Iranian Journal of Fisheries Sciences 19(3) 1073-1082 2020
DOI: 10.22092/ijfs.2018.119513.

Feeding frequency influences the growth performance of yellowfin seabream (*Acanthopagrus arabicus*) in cage culture

Ahmad N.[1]*; Siddiqui P.J.A.[1]*; Mir Khan K.[2,3]; Ali A.[1]; Khokhar F.[1]; Amir S.A.[4]

Received: April 2017 Accepted: August 2018

Abstract

This study examined the growth response of yellowfin seabream, *Acanthopagrus arabicus,* reared in floating net cage fed at variable daily feeding frequencies. Thirty healthy fish (49.7±0.3 g initial weight) were stocked in each of the 12 net cages (1.5×1.5×1.5m). Three cages in each group were assigned to four different feeding frequency i.e., two, three, four and six times/day designated as FF1, FF2, FF3 and FF4, respectively. Semi-purified diet (42% protein) was used to feed at seven percent body weight (%BW) day^{-1} for a total period of forty five days. The fish length and weight were measured fortnightly and the feeding rate was adjusted according to the new weight. At the end of the trial all fish remained healthy and active with survivals recorded 95-100%. The final weight, average daily weight gain (ADG) and specific growth rate (SGR) values were significantly higher for fish in groups FF3 and FF4 compared to FF1 and FF2. The SGR was the highest in groups FF3 (1.30±0.02) and FF4 (1.3±0.04) significantly different from FF1 (1.09±0.01) and FF2 (0.99±0.02) groups. Whole body proximate composition (protein, ash, moisture and lipid) remained similar in all the treatment groups. It may be concluded that yellowfin seabream, *A. arabicus*, may be grown in floating cages effectively by feeding four times day^{-1} to achieve significantly better growth.

Keywords: Fish juveniles, Sea bream, Feeding trial, Net cages, Growth rate.

1-Center of Excellence in Marine Biology, University of Karachi, Karachi 75270, Pakistan.
2-Bio-Protection Research Centre, Lincoln University, New Zealand.
3-Faculty of Agriculture, Lasbela University of Agriculture, Water and Marine Sciences Uthal Balochistan, Pakistan.
4-Pakistan Museum of Natural History, Garden Avenue, Shakarparian, Islamabad-44000, Pakistan
*Corresponding author's Email: naveedkhan.aqua@yahoo.com, jamal.siddiqui@yahoo.com

Introduction

A dramatic increase in the human population, expected to exceed 9 billion by 2050 with 22% individuals with age under 40 years (Heilig *et al*., 2012), will pose a threat to food security and insufficiency in the future which may be fulfilled by aquaculture (Godfray *et al*., 2010). For successful aquaculture practice fish nutrition feed needs to be managed in order to obtain healthy fish while keeping the production cost at the minimum. Fishmeal being a suitable source of essential amino acids, minerals, vitamins and essential fatty acid, remains the main constitute of fish feed (Hussain *et al*., 2011). About 30 – 60% of the production cost is incurred by fish feed (Huguenin, 1997; De Carvalho Gomes *et al*., 2006). Therefore, the supply of nutritionally balanced feed at an optimal feeding rate would ensure better growth rate, economic returns, and improved total production of fish (Silva *et al*., 2007).

Knowledge of optimal feeding regimes with efficient feeding frequency and feeding rate with respect to fish body weight can avoid overfeeding as well as insufficient feeding that may cause mortality and increases serious growth and health issues for the fishes and in the surrounding environment (Masser and Cline, 1990). For example, this may result in high feed conversion ratio with corresponding low growth (Thia-Eng and Seng-Keh, 1978), waste feed will affect water quality (Talbot *et al*., 1999) and inadequate feed supply would increase competition and cannibalism resulting in low total yield and profitability (Bureau *et al*., 2006). Feeding behavior and choice of a particular feed appear to vary from species to species, for example, Indian catfish, *Heteropneustes fossilis* (Sundararaj *et al*., 1982), goldfish, *Carassius auratus* (Noeske and Spieler, 1984), Channel catfish, *Ictalurus punctatus* (Noeske *et al*., 1985) and black sea trout, *Salmo trutta labrax* (Başçınar *et al*., 2007)

The members of family Sparidae, usually known as seabreams and porgies, are distributed generally in temperate to tropical seas (Froese and Pauly, 2015). Sparidae is mainly a marine family but few species of the family are found in brackish water (Platell *et al*., 2007). A total of 139 species of the family 14 species have been reported from Pakistan (Siddiqui *et al*., 2014). Many species of this family, being euryhaline, can tolerate wide range of temperature tolerance, fast growth with high demand for human consuming, have been successful used in aquaculture (Leu and Chou, 1996). The yellowfin seabream, *Acanthopagrus latus*, has been re-described in five separate species, including *A. latus* (East Asia), *A. longispinnis* (Northern Gulf of Bengal Bay), and three recently discovered species, *A. arabicus* (Middle-East, Iran and Pakistan), *A. morrisoni* (North-Western Australia) and *A. sheim* (The Persian Gulf) (Iwatsuki, 2013; Siddiqui *et al*, 2014). The *A. arabicus* has not been studied for its growth performance in captivity. Therefore the present study was designed to evaluate the optimum daily feeding frequency for maximum growth in floating net cages with respect to feed consumption and body composition.

Materials and methods

Feed formulation and preparation

Feed ingredients were procured from the local market in Karachi. Fishmeal was the major protein source used in the diet and protein level was maintained at 42%. The feed ingredients, as in Table 1, were mixed and blended with fish oil and water to form dough. The dough was passed through the palletizer machine to form required pelleted diet. Feed was stored under dry condition in a freezer until utilized. The dried feed samples were analyzed for percent proximate composition of dry matter, crude fat, crude protein, crude fiber and moisture contents (Table 1).

Table 1: Composition of the experimental diet (g kg^{-1}) and percent proximate composition used for *Acanthopagrus arabicus* grown in floating net cages.

Ingredients	Diet
Fish meal [a]	460
Wheat bran [a]	240
Wheat flour [a]	120
Rice bran [a]	80
Fish oil	50
Starch	30
Vitamins & minerals [b]	20
Proximate Composition of diet	
Dry matter	86
Moisture	10.6
Crude protein	42.1
Crude fat	13.3
Crude fibre	6.2

[a] Crude protein (CP) content: Fish meal (61.2%), wheat flour, (16.2%), wheat bran (12.6%), rice bran (6.1%), starch (9.4%).

[b] Vitamins and minerals have the following composition in the diet (g 1000g^{-1}):Water-soluble vitamins; ascorbic acid (vitamin C) 15, thiamine (vit. B1) 1.1, inositol (vit.B8) 38.5, choline chloride 3.7, pyridoxine (vit.B6) 1.2, folic acid (0.5); cyanocobalamine (vit.B 12) 0.004, nicotinic acid (vit.B3) 4.2, riboflavin (vit.B2) 1.1, pantothenic acid (vit.B5) 1.35 and biotin, 0.4.Fatsoluble vitamins; cholecalciferol (vit.D3) 6.8, retinol (vit. A) 1.1; menadione sodium bisulphite (vit.K3) 0.04, a-tocopherol acetate (vit. E) 5.2. Minerals; calcium 1.3; phosphorus 3.3, zinc 1.1, copper 1.02, magnesium 2.3, phospholipids 3.2, iodine 2.1, manganese 2.04, iron 1.1, sodium 1.02

Experimental design

Fish (*A. arabicus*) juveniles were collected from the vicinity of the experimental site (24º55'43.07" N, 66º44'26.18" E) and initially stocked in four net cages for 15 days adaptation. During this time, juveniles were adapted to accept the pelleted diet offered. Active fish juveniles in uniform size (49.7±0.3 g. mean body weight; n=360) were distributed (30 fish/cage) in four groups of triplicate floating net cages (1.5m×1.5m×1.5m). The fish in four diet groups were named (FF1, FF2, FF3 and FF4) which were fed two, three, four and six times day^{-1} at 7% BW, respectively for 45 days during April/May, 2016 (Table 2). Cages were cleaned to avoid algal and fungal growth, and to maintain free circulation of waters. Fish counts and individual weights were taken fortnightly and the amount of feed was adjusted according to the new weight. Fish growth was ascertain on the basis of weight gain ([(Average final weight–

Average initial weight) /Average initial weight]×100), Average daily weight gain [ADG=(Average final weight–Average initial weight)/Total cultured days] and specific growth rate [SGR=% weight gain per day=[(In Total final weight - In Total initial weight)/days)×100].

Proximate composition of fish diet and fish carcase was carried out using standard methods (AOAC, 1990) including dry matter, moisture (drying at 105 º C for 24 h), crude protein (Kjeldahl method; *N*×6.25), crude fat (soxhlet method) and crude fiber (filter bag technique). From the initial stock seventy two individuals were separately euthanized and stored at -20˚C for the entire carcass composition analysis. Similarly, at the end of feeding trial, five fish from each cage were randomly collected and anesthetized for subsequent final fish carcass composition.

Table 2: The experimental design for assessment of optimum feeding frequency for juveniles of *Acanthopagrus arabicus,* in floating net cages showing the average initial weight, length and other parameters in each feeding group.

Treatments	Number of replicates	Feeding frequency	Stocking per cage	Average initial weight (g)	Average initial length (cm)
FF1	3	2	30	50.07±0.02	17.33±0.79
FF2	3	3	30	49.50±0.18	17.87±0.52
FF3	3	4	30	49.83±0.28	18.16±0.41
FF4	3	6	30	49.40±0.14	17.89±0.52

Physico-chemical parameters (temperature, salinity, dissolved oxygen and pH) of the experimental site were recorded once in a week at low, mid and high tides which remained within the normal range. Daily feeding schedule for all the treatment groups are presented in (Table 3).

Table 3: Daily feeding schedule for *Acanthopagrus arabicus* in floating net cages showing feeding frequency and the time of the day for each feeding group were fed twice a day (FF1); thrice a day (FF2); four times a day (FF3); six times a day (FF4).

	Feeding frequency			
Feeding time	FF1	FF2	FF3	FF4
800		x	x	x
900	x			
1000				x
1100			x	
1200		x		x
1300				
1400			x	x
1500				
1600	x	x		x
1700			x	
1800				x

Statistical analysis

The triplicate data of each experimental group were presented as total mean± standard deviation (SD). One Way Analysis of Variance (ANOVA) was used to assess the differences in growth performance between treatment groups receiving daily feed at different frequencies. For significant differences among treatment groups the Tukey HSD test was applied. The statistical analysis was performed through SPSS ver.18 and Microsoft Excel 2010.

Results

Water physico-chemical parameters were within acceptable range and suitable for cage culture of *A. arabicus*. The average values of temperature (22.32±0.54 °C), pH (7.32±0.43), salinity (24.3±2.3‰) and dissolve oxygen (6.40±0.21 mg L^{-1}) were recorded. The fish remained healthy and active during the whole experimental period and the survival remained between 95% to 100%. Lower mortality rate in cages is the indication of healthy environments for culture.

Growth parameters, such as, percent weight gain (WG), average daily weight gain (ADG) and specific growth rate (SGR) are given in Table 4. At the end of the experiment, WG values in group FF1 (56.32±1.97 g) and FF2 (63.74±1.03 g) was lower compared to FF3 (79.8±2.42 g) and FF4 (79.77±1.3 g). There was no significant differences (p>0.05) in weight gain in treatment groups FF3 and FF4; however, they were significantly different from FF1 and FF2 groups. The ADG values increased gradually in all groups and the lowest final ADG was recorded in treatment FF1 (0.62±0.02 g), followed by FF2 (0.7±0.01 g). The highest ADG was recorded in FF3 (0.88±0.02 g) and FF4 (0.87±0.01 g). The high ADG values recorded in FF3 and FF4 were significantly different (p<0.05) from that of FF1 and FF2. Similarly, the specific growth rate (SGR; % per day) values were lower in FF1 (0.99±0.02) and FF2 (1.09±0.01) groups. The significantly higher (p<0.05) SGR values were detected in FF3 (1.3±0.02) and FF4 groups (1.3±0.04).

The initial and final proximate compositions of fish whole body, shown in Table 5, depict that the body composition of *A. arabicus*, was not influenced by the feeding frequency in floating net cages. Final body composition, moisture, protein, lipid and ash contents were not significantly different (p>0.05) from their respective initial values.

Table 4: Weight gain (g), average daily weight gain (ADG; g ind^{-1} day^{-1}) and Specific growth rate (SGR; %/day) of *Acanthopagrus arabicus.* Fish in each group were fed a fixed ration (7% body weight day^{-1}) at the respective frequencies as mentioned in Table 2. Values are mean ± DE. Values marked with different alphabetical letters in each experimental group in the last column (1-45 days) indicate significant differences.

Parameters	Feeding groups	Experimental duration (days)			
		1--14	15--29	30—45	1--45
Weight gain (g),	FF1	14.01±0.19	17.77±0.31	16.41±0.97	56.32±1.97^{c}
	FF2	15.53±0.70	19.75±0.79	18.35±0.64	63.74±1.03^{b}
	FF3	22.81±0.96	21.73±0.82	20.26±0.13	79.8±2.42^{a}
	FF4	23.26±0.45	21.68±0.18	20.82±0.57	79.77±1.36^{a}
ADG (g ind^{-1} day^{-1})	FF1	0.50±0.00	0.72±0.01	0.78±0.04	0.62±0.02^{c}
	FF2	0.54±0.02	0.80±0.02	0.89±0.03	0.70±0.01^{b}
	FF3	0.81±0.02	0.95±0.04	1.07±0.00	0.88±0.02^{a}
	FF4	0.78±0.01	0.93±0.00	1.09±0.02	0.87±0.01^{a}

Table 4 continued:

SGR (%/day)	FF1	0.93±0.01	1.16±0.02	1.08±0.05	0.99±0.02[c]
	FF2	1.03±0.04	1.28±0.04	1.2±0.03	1.09±0.01[b]
	FF3	1.46±0.04	1.4±0.04	1.31±0.00	1.30±0.02[a]
	FF4	1.43±0.02	1.4±0.00	1.35±0.03	1.30±0.04[a]

Table 5: Initial and the final whole body proximate composition (g kg^{-1} wet weight; mean ± SD; n=3) of *Acanthopagrus arabicus*, juveniles. The proximate composition of fish in all groups were not significantly different (*p*>0.05) from their respective initial values.

Parameters	**Initial values**	**Final proximate composition in experimental feeding groups**				
		FF1	**FF2**	**FF3**	**FF4**	**FF4**
Moisture	734	665±2	662±3	663±3	662±1	664±1
Protein	158	169±3	170±1	172±2	174±4	175±2
Lipids	55	83±4	85±4	84±4	87±2	87±3
Ash	46	52±2	49±2	50±3	51±4	50±1

Discussion

The present study has optimized daily feeding frequency for yellowfin seabream *A. arabicus* in floating net cages for which no previous information is available as to evaluate this local fish species as a candidate for aquaculture. Such data are important as an optimum feeding rate and frequency reduce fish size variability within the same groups (Wang *et al*., 1998) as well as a fully fed fish is less stressed and remain healthy. It is also known that both insufficient and overfeeding compromises fish growth and health condition (Ng *et al.,* 2000). In addition, excessive feed supply in cages not only causes feed losses which concomitantly, and increase the production cost (Silva *et al.,* 2007), but also accumulate as high organic debris and consequently, through decomposition, production of ammonia and depletion of oxygen, degrades water quality (Puvanendran *et al.,* 2003). We observed that hand feeding at reasonable rates (four times a day) would curtail feed losses and negative environmental impact. The water quality parameters (temperature, dissolved oxygen, pH and ammonia concentration) in and around cages remain within the acceptable range for fish culture. Similarly, the fish remained healthy throughout the trial period with very low mortality and no negative competition for feed and/or cannibalism was detected.

For the growing aquaculture industry feed and feeding frequency for different fish species is a challenge for feed being the main regulator of the total production cost (Silva *et al.,* 2007). For floating net cages, fish feed share 30 to 60% of the total production cost (De Carvalho Gomes *et al.,* 2006). Therefore, feeding frequencies and feeding ratios are of key importance in aquaculture, which not only determines the feed requirement for maximum growth and fish survival, but also establishes the production cost for a successful aquaculture practice (Aydin *et al.,* 2011; Kaiser *et al.,* 2011).

It is generally accepted that fish size, age and culture conditions, including the amount of feed provided, quality of feed and water temperature, defines the feeding frequency for fish in culture to have a maximum growth response (Goddard, 1996; Puvanendran *et al.*, 2003). Small size fish have higher energy demands and they must be fed frequently (Ndome *et al.*, 2011). Similarly, feed consumption and growth of larger fish is dependent on feed supply and to a certain limit of daily feeding frequency (Wang *et al.*, 1998; Basçınar *et al.*, 2007). In the present study by increasing feeding frequency in *A arabicus* increases the growth up to four times a day (FF3) and further increment in feed supply (FF4; six times day^{-1}) had no positive effect on growth and only the feed consumption was increased. Fish in group FF1 and FF2, with lower feeding frequency, had a significantly lower growth performance. This is also evident for other fish species , for instance, rainbow trout fry of 5.5 g and 16 g revealed better results when fed at four and three times day^{-1}, respectively (Grayton and Beamish 1977; Hung and Storebakken 1994); African sharptooth catfish (*Clarias gariepinu)* responded well at high frequency (five times day^{-1}; Ndome, 2011); Flounder (*Paralichthys olivaceus*) fed two or three times/day showed better growth compared to fish fed once in two days (Lee *et al.*, 2000); for blunt snout bream *Megalobrama amblycephala* fed three times day^{-1} frequency is optimum (Tian, *et al.*, 2015), Asian seabass (*Lates calcarifer*, 3 times day^{-1}, Biswas, *et al.*, 2010) red-spotted grouper (*Epinephelus akaara*) require four and six meals per day (Kayano *et al.*, 1993); hybrid sturgeon, Acipenser schrenckii Brandt♀× *A. baeri* Brandt♂ six meal day^{-1} frequency provided better growth (Luo *et al.*, 2015) milkfish *Chanos chanos*, growth, increased significantly from four times to eight times day^{-1} (Lee *et al.*, 1997). According to Shelbourn *et al.*, (1973) Sockeye salmon (*Oncorhyncus nerka*) had better growth when fed continuously for 15 h/day. We used hand feeding method at a slow rate that kept the fish satisfied with less stress, which yields uniform size healthy fish (Lee *et al.*, 1997; Başçınar *et al.*, 2001). Frequent feeding also provides a chance to subordinate fish in a group to fetch food as it is known that healthier and more active, dominant fish consume most of the feed and subsidiary fish eat nothing or a little (Jobling and Baardvik., 1994; Damsgård *et al.*, 1997).

It may be concluded from the present finding that yellowfin seabream, *A.arabicus*, was assessed for the first time and that it may be grown in floating cages effectively by feeding four times day^{-1} at 7% BW (42% protein diet) which would yield significantly better results under given rearing conditions.

Acknowledgements

We are thankful to the Center of Excellence in Marine Biology (CEMB), University of Karachi for laboratory space and logistics. We are indebted to Higher Education Commission of Pakistan (HEC) for providing funds (HEC Project 3716).

References

A.O.A.C., 1990. Official methods of analysis of the association of official analytical chemists. In: K Helrich (ed).15th edition, Arlington, VA: Association of Official Analytical Chemists, Inc. 1298 P.

Aydin, I., Küçük, E., Sahin, T., and Kolotoglu, L., 2011. The effect of feeding frequency and feeding rate on growth performance of juvenile Black Sea turbot (*Psetta maxima,* Linneaus, 1758). *Journal of Fisheries Sciences,* 5(**1**), 35-42.

Başçınar, N., Okumus, I., Basçinar, N.S. and Saglam, H.E., 2001. The influence of daily feeding frequency on growth and feed consumption of rainbow trout fingerlings (*Oncorhynchus mykiss*) reared at 18.5-22.5 °C. *The Israeli Journal Aquaculture Bamidgeh,* 53(**2**), 80-83.

Başçınar, N., Çakmak, E., Çavdar, Y. and Aksungur, N., 2007. The effect of feeding frequency on growth performance and feed conversion rate of Black sea trout (*Salmo trutta labrax* Pallas, 1811). *Turkish Journal of Fisheries and Aquatic Sciences*, 7(**1**), 13-17.

Biswas, G., Thirunavukkarasu, A.R., Sundaray, J.K. and Kailasam, M. 2010. Optimization of feeding frequency of Asian seabass (*Lates calcarifer*) fry reared in net cages under brackishwater environment. *Aquaculture*, 305(**1-4**), 26-31.

Bureau, D.P., Hua, K. and Cho, C.Y., 2006. Effect of feeding level on growth and nutrient deposition in rainbow trout (*Oncorhynchus mykiss* Walbaum) growing from 150 to 600g. *Aquaculture Research*, 37(**11**), 1090-1098.

Damsgård, B., Arnesen, A.M. Baardvik, B.M. and Jobling, M., 1997. State-dependent feed acquisition among two strains of hatchery-reared *Arctic charr*. *Journal of Fish Biology,* 50(**4**), 859-869.

De Carvalho Gomes, L., Chagas, E.C., Martins-Junior, H., Roubach, R., Ono, E.A. and de Paula Lourenço, J.N., 2006. Cage culture of tambaqui (*Colossoma macropomum*) in a central Amazon floodplain lake. *Aquaculture*, 253(**1**), 374-384.

Froese, R. and Pauly, D., (eds) 2015. Fish Base. World Wide Web electronic publication. http://www.fishbass.org. Accessed on December. 12, 1016.

Goddard, S., 1996. Feed Management in Intensive Aquaculture. Chapman and Hall, New York. 194 P.

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F Pretty, J., Robinson, S., Thomas, S.M. and Toulmin, C., 2010. Food security: the challenge of feeding 9 billion people. *Science*, 327(**5967**), 812-818.

Grayton, B.D. and Beamish, F.W.H., 1977. Effects of feeding frequency on food intake, growth and body composition of rainbow trout (*Salmo gairdneri*). *Aquaculture*, 11(**2**), 159-172.

Heilig, G.K., Gerland, P., Andreev, K., Li, N., Gu, D., Spoorenberg, T., Ravinuthala, S., Yamarthy, C. and Koshy, N., 2012. Population estimates and projections section: Work program, outputs, challenges, uncertainties. United Nations, Department of Economic and Social Affairs (DESA), Population Division.

Huguenin, J.E., 1997. The design, operations and economics of cage culture systems. *Aquaculture Engineering*, 16 (**3**), 167-203.

Hung, S.S. and Storebakken, T., 1994. Carbohydrate utilization by rainbow trout is affected by feeding strategy. *The Journal of nutrition*, 124(**2**), 223-230.

Hussain, S.M., Afzal, M., Salim, M., Javid, A., Khichi, T.A.A., Hussain, M. and Raza, S.A., 2011. Apparent digestibility of fish meal, blood meal and meat meal for *Labeo rohita* fingerlings. *The Journal of Animal and Plant Sciences*, 21(**2**), 807-811.

Iwatsuki, Y., 2013. Review of the *Acanthopagrus latus* complex (Perciformes: Sparidae) with descriptions of three new species from the Indo-West Pacific Ocean. *Journal of Fish Biology*, 83(**1**), 64-95.

Jobling, M. and Baardvik, B.M., 1994. The influence of environmental manipulations on inter–and intra–individual variation in food acquisition and growth performance of Arctic charr, *Salvelinus alpinus*. *Journal of Fish Biology*, 44(**6**), 1069-1087.

Kaiser, H., Collett, P.D. and Vine, N.G., 2011. The effect of feeding regimen on growth, food conversion ratio and size variation in juvenile dusky kob *Argyrosomus japonicus* (Teleostei: Sciaenidae). *African Journal of Aquatic Science*, 36(**1**), 83-88.

Kayano, Y., Yao, S., Yamamoto, S. and Nakagawa, H. 1993. Effects of feeding frequency on the growth and body constituents of young red-spotted grouper, *Epinephelus akaara*. *Aquaculture*, 110(**3-4**), 271-278.

Lee, C.S., Leung, P.S. and Su, M.S., 1997. Bioeconomic evaluation of different fry production systems for milkfish (*Chanos chanos*). *Aquaculture*, 155(**1-4**), 367-376.

Lee, S.M., Cho, S.H. and Kim, D.J., 2000. Effects of feeding frequency and dietary energy level on growth and body composition of juvenile flounder, *Paralichthys olivaceus* (Temminck and Schlegel). *Aquaculture Research*, 31(**12**), 917-921.

Leu, M.Y. and Chou, Y.H., 1996. Induced spawning and larval rearing of captive yellowfin porgy, *Acanthopagrus latus* (Houttuyn). *Aquaculture*, 143(**2**), 155-166.

Luo, L., Li, T., Xing, W., Xue, M., Ma, Z., Jiang, N. and Li, W., 2015. Effects of feeding rates and feeding frequency on the growth performances of juvenile hybrid sturgeon, *Acipenser schrenckii* Brandt♀× *A. baeri* Brandt♂. *Aquaculture*, 448, 229-233.

Masser, M. and Cline, D., 1990. Caged fish production in Alabama. Extension Aquaculturist. ANR-957. Alabama University.

Ndome, C.B., Ekwu, A.O. and Ateb, A.A., 2011. Effect of feeding frequency on feed consumption, growth and feed conversion of *Clarias gariepinus x Heterobranchus longifilis hybrids. American-Eurasian Journal of Scientific Research*, 6(**1**), 6-12.

Ng, W.K., Lu, K.S., Hashim, R. and Ali, A., 2000. Effects of feeding rate on growth, feed utilization and body composition of a tropical bagrid catfish. *Aquaculture International*, 8(**1**), 19-29.

Noeske, T.A. and Spieler, R.E., 1984. Circadian feeding time affects growth of fish. *Transactions of the American Fisheries Society*, 113(**4**), 540-544.

Noeske-Hallin, T.A., Spieler, R.E., Parker, N.C. and Suttle, A.A., 1985. Feeding time differentially affects fattening and growth of channel catfish. *Journal of Nutrition*, 115, 1228-1232.

Platell, M.E., Ang, H.P., Hesp, S.A. and Potter, I.C., 2007. Comparisons between the influences of habitat, body size and season on the dietary composition of the sparid *Acanthopagrus latus* in a large marine embayment. *Estuarine, Coastal and Shelf Science*, 72(**4**), 626-634.

Puvanendran, V., Boyce, D.L. and Brown, J.A., 2003. Food ration requirements of 0+ yellowtail flounder *Limanda ferruginea* (Storer) juveniles. *Aquaculture*, 220(**1**), 459-475.

Shelbourn, J.E., Brett, J.R. and Shirahata, S., 1973. Effect of temperature and feeding regime on the specific growth rate of sockeye salmon fry (*Oncorhynchus nerka*), with a consideration of size effect. *Journal of the Fisheries Board of Canada*, 30(**8**), 1191-1194.

Siddiqui, P.J.A., Amir, A. and Masroor, R., 2014. The sparid fishes of Pakistan, with new distribution records. *Zootaxa*, 3857(**1**), 71-100.

Silva, C.R., Gomes, L.C. and Brandão, F.R., 2007. Effect of feeding rate and frequency on tambaqui (*Colossoma macropomum*) growth, production and feeding costs during the first growth phase in cages. *Aquaculture*, 264(**1**), 135-139.

Sundararaj, B.I., Nath, P. and Halberg, F., 1982. Circadian meal timing in relation to lighting schedule optimizes catfish body weight gain. *The Journal of Nutrition*, 112(**6**), 1085-1097.

Talbot, C., Corneillie, S. and Korsøen, Ø., 1999. Pattern of feed intake in four species of fish under commercial farming conditions: implications for feeding management. *Aquaculture Research*, 30(**7**), 509-518.

Thia-Eng, C. and Seng-Keh, T., 1978. Effects of feeding frequency on the growth of young estuary grouper, *Epinephelus tauvina* (Forskål), cultured in floating net-cages. *Aquaculture*, 14(**1**), 31-47.

Tian, H.Y., Zhang, D.D., Li, X.F., Zhang, C.N., Qian, Y. and Liu, W.B., 2015. Optimum feeding frequency of juvenile blunt snout bream *Megalobrama amblycephala. Aquaculture*, 437, 60-66.

Wang, N., Hayward, R.S. and Noltie, D.B., 1998. Effect of feeding frequency on food consumption, growth, size variation, and feeding pattern of age-0 hybrid sunfish. *Aquaculture*, 165(**3**), 261-267.