. Aquatic Living Resources, 16: 533-540.

Savaş, E., Şener, E. and Yıldız, M. 2006. Japon balıklarında (*Carassius sp*.) embriyolojik ve larval gelişimin incelenmesi. İstanbul Üniversitesi, Veteriner Fakültesi Dergisi, 32: 7-19.

Tlusty, M. 2002. The benefits and risks of aquacultural production for the aquarium trade. Aquaculture, 205: 203-219.

Türkmen, G. and Çelik, İ. 2014. Türkiye'de Yetiştiriciliği Yapılan Akvaryum Balık Türleri Konusunda Ön Çalışma. 1. Ulusal Akvaryum Balıkçılığı ve Sorunları Çalıştayı Sonuç Raporu. 30-31 October, Antalya, Turkey.

Watson, C.A., Hill, J.E. and Pouder, D.B. 2004. Species profile: Koi and goldfish. SRAC Publication Number 7201.

Yıldız, N., Akbulut, Ö. and Bircan, H. 2011. İstatistiğe Giriş. Aktif Yayınevi, 7. Baskı, Erzurum, 326 pp.