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Effects of Dietary Lipid Increments on Growth Performance, Feed Utilization, Carcass Composition and Intraperitoneal Fat of Marble Goby, *Oxyeleotris marmorata*, Juveniles

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Abstract

The present study was conducted to investigate the growth performance and feed utilization of marble goby,*Oxyeleotris marmorata*, juveniles fed with different levels of dietary lipid. Juvenile fish (initial mean weight 2.76 g) were fed with is onitrogenous diets including 10, 14, 18 and 22% of dietary lipid in triplicate groups for 15 weeks. The results showed that the highest growth performance and feed utilization was observed in fish fed D10. The increase of dietary lipid from 10 to 22 % did not improve growth, feed conversion rates, protein efficiency ratio, nitrogen retention efficiency, and apparent digestibility coefficients of protein and lipid ($P>0.05$). The increase of dietary lipid had significantly increased the whole body and hepatic lipid, hepato-somatic index, visceral-somatic index and intraperitoneal fat levels ($P<0.05$). These results suggest that there is no protein sparing effect of high dietary lipid levels in *O. Marmorata* due to possibly a limited ability to utilize dietary lipid. Based on the second-order polynomial regression analysis on protein efficiency ratio, ca. 12.1% of dietary lipid appears to be optimumfor growth from 2.76g to 13.76g body weight of *O. marmorata* juveniles.

Keywords: Marble goby, feed utilization, high lipid diet, fat deposition.

Introduction

Oxyeleotris marmorata, marble goby is the biggest goby in the family of Eleotridae. This fish can be found in freshwater and brackish water habitats distributed naturally in the Southeast Asian region (Rainboth, 1996) and currently it is one of the important aquaculture fish species in countries such as Thailand, Vietnam, Malaysia, Indonesia, China and Taiwan (Luong *et al*., 2005; Hoa and Yi, 2007; Wang *et al*., 2011) due to tasty flesh and high market price. However, there is no commercially available diet for *O. marmorata*, and many farmers must use different diet types including farm made aqua-feed, low value fish and commercial feeds for other species, which may lead to nutritional disorders such as accumulation of excessive fat, fatty liver, and occasionally mortality (Bundit, 2007).

Dietary lipid is a source of energy and essential fatty acids that cannot be *de novo* synthesized by fish (López *et al*., 2009). Carnivorous fish are known to utilize protein as energy more efficiently than lipids and carbohydrates (Du *et al*., 2005). Several studies reported that unsuitable dietary lipid levels can adversely affect the growth, body composition and health of fish (Tucker *et al*., 1997). Excessive dietary lipid may reduce feed consumption and thus depress the growth of fish (Ellis and Reigh, 1991; Lin and Shiau, 2003). It may also negatively influence the ability of fish to digest and assimilate fatty acids (Ruyter *et al*., 2000). An increasing lipid deposition in the fish due to the excessive consumption of dietary lipid (Craig *et al*., 1999; Martino *et al*., 2002) can produce fatty fish that may have an unpleasant flavor and become easily rancid at postharvest.

However, several studies report that increasing dietary lipid within a certain limit can improve the growth and protein utilization of fish through the protein sparing effect by lipid (Peres and Oliva-Teles, 1999; López *et al*., 2009; Kim *et al*., 2010), where dietary lipid is used as the main energy source in the overall energy expenditure while dietary protein is utilized for growth (Xu *et al*., 2001). On the contrary, limited or no protein sparing effect is also reported in many fish species such as grass carp *Ctenopharyngodon idella*, tiger puffer *Takifugu rubripes* and turbot *Psetta maxima* where increasing levels of dietary lipid did not bring any beneficial effects on growth, protein efficiency ratio and feed utilization but resulted in a significant lipid accumulation in the body (Regost *et al*., 2001; Du *et al*., 2005; Kikuchi *et al*., 2009).

There is scarce information on the utilization of dietary lipid in *O. marmorata*. Thus, this study was conducted to investigate the effects of dietary lipid increments on growth performance, feed utilization, carcass composition, intraperitoneal fat and apparent digestibility coefficient of nutrients in *O. marmorata* juveniles.

Materials and Methods

This study was conducted in Borneo Marine Research Institute (BMRI), Universiti Malaysia Sabah. *O. marmorata* juveniles used were obtained from the hatchery of BMRI. Before commencing the feeding trial, the juveniles were weaned onto a formulated feed (crude protein 45%; crude lipid 9%) until it reached a suitable size.

Diets Preparation

The diets were formulated to contain four levels of dietary lipid; 10, 14, 18 and 22%, and named as D10, D14, D18 and D22, respectively (Table 1). These diets were onitrogenous with 50% of dietary protein where fishmeal was used as the main protein source while pollack liver oil as the main lipid source. The diets were produced according to the formulation and pelletized using a meat extruder after addition of 30%water. An inert marker chromium oxide (III) was added at 0.5% into the mixtures. The diets (~3mm diameter) were oven dried at 40°C for 6 hours and stored in freezer (-20°C) until use.

Experimental diets were subjected to proximate analysis before the feeding trial. All diets were confirmed to contain approximately 50% crude protein without any significant difference (P>0.05) while the crude lipid of D10, D14, D18 and D22 were 9.45, 14.49, 17.82 and 21.87%, respectively (Table 1).

Feeding Trial and Experimental Design

The *O. marmorata* juveniles used in this feeding trial had an average of 2.76±0.02 g body weight (BW) and 5.22±0.06 cm in body length (BL). These fish were randomly distributed into 27 L fiber glass tanks with a dimension of 30 cm x 30 cm x 30 cm at a stocking density of 20 fish per tank. Triplicate groups of fish were fed with each dietary treatment twice daily (09:00 and 14:00) until apparent satiation for 15 weeks. Uneaten feeds were siphoned out 1 hour after feeding. During the feeding trial, experimental fish were weighted individually using an analytical balance to the nearest 0.01g (Shimadzu, TXB622L, Japan) in every 3 week to determine its growth performance. Before each measurement, the fish were starved for 24 hours and anesthetized (500ppm, Transmore, Nika Trading, Co.) to reduce handling stress.

A simple re-circulating water system with coral rubbles as filter was used in the present trial. Effluent water from each aquarium was channeled into the filter tank then into a sump tank before distributing back into each aquarium at a flow rate of 0.5 L/minute. The water was changed at about 30% daily during bottom cleaning. In the trial, municipal tap water was used after aerated overnight and dechlorinated with sodium thiosulfate ($Na_2S_2O_3$). The recirculation system was in an indoor facility and subjected to the natural phtotoperiod (~12 hours light: 12 hours dark). Water quality was monitored every week; temperature, dissolved oxygen and pH being 28.26 ± 0.59°C, 7.40 ± 0.27 mg/L and 7.40 ± 0.14,

Table 1. Diet formulation and proximate analysis of experimental diets (dry matter basis)

Ingredients (g/100 g)	Dietary treatments			
	D10	D14	D18	D22
Fishmeal[a]	59.2	59.2	59.2	59.2
Pollack liver oil	5.4	9.4	13.4	17.4
Wheat gluten[b]	4	4	4	4
Vitamin mixture[c]	3	3	3	3
Mineral mixture[d]	2	2	2	2
Tapioca starch	6	6	6	6
Carboxymethylcellulose	3	3	3	3
Alpha-cellulose[e]	16.9	12.9	8.9	4.9
Chromium oxide(III)	0.5	0.5	0.5	0.5
Crude protein	50.28±0.58	51.11±0.31	49.51±0.14	49.96±0.35
Crude lipid	9.45±0.17	14.49±0.09	17.82±0.48	21.87±0.07
Crude fiber	14.58±0.15	12.06±0.08	10.78±0.24	7.77±0.15
Ash	10.41±0.07	9.42±0.09	10.26±0.09	10.36±0.02
NFE[f]	15.28±0.74	12.92±0.36	11.63±0.78	10.04±0.41
Dry matter	95.47±0.06	95.89±0.09	96.74±0.16	96.73±0.03
Gross energy (MJ/kg)	18.62±0.02	20.37±0.02	21.01±0.07	22.45±0.03

[a]Danish fishmeal (g/100g dry weight): 79 g crude protein, 7.74 g crude lipid (TripleNine 999 Fish Protein, Denmark)
[b]Wheat gluten (g/100g dry weight): 80 g crude protein (AAA brand, Bake with Me, Malaysia)
[c& d] Halver's Mixture (1957)
[e] Sigma, Apha-cellulose
[f]Nitrogen-free extract (NFE) = 100-(crude protein+crude lipid+crude fiber+ash)

respectively.

At the end of the trial, BW and BL of all the experimental fish were measured individually to determine their growth performance while some fish (n=18) from each treatment were sacrificed for biochemical analysis and to estimate viscerosomatic index (VSI), hepatosomatic index (HSI) and the intraperitoneal fat (IPF). The growth performance and body indexes (Ng *et al*., 2008; López *et al*., 2009; Bicudo *et al*., 2010) were estimated as followed:

Weight gain (%)= [(Final BW (g)–initial BW (g))/initial BW (g)] x 100

Specific growth rate (SGR)= {[In (final BW) – In (initial BW)]/days of experiment} x 100 (%growth/day)

Daily feed intake (DFI)(%)= Total feed (g) x 100 / ([total final BW (g) + total initial BW (g)] x days/2)

Feed conversion ratio (FCR) = Feed consumed (g)/ wet weight gained of fish (g)

Protein efficiency ratio (PER) = Wet weight gained of fish (g)/ protein intake (g)

Nitrogen retention efficiency (NRE %)= [Nitrogen gain (g/fish) x 100/ nitrogen intake (g/fish)]

Hepatosomatic indices (HSI %) = [Liver weight (g) / whole BW (g)] x 100

Viscerosomatic indices (VSI %)= [Viscera organ weight (g) / whole BW (g)] x 100

Intraperitoneal fat (IPF %) = [Intraperitoneal fat wet weight (g) / Body wet weight (g)] x 100

Condition factor (CF) = [BW (g) / [BL (cm)]^3] x 100

Digestibility Trial

After the feeding trial, the remaining fish were pooled together in a 60 L square tank (45cm x 45cm x 30cm) according to the respective treatments to collect feces for apparent digestibility coefficient analysis. One hour after feeding, tanks were cleaned and uneaten feed were siphoned out. At 2 to 3 hour intervals, fresh intact strand of feces were siphoned out carefully, dried with filter paper and frozen immediately (Lin *et al*., 2004). This trial was conducted in six weeks or until sufficient amount of feces was collected for analysis. Apparent digestibility coefficient (ADC) of the diets was calculated using the following formula (Cho *et al*., 1982):

$ADC = 100 - [(C_{feed}/C_{feaces})*(N_{feaces}/ N_{feed})] \times 100$

(C = Cr_2O_3 and N = nutrient)

Chemical Analysis

Proximate analyses of experimental diets and fish samples were conducted according to the AOAC methods (AOAC, 1990). Moisture and ash content were determined gravimetrically; samples were oven-dried at 105°C overnight until weight was constant for the former and they were subsequently incinerated in muffle furnace at 550°C for 5 hours for the later. Crude protein (N x 6.25) was determined using a Kjeldahl TM 2300 protein analyzer (FOSS Tecator, Sweden) after acid digestion using an Auto Kjeldahl digester system. Crude lipid was determined after petroleum benzene-extraction (boiling point 40°C-60°C) by using SoxtecTM2043 Hot Extraction (FOSS Tecator, Sweden). Crude fiber was determined gravimetrically after weak sulphuric acid (H2SO4) and sodium hydroxide (NaOH) digestion (Fibertec System 1021 Cold Extractor and hot extractor, FOSS Tecator, Sweden), then oven-dried at 130°C for 2 hours and transferred to a furnace at 525°C for 3 hours. Chromium oxide (III)(Cr_2O_3) level in diets and feces were estimated using the method of Furukawa and Tsukahara (1966).

Statistical Analysis

All data obtained were subjected to one-way analysis of variance using Statistical Package for the Social Sciences (SPSS package 11.5) and further analyzed using Tukey's multiple comparison when the data are found significant at $P<0.05$. A second-order polynomial regression analysis was conducted to determine the suitable dietary lipid inclusion level for *O. marmorata*.

Results

Growth Performances, Nutrient Utilization and Body Indices

Growth performance, nutrient utilization and body indices of *O. marmorata* juveniles fed with different levels of dietary lipid are presented in Table 2. At the end of the trial, fish fed with D10 achieved significantly higher weight gain (395%) compared to fish fed with D14 (304%) ($P<0.05$). However, weight gain of fish fed D10 was not significantly different from those fed with D18 and D22 ($P>0.05$). A similar trend was also observed in the SGR. The final CF and survival of *O. marmorata* were not affected by the different dietary lipid levels ($P>0.05$).

No significant differences were observed in FCR and DFI of fish fed with increasing dietary levels ($P>0.05$). In terms of protein utilization, PER of fish

Table 2. Growth performances, nutrient utilization, body indices and apparent digestibility coefficients of marble goby fed experimental diets

Parameters	Dietary treatments			
	D10	D14	D18	D22
Final BW(g)	13.76±0.57^{b}	11.21±0.56^{a}	11.55±1.09^{ab}	11.65±0.88^{ab}
Growth (%)	395.25±18.36^{b}	304.16±20.55^{a}	318.09±33.83^{a}	327.82±35.04^{ab}
SGR (%)	1.97±0.05^{b}	1.72±0.06^{a}	1.76±0.10^{ab}	1.79±0.10^{ab}
Initial CF	1.93±0.06	1.93±0.01	1.89±0.05	2.06±0.10
Final CF	2.43±0.16	2.48±0.05	2.64±0.01	2.59±0.10
Survival (%)	65.28±8.67	86.11±6.36	84.72±14.63	70.88±8.33
FCR	1.04±0.08	1.15±0.12	1.32±0.29	1.28±0.22
DFI (%)	1.36±0.16	1.51±0.08	1.78±0.42	1.82±0.13
PER	1.85±0.15^{b}	1.86±0.08^{b}	1.67±0.22^{b}	1.22±0.08^{a}
NRE (%)	24.79±1.18^{b}	20.72±0.69^{ab}	21.82±2.85^{ab}	19.80±1.00^{a}
HSI	3.06±0.17^{a}	3.60±0.34^{ab}	4.18±0.12^{b}	4.26±0.33^{b}
VSI	6.39±0.46^{a}	8.03±0.23^{b}	9.29±0.40^{bc}	9.98±0.49^{c}
IPF (%)	1.19±0.27^{a}	1.95±0.19^{b}	2.50±0.26^{bc}	3.06±0.08^{c}
ADC Protein	91.26±0.82	90.43±0.49	90.74±0.14	90.35±0.07
ADC Lipid	95.92±1.21	96.22±1.20	94.30±0.79	94.63±0.32

* Mean values with the same alphabet letter within the same row is not significant different
BW = Body Weight
SGR = Specific Growth Rate
CF = Condition Factor
FCR = Feed Conversion Ratio
DFI = Daily Feed Intake
PER = Protein Efficiency Ratio
NRE = Nitrogen Retention Efficiency
HSI = Hepatosomatic Index
VSI = Viscerosomatic Index
IPF = Intraperitoneal Fat
ADC = Apparent Digestibility Coefficiency

fed with D10, D14 and D18 were significantly higher than those fed D22 (P<0.05). Similarly, NRE of fish on D10 was significantly higher than those on D22 (P<0.05), while no significant differences were observed in fish on D14 and D18. Based on asecond-order polynomial regression of PER with increasing dietary lipid levels, an optimum lipid level for the highest PER in *O. marmorata* was estimated as 12.1% (Figure 1).

The increasing dietary lipid levels from D10 to D22 resulted in a gradual increase of HSI, VSI and IPF of fish. Fish fed with D10 had significantly lower HSI compared to fish fed D18 and D22 (P<0.05) which were comparable to D14. A significantly lower VSI was found in fish fed with D10 compared to fish in other treatments (P<0.05). Similarly, the lowest IPF was found in fish fed with D10. However, ADCs of dietary protein and lipid in fish fed with different dietary lipid levels were not significant different (P>0.05).

Carcass Composition

The proximate analysis of fish revealed that the body protein and ash contents were decreased with increasing levels of dietary lipid (P<0.05, Table 3), being significantly higher in fish onD10 than those on D22 (P<0.05). On the contrary, the increase in dietary lipid level led to a concomittant increase of whole body fat from 1.53% in fish on D10 to 3.73% in fish on D22 (P<0.05). The whole body dry matter levels were also significantly increased with dietary lipid levels (P<0.05). Asimilar trend was also observed in the hepatic lipid content with an increase from 30.9% in fish fed with D10to 51.9% in fish fed with D22 (P<0.05).

Discussion

In the present study, fish fed with D10 achieved the best growth rate and feed utilization. A further increase of dietary lipid level beyond D10 resulted in a decrease growth performance, PER, and NRE, and induced a fat deposition as indicated by aelevated HSI, VSI, IPF, body and hepatic lipid levels in fish fed with D22 (P<0.05). The FCR and ADC of protein and lipid in this present study were not affected by increasing dietary lipid levels. The decline of growth in *O. marmorata* when fed with high dietary lipid diets indicates a limited or absence of protein sparing effect of lipid. This result is in agreement with those in other fish species including turbot *Psetta maxima* (Sevgili *et al*., 2014) and blunt snout bream *Megabrama amblycephal* (Li *et al*.,2010). However, protein sparing effect was reported in rockfish juvenile *Sebates schlegeli* by (Lee *et al*., 2002) who recorded significantly better protein utilization, weight gain, feed efficiency, ADC of protein and lipid in fish fed with 42% protein and 14% lipid compared to those fed with 49% protein and 7% lipid. Similar

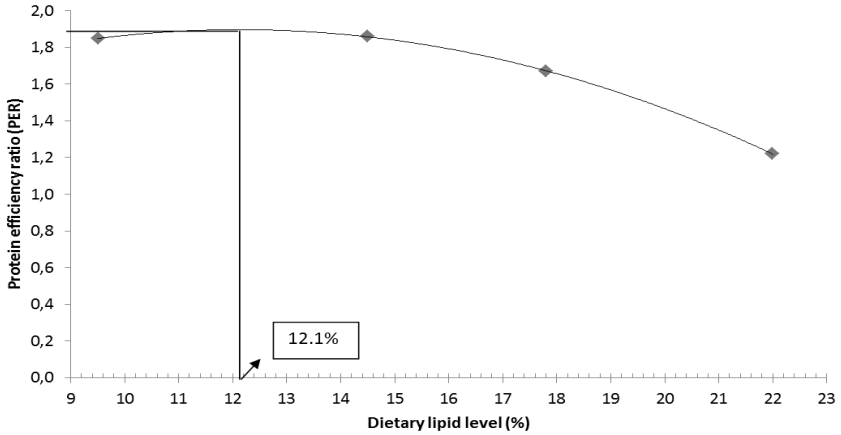

Figure 1. Relationship between dietary lipid levels of PER in juvenile *O. marmorata* ($y = -0.007x^2 + 0.1686x + 0.874$, $R^2 = 1$).

Table 3. Whole body composition and hepatic lipid contents of *O. marmorata* fed experimental diets

Proximate Analysis (%)[1]	Dietary treatments			
	D10	D14	D18	D22
Protein	53.01±0.58[b]	48.69±0.47[ab]	47.14±0.67[ab]	45.58±0.55[a]
Lipid	1.53±0.44[a]	1.59±0.49[a]	2.67±1.30[ab]	3.74±1.34[b]
Dry matter	32.03±0.92[b]	33.17±0.53[ab]	34.07±0.88[a]	34.49±0.92[a]
Ash	12.60±1.26[b]	12.41±0.61[b]	11.93±0.77[b]	10.37±0.90[a]
Hepatic lipid	30.92±6.02[a]	41.74±6.11[b]	46.30±5.02[bc]	51.85±5.14[c]

* Mean values with the same alphabet letter within the same row is not significant different
[1](n=9)

positive protein sparing effect of lipid was also reported in gilthead seabream *Sparus aurata* (Vergara *et al*., 1999), haddock *Melanogrammus aeglefinus* (Tibbetts *et al*., 2005) and brown-marbled grouper *Epinephelus fuscoguttatus* (Shapawi *et al*., 2014). The absence of protein sparing effect in the present study may be due to employment of a sufficient amount of dietary protein (50%) for *O. marmorata*. For instance, (Tibbetts *et al*., 2005) reported a protein sparing effect at lower protein level compared to the higher protein level when a high dietary lipid was provided in juvenile haddock.

The PER values declined when fish were fed with diets containing increasing levels of dietary lipid in the present study. Similarly, a lower NRE was also observed in the fish receiving higher lipid diets (D14, D18 and D22). This is in agreement with a study on grouper *Epinephelus malabaricus*, which showed that the PER decreased from 1.67 to 1.25 when dietary lipid increased from 4% to 16% (Lin and Shiau, 2003). Similar observation was also made in grass carp juvenile *Ctenopharyngodon idella* where PER decreased from 1.42 to 1.12 when dietary lipid level was increased from 2% to 12% (Du *et al*., 2005). In the present study, the ADCs of protein and lipid in all treatments were more than 90 and 94%, respectively. These high values are due to the use of readily digestible fish meal and oil as main protein and lipid respectively. Despite similar FCR and ADCs values of the treatments, the higher utilization and retention of protein may have contributed to higher growth in *O. marmorata* fed with D10 and the growth in fish fed with higher lipid level diets may partially be attributed to the significant higher deposition of fat in fish fed with D14 to D22. Asecond-order polynomial regression analysis on PER suggested that ca. 12.1% of dietary lipid is sufficient to achieve the highest protein utilization by *O. marmorata* juveniles. This lipid level of *O. marmorata* juvenile is comparable to the other carnivorous fishes European seabass *Dicentrachus labrax* requires an optimum level of 12% (Peres and Oliva-Teles, 1999); tiger puffer *Takifugu rubripes* requires less than 11% of dietary lipid (Kikuchi *et al*., 2009); white sea bream *Diplodus sargus* requires less than 9% (Sá *et al*., 2008) to achieve optimum growth. It should be noted that no improvement on the growth performance of tiger puffer (Kikuchi *et al*., 2009), white sea bream (Sá *et al*., 2008) and European seabass (Peres and Oliva-Teles, 1999) was observed when they were fed with dietary lipid level beyond their optimum lipid levels.

Dietary lipid levels higher than the optimum can induce an excessive lipid accumulation and mortality due to the fatty liver disease. This has been reported in adult *O. marmorata* by Bundit, 2007.In the present study, the whole body (1.53% to 3.74%) and hepatic lipid contents (30.2% to 51.85%) as well as intraperitoneal fat (1.19% to 3.06%) were

significantly higher in fish on D10 than those on D14 to D22. This is consistent with the findings of a study on grouper where optimum dietary lipid level was found as9% and higher lipid levels than this resulted in an elevated fat deposition from 4.12% to 6.39% (Lin and Shiau, 2003). Similar lipid accumulation in the whole body, liver and viscera organs with increasing dietary lipid was also observed in silver barb *Puntius gonionotus* (Mohanta *et al*., 2008), European sea bass *Dicentrarchus labrax* (Peres and Oliva-Teles, 1999), freshwater catfish *Mystus montanus* (Raj *et al*., 2007) and marbled spinefoot rabbitfish *Siganus rivulatus* (Ghanawi *et al*., 2011). In the present study the muscle lipid was not analyzed; however, significantly higher HSI, VSI, IPF and hepatic lipid found in fish fed with higher dietary lipid, indicating that the hepatic lipid and intraperitoneal fat are the main organ involved in the accumulation of fat and main contributor to the whole body lipid levels. The body lipid of juvenile *O. marmorata* in the present study was higher than the wild adult *O. marmorata* with 0.95% of body lipid (Bundit, 2007). This may due to the intake of different types of diet in captivity compared to the food resources in a natural habitat (Karapangiotidis *et al*., 2006; Karapangiotidis *et al*., 2010).

In the present study, the body lipids and dry matter increased significantly with the increase of dietary lipid levels being in agreement with astudy on turbot that showed an increase of body lipid and dry matter when fed with diets containing 10% to 19% of dietary lipid (Sevgili *et al*., 2014). On the contrary, the body protein and ash contents of *O. marmorata* declined significantly with an increase in dietary lipid levels. The protein and ash content showed an inverse relationship with the body lipid and dry matter. However, in turbot no significant change on the body protein with the increase of dietary lipid levels (Sevgili *et al*., 2014). A study on gilthead sea bream *Sparus aurata* suggested that at higher protein-energy intake, the energy retained in the form of protein declined and that protein energy may be utilized for protein and lipid deposition (Lupatsch *et al*., 2003). This study may support our observation that lower protein utilization and retention in the body of *O. marmorata* that was fed with higher lipid content may be attributed to the utilization of the protein energy for protein and lipid deposition.

Another reason of the increase in body lipid and deposition of fat in the peritoneal in the present study may be that the fish have limited ability to utilize high dietary lipid levels (Schulz *et al*., 2008).In general, high energy diet should be avoided for lean fish species such as white grouper *Epinephelus aeneus* (Lupatsch and Kissil, 2005), mouse grouper *Cromileptes altiveles* (Williams *et al*., 2004), and turbot (Sevgili *et al*., 2014), since these fish species do not appear to require high energy diets per unit of body weight gain compared to relatively energy-dense fish such as European seabass and gilthead sea bream (Lupatsch *et al*., 2003). *O. marmorata* can also be considered as a lean fish with low body lipid content and have limited ability to utilize high dietary lipid diets. A study on haddock revealed that the inefficient lipid utilization and occurrence of fatty liver in the fish are due to the limited mobilization of lipid from liver to muscle and low catabolic activity of lipid in the liver (Nanton *et al*., 2003, Tibbetts *et al*., 2005; Zeng *et al*., 2010). However, such information is not available for *O. marmorata* and reserved further investigation. Furthermore, *O. marmorata* is referred as a "sleeper" (Larson and Murdy, 2001) and sedentary fish and do not move actively in captivity; thus they do not spend much energy for their movement. Feeding fish with high dietary lipid that have limited ability to utilize the high dietary lipid efficiently not only results in low growth, feed utilization, but it also reduces the commercial value of the final product of fish by affecting the processing yield, product quality and the storage stability (Cowey, 1993). The high dietary lipid that is poorly utilized by fish has also been reported lead to high loads of carbon (mainly contributed by the carbon in dietary lipid) in the environment (Sevgili *et al*., 2014).

In the present study, based on asecond-order polynomial regression analysis 12.1% of dietary lipid is suggested to be sufficient for marble goby juvenile to achievea better protein utilization by *O. marmorata*. A further increase of dietary lipid level deteriorates the growth performance, PER, NRE and induces excessive body fat deposition.

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