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Effect of Raw Fish-Based Moist Pellet (MP) and Commercial Red Sea Bream Feed (CF) on Growth and Body Composition of Sunshine Bass (*M. saxatilis* male×*M. chrysops* female) Reared at Various Salinity During the Winter Season

Sung Hwoan Cho* and Jong Kwan Lee

**Uljin Marine Hatchery, National Fisheries Research & Development Institute*
#22 Osan-Ri, Wonnam-Myon, Uljin, Kyungbook 767-863, Korea

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Possibility of raising sunshine bass during the winter season in Korea was investigated. Also, the effect of feed on growth and body composition of sunshine bass was compared at the various salinity. Twenty sunshine bass (Mean weight ± S.D.: 53.9 ± 0.24 g) were stocked into the eighteen circular flow-through tanks. A 2 (feed)×3 (salinity) factorial design with triplicate was used for this study. Feed was prepared into the 2 groups: the raw fish-based moist pellet (MP) containing 59.5% crude protein and 9.4% crude lipid, and commercial sinking red sea bream feed (CF) containing 49.9% crude protein and 9.4% crude lipid, respectively. And salinity was prepared into the 3 groups: freshwater (0‰), brackishwater (15‰), and seawater (32‰). Fish were fed to satiation twice daily for 6 days a week. Fish were all survived at the end of the 8-week feeding trial. Weight gain (WG) and specific growth rate (SGR) of sunshine bass were significantly ($P<0.05$) affected by both feed and salinity. WG and SGR of sunshine bass fed the MP were significantly ($P<0.05$) higher than those of fish fed the CF in the same salinity. Amount of dry feed fed was significantly ($P<0.05$) affected by both feed and salinity. Feed consumption by sunshine bass fed on the MP was significantly ($P<0.05$) higher than by fish fed on the CF in the same salinity. Feed efficiency ratio (FER) was significantly ($P<0.05$) affected by salinity, but not by feed. Protein efficiency ratio (PER) was significantly ($P<0.05$) affected by both feed and salinity. Moisture and protein content of the whole-body of fish was not significantly ($P>0.05$) affected by either feed or salinity. However, lipid and ash content of the whole-body of fish was significantly ($P<0.05$) affected by salinity, but not by feed. In conclusion, the MP was superior to CF for growth of sunshine bass during the winter season in Korea and no mortality occurred. And sunshine bass seemed to grow better in freshwater (0‰) and brackishwater (15‰) than seawater (32‰) under these experimental conditions, in terms of improvement in FER and PER in freshwater or brackishwater.

Key words: Sunshine bass, Feed, Salinity, WG, FER, PER

Introduction

Since commercially available fish for aquaculture in freshwater and seawater are limited in Korea, development or introduction of a new fish species which has high potential for aquaculture is desired. Recently, aquaculture production of hybrids of two *Morone* species, striped bass *M. saxatilis* and white bass *M. chrysops* has been sharply increased since the mid-1960s in USA. Thus, hybrid striped bass, original cross (*M. saxatilis* female×*M. chrysops* male), called palmetto bass and reciprocal cross (*M. saxatilis* male×*M. chrysops* female), called sunshine bass which are more recently produced have been one of most important fish for sports and food in USA. Most aquaculture production of hybrid striped bass was done in freshwater and their production reached 4,415 tones in 1999 in USA. And their aquaculture production in freshwater and seawater in Israel also recently increased

*Corresponding author: chosunh@yahoo.com

and reached 227 and 49 tones in 1999, respectively (FAO, 2000). Therefore, aquaculture technique of these fish had been well developed. And many feeding trials with hybrid striped bass have been performed in USA (Brown et al., 1992; Nematipour et al., 1992a, b; Keembiyehetty and Wilson, 1998; Webster et al., 2000). And Gatlin (1997) also demonstrated the several nutrient requirements in a diet and feeding strategy for sunshine bass.

Hybrid striped bass are carnivorous species throughout their life. As larvae they feed on zooplankton and convert to fish as they mature (Hodson, 1989). Hybrid striped bass could survive and do well a wide range of environmental conditions. A temperature range of 4 to 33℃ is acceptable, but the optimum temperature ranges from 25 to 27℃ for growth of hybrid striped bass (Hodson, 1989). And hybrid striped bass are also known to grow faster and tolerance to a wider range of salinity and lower metabolic energy needs (Tuncer et al., 1990) than their parental species. And some countries in Asia like Japan and Thailand have recently imported hybrid striped bass from USA to develop as a new candidate for aquaculture. In these aspects, hybrid striped bass have high potential for aquaculture in Korea as well. Therefore, possibility of raising hybrid striped bass, especially sunshine bass, during the winter season in Korea was investigated. Besides, the effect of moist pellet and commercial feed on growth and body composition of sunshine bass at the various salinity was compared.

Materials and Methods

Preparation of the experimental fish

Juvenile (Mean weight ± S.D.: 2.2 ± 0.44 g) sunshine bass were purchased from Keo Fish Farms (Keo, Arkansas, USA) and transferred into Uljin Marine Hatchery, Kyungbook, Korea in the end of July. Fish were transferred and stocked into a circular concrete tank by feeding a commercial floating flounder feed or raw fish-based moist pellet composed of frozen sardine and flounder compound at the ratio of 8:2, and grew well during the summer season. Sunshine bass were grown for about 100 days before an initiation of the feeding trial. Fish were fed twice daily and feed size adjusted as fish grew. Twenty sunshine bass (Mean weight ± S.D.: 53.9 ± 0.24 g) were stocked into the eighteen of 200-L circular flow-through tanks (water volume: 160 L). Fish were acclimated for 5 days before the initiation of the experiment. During the acclimation period, sunshine bass were fed twice daily at 3% of body weight.

Conditions of the feeding trial

Sunshine bass were fed to satiation twice daily at 09:30 and 17:00 for 6 days a week throughout the feeding trial based on Thompson et al. (2000)'s study. Water flow rate in each tank was 10 L/min and photoperiod followed natural condition throughout the feeding trial. Since the feeding trial was performed during the winter season, temperature ranged from 10.7 to 16.8℃ (Mean ± S.D.: 15.3 ± 1.17℃). Uneaten feed was siphon-removed after every meal from each tank and deducted from feed consumption.

Experimental design

A 2 (feed)×3 (salinity) factorial design with triplicate was used for this study. Feed was prepared into the 2 groups: the commercial red sea bream feed (CF) and raw fish-based moist pellet (MP). The commercial sinking feed for red sea bream labeled with above 42% crude protein and 7% crude lipid to satisfy dietary protein requirement for sunshine bass (Brown et al., 1992) and MP composed of frozen sardine and commercial flounder compound at the ratio of 8:2 as-fed basis were prepared. The MP was stored into freezer at −20℃ until use. However, crude protein and lipid contents for the CF and MP were 49.9 and 9.4, and 59.5 and 9.4% on dry basis, respectively, according to the result of proximate analysis.

Salinity was prepared into the 3 groups: freshwater (0‰), brackishwater (15‰) and seawater (32‰). And freshwater source was the natural springwater and its temperature ranged from 14.7 to 16.5℃ (15.7 ± 0.34℃) throughout the feeding trial. Seawater source was the sand-filtered seawater and its temperature ranged from 10.7 to 16.8℃ (14.0 ± 1.41℃). And brackish water was obtained by mixing the seawater and freshwater into the 2-ton tanks and pumped into the designed experimental tanks and its temperature ranged from 13.2 to 16.0℃ (14.9 ± 0.76℃). Salinity of brackishwater was regularly monitored by refractometer (Atago, Japan). The feeding trial lasted for 8 weeks. At the end of the feeding trial, fish were collectively harvested and totally weighed.

Chemical analysis

Five randomly chosen fish at the beginning and 3 fish from each tank at the end of the feeding trial were sacrificed for proximate analysis based on standard method (AOAC, 1990). Protein (Kjeldahl method), lipid (ether extraction method), ash (muffler furnace, 600℃ for 3 hours) and moisture contents (dry oven, 105℃ for 24 hours) were measured.

Statistical analysis

One-way ANOVA and Two-way ANOVA test were applied to test the significance of treatments. And if the significance was observed, Duncan's multiple range test (Duncan, 1955) was applied to detect the difference among treatments by using SAS program (SAS Institute, Inc., Cary, North Carolina, USA).

Table 1. Weight gain (WG) of fish (g/fish), specific growth rate (SGR) of sunshine bass fed the raw fish-based moist pellet (MP) and commercial red sea bream feed (CF) at the various salinity for 8 weeks during the winter season[1]

Feed type	Salinity (‰)	Initial weight of fish (g/fish)	Final weight of fish (g/fish)	WG (g/fish)	SGR[2]
MP	0	63.1±0.03	82.8±0.62[a]	19.7±0.61[a]	0.49±0.090[a]
	15	63.0±0.10	79.2±0.87[b]	16.2±0.87[b]	0.41±0.129[a]
	32	63.1±0.23	70.9±0.20[c]	7.8±0.13[c]	0.21±0.024[b]
CF	0	63.1±0.38	72.9±0.90[c]	9.8±0.93[c]	0.26±0.147[b]
	15	63.2±0.23	73.6±0.69[c]	10.3±0.65[c]	0.27±0.100[b]
	32	62.8±0.37	66.6±0.86[d]	3.8±0.86[d]	0.10±0.141[c]
Two-way ANOVA					
Feed type			P<0.0001	P<0.0001	P<0.0001
Salinity			P<0.0001	P<0.0001	P<0.0001
Interaction			P<0.05	P<0.05	P<0.09

[1]Values (Mean±SE) in the same column sharing a common superscript are not significantly different (P<0.05).

[2]SGR=(Ln final weight of fish-Ln initial weight of fish)/days of feeding.

Results and Discussion

Weight gain (WG) and specific growth rate (SGR) of sunshine bass fed MP or CF at the various salinity for 8 weeks are given in Table 1. Fish were all survived at the end of the feeding trial. WG and SGR of sunshine bass was significantly (P<0.05) affected by both feed and salinity. WG and SGR of sunshine bass fed the MP were significantly (P<0.05) higher than those of fish fed the CF in the same salinity. Improvement in growth of sunshine bass fed the MP did not seem to be related high dietary protein content in the MP because growth of sunshine bass was not further improved beyond the optimum level, 41%, according to Brown et al. (1992)'s study. Relatively poor growth and SGR of sunshine bass were observed in this study due to low temperature condition during the winter season comparing to the study performed within the optimal temperature ranges (24~26℃) for growth of sunshine bass (Brown et al., 1992). Hybrid striped bass grew when water temperature was above 15℃ (Hodson, 1989). Also, higher energy requirement for maintenance and/or activity in sunshine bass held above optimal temperature condition (32.2℃) than optimal temperature (26.7℃) was observed, and poor growth and nutrient utilization was achieved in the former (Keembiyehetty and Wilson, 1998). WG and SGR of sunshine bass fed the MP linearly increased with a decrease in salinity in this study. And WG and SGR of sunshine bass fed the CF at 0 and 15‰ was significantly (P<0.05) higher than 32‰. However, this could be resulted from the differences in water temperature in this study: mean water temperature of 15.7, 14.9 and 14.0℃ at 0, 15 and 32‰, respectively, during the feeding trial. A significant (P<0.05) interaction between feed and salinity on weight gain was observed in this study. Growth of sunshine bass was depressed when grown in full length of salinity (32‰), but fish achieved normal growth when transferred and grown at 7‰ (Brown et al., 1992). Hodson (1989) reported that hybrid striped bass grew in salinity of 0 and 25‰ and survived up to 35‰. Growth of Nile tilapia *Oreochromis niloticus* fed a 50% protein diet at 0, 8 and 12‰ for 56 days was not different, but higher than 16‰ in all tested temperature conditions (Likongwe et al., 1996).

Amount of dry feed fed (g/fish), feed efficiency ratio (FER), protein efficiency ratio (PER) and protein retention (PR) of sunshine bass fed MP and CF at the various salinity for 8 weeks are presented in Table 2. Amount of dry feed fed was significantly ($P<0.05$) affected by both feed and salinity. Feed consumption by sunshine bass fed on the MP was significantly ($P<0.05$) higher than by fish fed on the CF in the same salinity. Improvement in growth of sunshine bass fed the MP could be explained by higher feed consumption of fish fed the MP than CF. Difference in palatability for sunshine bass between the MP and CF could reduce feed consumption and eventually result into poor growth in the CF in this study. This might indicate that the MP seemed to be preferable over the CF for sunshine bass during the winter season because improvement in WG and SGR was observed in fish fed the MP. And feed consumption by sunshine bass on the both MP and CF at 0 and 15‰ was significantly ($P<0.05$) higher than 32‰.

FER was significantly ($P<0.05$) affected by salinity, but not by feed. FER for sunshine bass fed on the both MP and CF at 0 and 15‰ were significantly ($P<0.05$) higher than 32‰. This was consistent with Brown et al. (1992)'s study that improved FER was observed in sunshine bass grown at 0 and 7‰ than 32‰ although FER was compared among slightly different size of juvenile fish. FER in the MP linearly decreased with the increase in salinity in this study. Altinok and Grizzle (2001) showed that three euryhaline species (rainbow trout *Oncorhynchus mykiss*, striped bass, and Gulf sturgeon *Acipenser oxyrinchus desotoi*) had higher SGR and more efficient FER and energy absorption efficiency in 3 and 9‰ salinity than in lower salinity (0 and 1‰). Growth, feed consumption and FER for juvenile turbot *Scophthalmus maximus*, which may be considered euryhaline were highest at 15‰ and lowest at 33.5‰ when fish were raised at 15, 25 and 33.5‰ with the various temperature (Imsland et al., 2001).

Table 2. Amount of dry feed fed (g/fish), feed efficiency ratio (FER), protein efficiency ratio (PER) and protein retention (PR) for sunshine bass fed the raw fish-based moist pellet (MP) and commercial red sea bream feed (CF) at the various salinity for 8 weeks[1]

Feed type	Salinity (‰)	Amount of dry feed fed (g/fish)	FER[2]	PER[3]	PR[4]
MP	0	22.6 ± 0.63^{a}	0.87 ± 0.100^{a}	1.47 ± 0.129^{ab}	26.4 ± 1.80^{a}
	15	23.3 ± 0.80^{a}	0.69 ± 0.119^{a}	1.16 ± 0.154^{bc}	15.0 ± 0.92^{ab}
	32	16.3 ± 0.25^{b}	0.48 ± 0.038^{b}	0.80 ± 0.050^{c}	10.1 ± 1.28^{ab}
CF	0	11.7 ± 0.80^{c}	0.83 ± 0.179^{a}	1.66 ± 0.253^{a}	17.9 ± 1.75^{ab}
	15	11.6 ± 0.53^{c}	0.89 ± 0.177^{a}	1.78 ± 0.250^{a}	15.3 ± 2.17^{ab}
	32	8.5 ± 0.64^{d}	0.42 ± 0.260^{b}	0.85 ± 0.369^{c}	8.1 ± 1.82^{b}
Two-way ANOVA					
Feed type		$P<0.0001$	$P<0.5$	$P<0.01$	$P<0.4$
Salinity		$P<0.0001$	$P<0.0001$	$P<0.0001$	$P<0.08$
Interaction		$P<0.08$	$P<0.09$	$P<0.07$	$P<0.7$

[1]Values (Mean ± SE) in the same column sharing a common superscript are not significantly different ($P<0.05$).
[2]Feed efficiency ratio (FER) = Wet weight gain of fish/dry feed fed.
[3]Protein efficiency ratio (PER) = Wet weight gain of fish/protein fed.
[4]Protein retention (PR) = Protein gain × 100/protein fed.

PER was significantly ($P<0.05$) affected by both feed and salinity. PER for sunshine bass fed the MP linearly decreased with the increase in salinity. Similarly, Likongwe et al. (1996) reported that FER and PER for Nile tilapia in the optimum temperature condition (28 and 32℃) was not different at between 0 and 8‰, but higher than 16‰. However, FER and PER was not different among salinity conditions tested (0, 8, 12 and 16‰) in 24℃ in their study. At 15‰, PER for sunshine bass fed the MP was significantly ($P<0.05$) lower than for fish fed the CF, agreeing with other studies that PER lowered with the increase in dietary protein level (Brown et al., 1992; Keembiyehetty and Wilson, 1998; Cho et al., 2000).

PR was not significantly ($P>0.05$) affected by either feed or salinity, probably indicating that performance of sunshine bass was not affected by the difference in dietary protein level between the MP and CP in this study. However, PR of fish fed the MP at 0‰ was significantly higher ($P<0.05$) than that of fish fed the CF at 32‰.

Proximate composition of the whole-body composition of sunshine bass at the end of the feeding trial is shown in Table 3. Moisture and protein content of sunshine bass was not significantly ($P>0.05$) affected by either feed or salinity. Keembiyehetty and Wilson (1998) showed that proximate composition of the whole-body of sunshine bass was not affected

Table 3. Proximate composition of the whole-body of sunshine bass at the end of the feeding trial (%)[1]

Feed type	Salinity (‰)	Moisture	Protein	Lipid	Ash
MP	0	68.5±0.56$^{n.s.}$	18.6±0.70$^{n.s.}$	9.9±0.51^{ab}	4.2±0.19^{ab}
	15	68.3±0.76	17.6±0.49	10.3±0.72^{a}	3.9±0.26^{bc}
	32	70.4±0.63	18.2±0.47	8.3±0.45^{b}	4.2±0.28^{ab}
CF	0	68.4±0.65	17.8±0.32	10.2±0.67^{ab}	4.2±0.22^{a}
	15	68.7±0.46	17.4±0.56	10.3±0.56^{a}	3.7±0.26^{c}
	32	68.9±0.31	18.3±0.44	9.2±0.32^{ab}	4.3±0.09^{a}
Two-way ANOVA					
Feed type		P<0.4	P<0.5	P<0.4	P<0.9
Salinity		P<0.1	P<0.2	P<0.05	P<0.01
Interaction		P<0.3	P<0.6	P<0.7	P<0.3

[1]Values (Mean±SE) in the same column sharing a common superscript are not significantly different (P<0.05).

by temperature. Therefore, no difference in moisture and protein content of fish could be resulted from any difference in dietary lipid level between MP and CF in this study, indicating that dietary lipid level rather than dietary protein level affected protein content of the whole-body of fish. This agreed with other studies (Nematipour et al., 1992a; Keembiyehetty and Wilson, 1998). However, unlike Keembiyehetty and Wilson (1998), study, protein content of the whole-body of turbot was significantly affected by either temperature or salinity (Imsland et al., 2001). Lipid and ash content was significantly (P<0.05) affected by salinity, but not by feed. At 15‰, the highest lipid and lowest ash content were observed in sunshine bass fed the either MP or CF. This was partially in agreement with other studies that moisture, protein and ash content of fish was inversely related to lipid content of fish (Brown et al., 1992; Nematipour et al., 1992a; Keembiyehetty and Wilson, 1998; Cho et al., 2001).

In considering results of this study, it could be concluded that the raw fish-based moist pellet was superior to commercial red sea bream feed for growth of sunshine bass during the winter season under these experiment conditions and no mortality of fish occurred. And sunshine bass showed improvement in FER and PER in freshwater (0‰) and brackishwater (15‰) than seawater (32‰) although poor fish performance was observed during the feeding trial. Protein and ash content in the whole-body of sunshine bass was not significantly affected by either feed or salinity, but lipid and ash content was significantly affected by salinity.

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