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Influence of different feeding rates using commercial dry pellets on growth, feed efficiency and survival for hatchery produced sea bass *Lates calcarifer*

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Abstract. Feeding rate is one of the crucial factors to be considered in aquaculture production. In this experiment a 60-day feeding trial was conducted to investigate the influence of different feeding rates on the growth, feed efficiency and survival rates for hatchery produced sea bass *Lates calcarifer* fed with commercial dry pellets (47.80% protein, 7.10% lipid, 1.62% ash, 0.77% crude fiber and 7.70% moisture). Triplicate groups of sea bass juveniles (weight, 5.50 ± 0.01 g; total length, 6.9 cm) were fed six times a day (09:00 - 10:30 - 12:00 - 13:30 - 15:00 - 16:30) at 3%, 6%, 9% and 12% body weight (BW) of fish throughout the feeding trial. Ten fish were stocked in each 12 units conical fiber glass tanks (100L capacity) at three replicates per treatment at the UPV Multi Species Hatchery. The best specific growth rate (SGR) was 0.48±0.11, food conversion ratio (FCR) of 1.97±0.027, feed efficiency (FE) of 0.51±0.013 and protein efficiency ratio (PER) of 1.06± 0.031 were recorded for fish feed at 12% daily application feeding rate and the difference between fish fed at 12% body weight per day was statistically different ($p > 0.05$) from other groups of sea bass fed at 3, 6 and 9% body weights per day. For the whole body composition, the feed application rate of 12% had a significant effect on the crude protein (18.42±0.00), crude lipid (6.36±0.03) but no significant differences were detected for the ash concentration among the different treatments. The survival rate (80%) of the fish during the experiment did not differ significantly ($p < 0.05$) among the treatments. At the end of the 60-day feeding trial, the group of fish fed at 12% BW had a significantly higher hepatosomatic index (HSI) of 1.7±0.02 and viscerosomatic index (VSI) of 6.4±1.9 than the rest of experimental groups. The lowest HSI (0.99±0.11) and VSI (3.69±1.1) was achieved by group of fish fed at 3% BW. The condition factor (CF) of 9.65±0.022 was highest in fish fed 12% BW and the lowest (8.05±0.028) was on 3% BW. On the other hand, the groups of fish fed on 9 and 6% BW showed no statistical difference between treatments. Results showed that growth and feed efficiency of hatchery produced *L. calcarifer* were greatly enhanced by feeding the fish six times daily at 12% as compared to fish fed at 9, 6 and 3% BW using commercial dry pellets.
Key Words: feeding rates, sea bass, growth, viscerosomatic index, feed conversion ratio.

Introduction. Asian sea bass, *Lates calcarifer* Bloch (Centropomidae) was first bred artificially in Songkhla, Thailand in the mid-1970s and later at the Fisheries Research Institute, Glugor, Penang, Malaysia in 1982 (Awang 1986). According to Thirunavukkarasu et al (2004) sea bass are highly cannibalistic, fast growing marine species with high commercial value (Appelbaum & Arockiaraj 2010). De Angelis et al (1979) and Hecht & Pienaar (1993) stated that cannibalism among sea bass was highly contributed to its size variation caused by genotypic differences and the behavior of the fish. The global annual production of sea bass was about 400,000 metric tons in 2006 (Wang et al 2007). This marine fish was extensively cultured in Southeast Asian countries and in the Indo-Pacific región (Tucker et al 2002) owing to its rapid growth rate and ability to accept formulated feeds. The Asian sea bass has been considered a potential prospect for intensive aquaculture from fry to marketable size (Barlow et al 1996), therefore controlling the application of daily feeding rates on the fish would likely insure optimum feed consumption with minimum waste, improves nutritional and food conversion efficiency, reduces production cost and water pollution which are deemed important in rearing the fish in culture conditions (FAO 1999).

Feed management in terms of feeding rate is an important aspect in the field of aquaculture system and has become one of the critical areas for research. Numerous studies had been already conducted on the feeding rates of fish species (Deng et al 2003) and was reported that optimum feeding rate is affected by fish size, water temperature, feeding strategy and differences in environmental conditions such as feeding method and stocking density (Hung et al 1993; Ballestrazzi & Lanari 1996; Cho et al 2003; Ganzon-Naret 2013). Feed accounts 60% in the production cost for intensive aquaculture (Anderson et al 1997; Sheunn et al 2003; Erondu et al 2006) with protein as the most expensive component in terms of overall feed cost. In aquatic nutrition, protein is considered as the major component because it provides the essential and non-essential amino acids to synthesize body protein and to supply energy for the repair and maintenance. Several investigations have been conducted on the effects of feeding rate on the growth performance of 20-40 g white sturgeon (*Acipenser transmontanus*) juveniles (Hung & Lutes 1987); Qin & Fast (1996) reported that a daily ratio of 10% body weight was optimum for 0.5 g juvenile *Clarias gariepinus* while in grass carp *Ctenopharyngodon idella* (6.2±0.1 g) the best body weight gain was obtained at 60% feeding rate fed with duckweeds *Lemna* sp. (Nekoubin et al 2012). Therefore, more attention shall be given to the optimum feeding management in order to reduce overfeeding, feed wastage, environmental pollution and increase fish production efficiency (Lee et al 2000; Bolliet et al 2001; Dwyer et al 2002). Feeding rate is an important factor that influences fish growth, thus, knowing the optimal feeding rate is essential in minimizing feed loss, reduces water pollution and decreases the cost of aquaculture production (Marimuthu et al 2011). Some authors have reported that feeding rate becomes more imperative in the culture of marine and freshwater fish in order to optimize the amount of nutrients and metabolic fuel for the rapid fish growth and minimize waste production (Kaushik & Gomes 1988; Kaushik & Meadale 1994). However, many problems related to feeding conditions remained to be solved. Some studies show that feeding at an optimum rate will increase growth and feed efficiency; impedes unnecessary feed loss and environmental pollution (Turker & Yildirim 2011).

Currently, there is no information on the feeding application rates for sea bass having a size group of 6.9 cm in total length. Therefore, the present study was carried out to investigate the influence of different feeding rates using commercial dry pellets on growth, feed efficiency and survival for hatchery produced sea bass.

Material and Method

Experimental fish and rearing condition. Hatchery-bred sea bass were acclimated for two weeks in 1000 L circular fiberglass tanks at the IA Multi-Species Hatchery of the University of the Philippines Visayas, Miag-ao, Iloilo Philippines. During the acclimation, the fish were fed with a commercial dry pellets (2 mm) twice per day to satiation. The experimental fish (average weight 5.50±0.01 g; average total length 6.9 cm) weighed to the nearest 0.1 g were randomly distributed at a stocking rate of 10 fish per tank with three replicates in twelve 100 L conical fiberglass tanks each filled with filtered seawater in a closed recirculating system. The water inflow was adjusted to 3 L min^{-1} and continuous aeration was provided in each tank. Feces and uneaten feed were siphoned daily to maintain good water quality, dead fish were removed and mortality was recorded daily during the experiment. The light and dark cycle was maintained at 12h:12h.

Individual weights and total lengths of fish from each tank were taken to determine the condition factors at the end of 60 days from June 30 – August 28, 2011. Feeding was done manually and the amount of feed given daily at each meal was recorded.

Dissolved oxygen and water temperature were measured using oxygen meter daily, which ranged from 6.5–7.4 mg L^{-1} and 28-32^{o}C, respectively. Salinity was 29-32 ppt, and pH ranged between 6.2-7.9 during the experiment. Total ammonia-nitrogen and nitrite-nitrogen of the water samples were determined every two weeks according to

Strickland & Parsons (1972) and the water quality parameters measured were within the acceptable level for the fish growth (Boyd 1984).

Experimental design. Four feeding rates (FR) at 3%, 6%, 9% and 12% body weight with three replicates per treatment were tested using commercial dry feeds for sea bass. The fish were fed six times a day and the proximate composition of feed was determined by the standard AOAC (1995) and is presented in Table 1.

Table 1

Proximate composition of feed used in the feeding trial

Analysis	*%*
Moisture	7.70
Crude protein	47.80
Crude lipid	7.10
Crude fiber	0.77
Crude fiber	1.62

Chemical analyses. Commercial feed was analyzed for proximate composition according to AOAC (1995). Crude protein was analyzed according to the micro-Kjeldahl method (N x 6.25). Crude lipid was determined by 40 to 60°C petroleum ether extraction in a Soxhlet apparatus and ash by incinerating the sample for 12h in a muffle furnace at 550°C. Crude fiber was determined using the Hot Extractor (Fibertec System). Dry matter was determined by drying the feed sample to a constant weight at 105°C. At the beginning of the feeding trial, 15 fish were randomly sampled from the initial population and killed for the analyses of the whole body composition. Six fish were sampled from each group at the end of the study, homogenized for the determination of whole body composition and another four fish from each treatment were obtained for the morphometry determination of the hepatosomatic and viscerosomatic indices.

Calculation and statistical analysis. The data obtained for growth and feed utilization parameters were evaluated by calculating weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), feed efficiency (FE), protein efficiency ratio (PER), condition factor (CF) and survival rate (%), hepatosomatic index (HSI) and viscerosomatic index (VSI) using the following formulae:

WG = final weight (g) – initial weight (g);
SGR (% day $^{-1}$) = [In final weight (g) – In initial weight (g)/no. of culture days] x 100;
FCR = feed intake (g)/weight gain;
FE = (weight gain/feed intake);
PER = wet weight gain (g)/dietary protein intake (g);
Condition Factor (CF) (%) = fish weight (g)/fish length^3 (cm) x 100;
Survival rate (%) = No. of fish recovered/No. of fish stocked x 100;
HSI = 100 x (hepatosomatic weight/whole body weight);
VSI = 100 x (viscera weight/whole body weight).

All the data were subjected to one-way analysis of variance (ANOVA). Duncan's multiple range test (DMRT) was used as a *post hoc* test to compare between means at $p \leq 0.05$. The statistical analyses were performed using the SPSS version 16 for Windows Software program.

Results and Discussion

Growth and feed utilization. The growth performance, feed utilization and survival of sea bass fed with commercial feeds at different feeding rates after 60 days was presented in Table 2. During the feeding experiment fish readily accepted and consumed the commercial feed. Initially sea bass juveniles had more or less similar weight, and no significant difference was observed among the treatment ($p < 0.05$). The highest growth (10.72±0.03 g) was obtained in fish fed with 12% followed by (9.25±0.62 g) 9%; (8.13±0.24 g) 6%; and the lowest value (7.26±0.29 g) at 3%. Mean weight gains were 1.76±0.34 g, 2.63±0.19 g, 3.75±0.28 g and 5.22±0.36 g for fish in the 3%, 6%, 9% and 12% feeding rates, respectively. The mean weight increase of fish fed on 12% daily feeding rate differed significantly among 3%, 6% and 9% daily food intake rates ($p > 0.05$). Result revealed that the highest SGR (0.48±0.11) was recorded at the highest feeding rate (12%) and the lowest value (0.20±0.09) was at 3%. A significant difference ($p < 0.05$) was observed in SGR among the different treatments.

Table 2

Growth performance, feed efficiency and survival of size group (5.50±0.01 g) juvenile sea bass fed at different feeding rates with commercial feed after 60 days

Parameters	*Feeding rate*			
	3%	*6%*	*9%*	*12%*
Initial weight (g)	5.50±0.01	5.50±0.01	5.50±0.01	5.50±0.01
Final weight (g)	7.26±0.29[d]	8.13±0.24[c]	9.25±0.62[b]	9.25±0.62[b]
Weight gain	1.76±0.34[d]	2.63±0.19[c]	3.75±0.28[b]	5.22±0.36[a]
SGR (%/day)	0.20±0.09[d]	0.28±0.14[c]	0.38±0.07[b]	0.48±0.11[a]
FCR	2.79±0.25[a]	2.36±0.04[a]	2.02±0.039[b]	1.97±0.027[c]
FE	0.36±0.016[c]	0.43±0.02[b]	0.50±0.018[a]	0.51±0.013[a]
PER	0.75±0.022[c]	0.89±0.0172[b]	1.04±0.015[a]	1.06±0.031[a]
CF initial	6.90±0.05[a]	6.90±0.10[a]	6.90±0.06[a]	6.90±0.04[a]
CF final	8.05±0.028[c]	8.56±0.103[b]	8.99±0.021[b]	9.65±0.022[a]
Survival (%)	80.00	80.00	80.00	80.00
HSI (%)	0.99±0.11[b]	1.05±0.28[b]	1.14±0.12[ab]	1.7±0.02[a]
VSI (%)	3.69±1.1[c]	4.49±1.2[b]	6.2±1.4[a]	6.4±1.9[a]

Data represent the mean of three replicates. Values in the same row with different superscript are significantly different ($p < 0.05$).

The best FCR (1.97±0.027) was obtained in fish fed at 12%, while the poorest FCR (2.79±0.25) was in fish fed at 3% FR, however the difference between groups of fish at 3% and 6% feeding rate was not statistically significant ($p > 0.05$). The same trend was also observed in the FE and PER among the fish fed at different feeding rates. After the 60-day feeding trial, fish fed the highest feeding rate (12%) had higher CF, HSI and VSI values than those fed with the lowest feeding rate (3% and 6%) and these were significantly different among treatments ($p < 0.05$). The survival was 80%, hence not affected by different feed application rates for sea bass. Results of the whole body composition of sea bass juveniles are presented in Table 3.

Table 3

Whole body composition (%) of sea bass juveniles fed at four different feeding rates using commercial feed for 60 days

Analysis	*Feeding rate*				
	Initial	*3%*	*6%*	*9%*	*12%*
Moisture	55.81±0.42	53.68±0.23[b]	53.56±0.16[b]	53.78±0.62[b]	54.9±0.76[a]
Crude protein (%)	14.22±0.2	17.62±0.5[b]	17.68±0.42[b]	17.65±0.44[b]	18.42±0.33[a]
Crude lipid (%)	4.05±0.31	5.49±0.12[b]	5.72± 0.13[b]	5.79±0.38[b]	6.36±0.03[a]
Crude ash (%)	1.38±0.06	1.85±0.32[a]	1.86±0.23[a]	1.87±0.29[a]	1.86±0.023[a]

Values in the same row with different superscript are significantly different ($p < 0.05$).

The highest crude protein, crude lipid and moisture was clearly observed in fish fed at 12% body weight per day and this was significantly different ($p < 0.05$) than those groups of fish fed at 9%, 6% and 3% feeding rates. High body lipid content (6.36±0.03) of fish increases with feed application rate above the optimal rate. No significant differences occurred in ash concentration of the body composition among the treatments ($p > 0.05$).

In the present study, the results indicated that the FW, WG, SGR, FE and PE increased with the increase level of feeding rates per day based on body weighs using commercial feeds for sea bass. The best growth was achieved at 12% daily food intake than those fed on 3, 6 and 9% ($p < 0.05$) daily food intake using commercial feeds (47.80% protein). This result is in agreement with the report of Sun et al (2006), which showed that there was improvement in the specific growth rate for juvenile cobia (*Rachycentron canadum*) when fed at 7% body weight per day than with 3% body weight. Many studies (Borghetti & Canzi 1993; Robinson & Li 1999; Marimuthu et al 2011) showed that higher growth rates were obtained for pacu (*Piaractus mesopotamicus*), European sea bass (*Dicentrarchus labrax*) and African catfish (*Clarias gariepinus*) fingerlings respectively when fed with higher feeding rates as compared with lower level of feeding rate. According to Grayton & Beamish (1977) they reported that increase in the level of food in rainbow trout (*Oncorhynchus mykiss*) resulted to increase in the growth performance. The influence of feeding rates may vary with the different species, size, age of fish, dietary protein, energy levels, environmental factors as well as the feeding time (Wang et al 1998; Lee et al 2000; Mihelakakis et al 2001). Earlier authors have also observed that different fish species have different optimal feeding rates. Tambaqui (*Colossoma macropomum*) requires optimum feeding rate of 10% (Silva et al 2007), *Channa striatus* at 6% body weight (Qin & Fast 1996) and *Clarias fuscus* at 6% body weight (Anderson & Fast 1991).

In this study, using commercial feed provided maximum efficiency for the fish. The highest weight gain, SGRs in juvenile sea bass were obtained ($p < 0.05$) by feeding the fish at a rate of 12% body weight. Poor growth, reduced FE (0.36 ± 0.016) and PER (0.75 ± 0.022) were observed in fish fed with the 3% feeding rate. It is evident that growth increases with the increase of feeding rate and the highest quantity of feed was consumed in multiple feeding resulting in higher feed efficiency indices. Fish fed at 12% body weight per day had a better FCR (1.97 ± 0.027) than other treatments at 2.02 ± 0.039, 2.36 ± 0.04 and 2.79 ± 0.25 for 9, 6 and 3% feeding rates respectively. There were no pathological signs observed among treatments, however due to the cannibalistic behavior of sea bass it is always common among the fish that frequent tail biting occurs. The data clearly indicate that increasing the level of feeding rate at 12% significantly increases the CF, HSI and VSI in sea bass having a similar size group 0f 5.50 ± 0.01 g and once daily (3.99). There was an observed significant decrease ($p < 0.05$) in the FE when the group of fish was fed at daily application rate of 3% (0.36 ± 0.016) among the different feeding rates. Thus, it appears to determine the optimum feeding rates for various fish species on practical application (Zakes et al 2006). The ability of the organism to utilize nutrients particularly protein will positively enhance its growth rate (Sogbesan & Ugwumba 2008).

No significant differences were found in the whole body composition (crude protein, crude lipid and ash content) of sea bass fed at 9, 6 and 3% feeding rates. The highest crude protein (18.42 ± 0.33) and crude lipid (6.36 ± 0.03) were observed in sea bass fed at 12% and differ significantly among 9, 6 and 3% daily application rates ($p < 0.05$). The application of different feeding rates had a significant effect on the crude protein and crude fat on the whole body composition of fish, but no significant differences ($p < 0.05$) were observed with the ash concentration among treatments. In the present study, the moisture was increased with increasing level of feeding rate at 12% and showed a significant difference ($p < 0.05$) compared to other treatments (3, 6, and 9%) in body composition. Overall results show that best growth (WG 5.22 ± 0.036; SGR 0.48 ± 0.11) and feed efficiency (FCR 1.97 ± 0.027; PER 1.06 ± 0.031) were obtained in juvenile sea bass at 12% BW/day fed with commercial dry pellets. There were no significant difference at $p < 0.05$ in the survival rates among the different treatments.

Conclusion. To sum up, it could be concluded that increasing feeding rates at 12% in hatchery produced sea bass (5.55 ± 0.01 g) resulted in a better growth performance, feed efficiency, body composition and survival rates under controlled experimental condition after 60 days of feeding trial. In order to achieve better survival and growth for sea bass juveniles during the culture period, size uniformity should always be maintained.

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