The effects of dietary lipid level on the growth performance, body composition and feed utilization of juvenile kelabau (*Osteochilus melanopleura*)

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Abstract. Kelabau is a herbivorous fish that lives in rivers and lakes on the islands of Kalimantan and Sumatra. Its growth requires nutrients such as proteins, carbohydrates and lipids. Lipid, in addition to supporting the metabolism and absorption of vitamins, also play an important role in providing energy. The purpose of this study was to determine the influence of varied lipid content feed on the growth performance and body composition of kelabau (*Osteochilus melanopleura*). In this study, four isonitrogen, isoCHO experimental diets, with a 1:1 ratio of fish oil and corn oil, were used. The lipid contents of each diet were 5% (A), 7% (B), 9% (C), and 11% (D). The experimental kelabau specimens were obtained from the Mandiangin Freshwater Seed Center, with an average weight of 3.18±0.26 g. The experimental fish were reared in plastic tanks measuring 54.3 x 38 x 31.5 cm^3 and filled with 40 liters of water, at a density of 20 fish $tank^{-1}$. Fish were fed twice a day at satiation for 60 days. The results showed that feed B (7%) resulted in higher growth performance and feed utilization than the other groups (C, D and A) ($p<0.05$). Furthermore, increasing the lipid content from 5% to 7% influenced the protein, lipid and energy retention.

Key Words: lipid content, protein, isonitrogenous diet.

Introduction. Kelabau (*Osteochilus melanopleura*) is a valuable commodity with a high commercial worth. Since 2013, this fish has been cultivated. *O. melanopleura* is an ecologically important herbivorous fish that plays an important role in river and lake ecosystems. According to research on *O. melanopleura* feeding habits, plants, phytoplankton, and aquatic algae were detected in the digestive tract of *O. melanopleura (*Kotellat et al 1984*)*. The gut of juvenile *O. melanopleura* measuring 200-299 mm contained 83.3 g 100 g^{-1} plant, but the intestine of larger *O. melanopleura* (300 mm) contained 100 g kg^{-1} plant (Aizam et al 1983). Efforts have been made to improve *O. melanopleura* growth performance. Susanto et al (2019) observed that kelabau fed with feed containing 31.88 g 100 g^{-1} protein and 11 g 100 g^{-1} lipid resulted in the highest growth. Furthermore, Susanto et al (2020) observed that *O. melanopleura* fed with feed comprising 32.76 g 100 g^{-1} carbohydrate and a lipid range from 9.1 to 9.6 g 100 g^{-1} exhibited the highest growth performance and feed utilization. Lipid in fish is different from lipid in mammals. Fish lipid contains more than 40 g 100 g^{-1} long-chain fatty acids (14-22 carbon atoms) that are highly unsaturated. Mammalian lipid rarely contains more than two double bonds per fatty acid molecule whereas fish lipid deposition contains some fatty acids with five or six double bonds (Secci & Parisi 2016). In fish, the liver organ has a higher concentration of fatty acids than adipose tissue, however in mammals, lipids are more concentrated in adipose tissue (Lovell 1989).

Fish requirements for essential fatty acids are different for each fish species (Furuichi 1988). These differences are mainly related to their habitat. Fish that live in the sea need more n-3 fatty acids, while fish that live in fresh water need either only n-3 fatty acids or a combination of n-3 and n-6 fatty acids (Hepher 1990). Among freshwater species such as ayu fish, channel catfish, coho salmon and rainbow trout require 18:3 (n-3) or EPA and/or DHA. Chum salmon, carp and Japanese eel require an equal mixture of 18:2 (n-6) and 18:3 (n-3) while tilapia and *Tilapia zillii* only require 18:2 (n-6) for maximum growth and feed efficiency (Webster & Lim 2002). The protein content of rainbow trout feed can be reduced from 48 to 35 g 100 g^{-1} without decreasing body weight gain, if the lipid content of the feed is increased from 15 to 20 g 100 g^{-1} (NRC 1993). When rainbow trout are fed high-fat diet, they develop and store more fat in their perivisceral tissues (Trenzado et al 2018).

The presence of lipid in feed is strongly influenced by the size of fish, age, feeding technique, and feed composition (NRC 1993). The grass carp (*Ctenopharyngodon idella*) ingesting 36 g 100 g^{-1} lipid had the best SGR, percent weight growth, and feed consumption rate (Ni et al 2016). *Nibea albiflora* fed with feed containing 13 g and 15 g 100 g^{-1} lipid resulted in higher weight and SGR growth than fish fed a diet with 5 g 100 g^{-1} lipid, while fish fed 13 g 100 g^{-1} lipid resulted in the best FCR (Wang et al 2016). Black snapper (*Micropterus salmoides*) was able to grow well at a lipid content of 18 g 100 g^{-1} (Guo et al 2019). The highest daily (weight) growth coefficient (DGC) and protein efficiency ratio (PER) were produced by red catfish (*Hemibagrus wyckioides*) fed with feed containing 10.5 g 100 g^{-1} lipid (Deng et al 2021). Tilapia (*O. niloticus*) fed with feed containing 7-8.5 g 100 g^{-1} lipid resulted in the optimum growth rate and feed utilization efficiency (Abdel-Ghany et al 2021). The results of these studies indicated that the requirement for lipid in feed is species-specific. In absence of similar studies conducted on *O. melanopleura*, the present work focuses on the influence of lipids in feed on the growth parameters, in order to optimize *O. melanopleura*'s culture.

Material and Method

Experimental diets. Four isonitrogenous (33.0 g 100 g^{-1} crude protein) experimental diets containing carbohydrates ranging from 26.94 to 28.63 g 100 g^{-1} were formulated to contain different lipid levels, and named as feed A (5 g 100 g^{-1} lipid), feed B (7 g 100 g^{-1} lipid), feed C (9 g 100 g^{-1} lipid) and feed D (11 g 100 g^{-1} lipid). Dietary CP ratio ranged from 7.21-8.57 kcal (Table 1).

Table 1

Composition of experimental diets and nutrient content*

No.	Source of feed ingredients	*Composition*			
		Feed A (5 g 100 g^{-1} lipid)	*Feed B (7 g 100 g^{-1} lipid)*	*Feed C (9 g 100 g^{-1} lipid)*	*Feed D (11 g 100 g^{-1} lipid)*
1	Fish meal	28.25	28.25	28.25	28.25
2	Soybean meal	25.70	25.70	25.70	25.70
3	Wheat flour	14.50	14.50	14.50	14.50
4	Bran flour	10.00	10.00	10.00	10.00
5	Fish oil	1.55	2.55	3.55	4.55
6	Corn oil	1.55	2.55	3.55	4.55
7	Vitamin mix[1)]	3.00	3.00	3.00	3.00
8	Mineral mix[2)]	3.00	3.00	3.00	3.00
9	Coline chloride	2.00	2.00	2.00	2.00
10	Cmc[3)]	2.00	2.00	2.00	2.00
11	Organic chromium	0.18	0.18	0.18	0.18
12	filler	8.27	6.27	4.27	2.27
		Feed proximate test results			
	Protein (g 100 g^{-1})	33.1	33.0	33.1	33.0

No.	Source of feed ingredients	*Composition*			
		Feed A (5 g 100 g⁻¹ lipid)	*Feed B (7 g 100 g⁻¹ lipid)*	*Feed C (9 g 100 g⁻¹ lipid)*	*Feed D (11 g 100 g⁻¹ lipid)*
	Ether extract (g 100 g^{-1})	5.8	7.3	9.6	11.7
	FNE (g 100 g^{-1})	30.2	30.8	30.8	28.9
	Energy (Kcal)[4)]	238.35	252.06	267.15	282.72
	C/P (Kcal g^{-1} protein)	7.21	7.63	8.34	8.57

*Calculation based on dry weight; [1)]In mg kg^{-1} feed: vit.B_1 60; vit. B_2 100; vit. B_{12} 100; vit.C 2000; vit. K_3 50; vit. A/D_3 400; Vit. E 200; Ca pantothenic acid 100; inositol 2000; biotin 300; folic acid 15; niacin 400; [2)]In mg kg^{-1} feed: $MgSO_4 .7H_2 0$ 7.5; NaCl 0.5; $NaH_2 PO_4 .2H_2 O$ 12.5; $KH_2 PO_4$ 16.0; $CaHPO_4 .2H_2 O$ 6.53; Fe citrate 1.25; $ZnSO_4 .7H_2 O$ 0.1765; $MnSO_4 .4H_2 O$ 0.081; $CuSO_4.5HO_2$ 0.0155; KIO_3 0.0015; $CoSO_4$ 0.0003; [3)]Carboxymethyl cellulose; [4)]Protein = 3.5 kcal g^{-1}; Free Nitrogen Extract (FNE) = 2.5 kcal g^{-1}; Ether Extract = 8.1 kcal g^{-1}.

Fish rearing. *O. melanopleura* seeds were obtained from the Mandiangin Freshwater Seed Centre in South Kalimantan. *O. melanopleura* were raised in plastic tanks of 54.3 cm x 38 cm x 31.5 cm in size and filled with 40 L of water. Each plastic tank was stocked with 20 fish weighing with average weight of 1.03±0.19 g each. Fish were grown for 60 days by feeding twice a day at satiation, in the morning and evening. A semi-closed circulation system was used to keep *O. melanopleura*. Faeces syphoning was conducted in the morning. The volume of water lost due to syphoning was replenished. Every day, the filters were cleaned. Once a week, the filter tank is cleaned and the water is changed. During the study, the water temperature averaged 28.6±1.0^o C, the dissolved oxygen was 4.55-5.10 mg L^{-1}, the pH was 6.82-6.90, and the total ammonia nitrogen was 0.37-0.63 mg L^{-1}. This indicates that the water quality during the study was optimal (Effendi 2003).

Data collection and chemical analysis. Body weight weighing was carried out at the beginning and end of the study in the state of anesthetized fish. Fish were anesthetized using clove oil. Weighing is done to determine the daily growth rate (SGR) (Dewantoro et al 2018). Feed consumed during the study was recorded to determine total feed consumption (Andriani et al 2018), and feed efficiency, protein retention, lipid retention, energy retention (NRC 1993), and protein efficiency ratio (PER) (Coutinho et al 2018). Body proximate analysis was conducted at the beginning and end of the study which was used to determine the nutrient composition of the fish (Takeuchi 1988).

Statistical analysis. This research design is a laboratory experimental model, using a complete randomized design (CRD) consisting of 3 treatments and 5 replicates. Data on feed efficiency, weight growth, total feed consumption, protein retention, lipid retention, and energy retention as well as protein efficiency ratio were analyzed for diversity with ANOVA and continued with Tukey test at 95% confidence interval, using SPSS program.

Results

Weight growth, relative growth, total feed consumption and feed efficiency. The values of feed utilization parameters including weight gain, specific growth rate, relative growth rate, and protein efficiency ratio as well as feed efficiency, protein retention, lipid retention and energy retention of *O. melanopleura* after being reared for 60 days with feed containing different proteins are presented in Table 2. Weight gain, relative growth rate, specific growth rate, average daily growth, protein efficiency ratio, feed utilization efficiency, protein retention, lipid retention, and energy retention were all significantly affected in *O. melanopleura* fed with feed containing a varying lipid concentration ($p \leq 0.05$). The fish group consuming feed with 7 g 100 g^{-1} lipid content had the highest final weight of 82.3±6.0 g, followed by the fish groups consuming 9 g 100 g^{-1} and 11 g 100 g^{-1} lipid. The fish group consuming feed with 5 g 100 g^{-1} lipid content had the lowest final weight. The best biomass weight growth was obtained in the fish group consuming feed B (7 g 100 g^{-1}) at 63.1±7.3 g, followed by fish consuming feed C (9 g 100 g^{-1}) at

52.4±6.8 g, and eventually feed D (11 g 100 g^{-1}) and feed A (5 g 100 g^{-1}), at 47.6±4.5 g and 46.8±5.3 g, respectively ($p \leq 0.05$).

The best relative growth rate was obtained in the fish group fed feed B, which amounted to 5.5±1.1% day^{-1}, equal to the fish group eating feed C, which amounted to 5.2±2.1% day^{-1}, and it was substantially different in the fish groups consuming feed D and A ($p \leq 0.05$). The same phenomenon was observed in the specific growth rate, with the fish group consuming feed B having the best specific growth rate of 2.4±0.2% day^{-1}, similar to the fish group consuming feed C, which amounted to 2.3±0.4% day^{-1}, and it was significantly different in fish consuming feed D and A ($p \leq 0.05$). The findings of this experiment confirmed that the feed provided can be used by *O. melanopleura* to increase their growth. Fish lipids can be used as a source of energy in addition to carbohydrate to support a variety of activities.

The lipid contained in feed B appeared to provide the highest growth compared to other treatments. This indicates that the lipid content in feed B is able to meet the energy requirements of the fish and utilize protein optimally in its growth, whereas in treatment A the lipid is not optimally utilized in growth because part of the protein portion is catabolized to meet energy for its activities due to low feed energy. This is in line with the opinion of Ensminger et al (1990) which stated that if the energy consumed by fish is insufficient, the fish will catabolize protein to be used in its activities.

Excess lipid in fish groups C and D, on the other hand, does not always result in the highest growth; this is due to the availability of energy in the feed ingested. When the energy content of the feed taken is high, fish tend to limit the amount of feed consumed, limiting the protein content of the feed consumed. If the feed energy content is too low, most of the feed protein will be catabolized to meet energy needs, causing fish to consume a large amount of feed to meet their needs. If the feed energy content is too high, the fish will limit their feed consumption because their basic energy needs have been met (Mokoginta et al 1995).

Table 2

Mean growth parameter values of *Osteochilus melanopleura* reared for 60 days with feed containing different lipid concentrations

Parameters	*Feed lipid (% Dry weight)*			
	A(5 g 100 g^{-1})	*B(7 g 100 g^{-1})*	*C(9 g 100 g^{-1})*	*D(11 g 100 g^{-1})*
Initial weight (g)	22.1±1.3	19.2±1.7	18.1±3.8	22.6±5.8
Final weight (g)	68.9±6.3^{a}	82.3±5.9^{b}	70.5±5.0^{ab}	70.3±10.2^{ab}
Weight gain (g)	46.8±5.3^{a}	63.1±7.3^{b}	52.4±6.8^{ab}	47.6±4.5^{a}
RGR (% day^{-1})	3.5±0.3^{a}	5.5±1.1^{b}	5.2±2.1^{ab}	3.6±0.6^{a}
ADG (g day^{-1})	0.8±0.1^{a}	1.0±0.1^{b}	0.9±0.1^{ab}	0.8±0.1^{a}
SGR (% day^{-1})	1.9±0.1^{a}	2.4±0.2^{b}	2.3±0.4^{ab}	1.9±0.2^{a}
TFC (%)	87.3±6.3^{a}	79.7±11.7^{a}	81.4±5.4^{a}	77.9±3.3^{a}
PER (%)	1.6±0.2^{a}	2.4±0.3^{b}	2.0±0.2^{a}	1.9±0.1^{a}
FE (%)	54.0±7.8^{a}	79.9±10.5^{b}	64.2±5.7^{a}	61.2±4.7^{a}
PR (%)	110.8±14.3^{a}	153.2±18.6^{b}	125.7±10.4^{a}	120.3±10.0^{a}
LR (%)	175.5±41.6^{a}	267.6±33.8^{b}	164.7±22.4^{a}	135.1±23.0^{a}
ER (%)	89.5±14.3^{a}	133.6±16.5^{b}	101.7±10.1^{a}	94.3±9.1^{a}

RGR-relative growth rate; SGR-specific growth rate; ADG-average daily growth; TFC-total feed consumption; PER-protein efficiency ratio; FE-feed efficiency; PR-protein retention; LR-lipid retention; ER-energy retention. Numbers followed by the same letter in the same row indicate no significant difference ($p > 0.05$).

O. melanopleura fish fed with C consumed more feed than under the other treatments, although the levels of feed intake in these four groups of fish were not significantly different ($p \geq 0.05$). The feed utilization rate of *O. melanopleura* fed with varied lipid content feed indicated a satisfactory utilization rate. *O. melanopleura* consuming feed B had the lowest protein efficiency ratio (PER) compared to fish consuming feed C, D and A ($p \leq 0.05$). The best feed efficiency value, 79.9±10.5%, was obtained in fish consuming feed B, which was different from the fish group consuming feed C and D, with 64.2±5.7% and 61.2±4.7%, respectively. Fish that consumed feed A produced a low feed efficiency value, of 54.0±7.8%.

Initial and final body proximate composition. The proximate body composition of kelabau fish both at the beginning of the study and at the end of the study and after the fish had been reared for 60 days by feeding with different lipid content is presented in Table 3. Fish body protein content at the end of the study tended to decrease with an increasing feed lipid concentration until the lipid content reached 9.0 g 100 g^{-1} but not significantly ($p \geq 0.05$). Fish body lipid content tended to increase with increasing feed lipid content, while the ash content tended to be the same ($p \geq 0.05$). FNE content tended to decrease up to 7 g 100 g^{-1} feed lipid content and increased again with increasing lipid content ($p \geq 0.05$).

Table 3

Initial and final body proximate composition of *Osteochilus melanopleura* reared for 60 days on diets containing different lipid concentrations (in % dry weight)

Parameters	*Feed lipid level (% Dry weight)*			
	A(5 g 100 g^{-1})	*B(7 g 100 g^{-1})*	*C(9 g 100 g^{-1})*	*D(11 g 100 g^{-1})*
Initial proximate composition (%)				
Protein	62.1	62.1	62.1	62.1
Lipid	21.9	21.9	21.9	21.9
Ash	13.5	13.5	13.5	13.5
FNE	2.5	2.5	2.5	2.5
Final proximate composition (%)				
Protein	66.1±1.1^{b}	63.1±0.9^{a}	62.5±0.8^{a}	63.0±1.3^{a}
Lipid	19.8±1.7^{a}	23.9±0.3^{b}	24.0±1.7^{b}	24.6±2.6^{b}
Ash	11.2±0.5^{a}	11.5±0.9^{a}	11.3±1.1^{a}	10.5±0.9^{a}
FNE	1.5±0.4^{b}	0.5±0.2^{a}	1.3±0.2^{b}	1.4±0.4^{b}

Numbers followed by the same letter in the same row indicate no significant difference ($p > 0.05$). FNE-Free Nitrogen Extract.

Discussion. Feeding with increased lipid content of up to 7 g 100 g^{-1} significantly improved the growth performance of *O. melanopleura*, which then decreased with the rising of lipid content of up to 11 g 100 g^{-1}. This indicates that *O. melanopleura* consuming feed B are better able to utilize non-protein feed energy sources, particularly lipid, for their activities and are more efficient in utilizing protein for growth compared to fish groups consuming feed C, feed D, and fish groups consuming feed A. According to Halver & Hardy (2002), the availability of energy, particularly from carbohydrate as an energy source in addition to fat and protein, is used primarily for metabolism, then for growth, and finally for reproduction in nature. As a result, if the energy requirements for metabolism are met, extra nutrients or energy will be retained or used for reproduction. Wilson (1994) added that if energy is scarce, other nutrients such as protein will be metabolized for energy, resulting in delayed fish growth.

In this study, the feed utilization efficiency ranges from 55 to 79%. Feed efficiency in the study is nearly identical to the results of Abdel-Ghany's et al (2021) on tilapia (*Oreochromis niloticus*) fed with 7 g 100 g^{-1} lipid content, resulting in a lower FCR than the fish group that received feed with greater lipid content. Deng et al (2021) reported high feed efficiency findings in the red tail fish (*Hemibagrus wyckioides*) fed with 3 g 100 g^{-1}, 5.5 g 100 g^{-1}, 8 g 100 g^{-1}, 10.5 g 100 g^{-1}, and 13 g 100 g^{-1} lipid content, with feed efficiency values ranging from 90.98% to 113.37% and a biomass growth only reaching 7.17-8.31 g. The feed efficiency obtained in this study is still in line with the results of Wu et al (2020) on the grass carp (*Ctenopharyngodon idellus*) and Li et al (2016) on *Nubea diachantus* but the feed efficiency value is lower. The research of Wu et al (2020) on *C. idellus* indicated an increase of feed efficiency from 37 to 80%. Guo et al (2019) also obtained feed efficiency of *Micropterus salmoides* fish of 66.66% at 3% feed lipid content, increasing to 83.34% in fish consuming feed with 13% lipid content.

Feed consumption rate describes the level of energy uptake by living organisms. The results of this study showed almost the same level of feed consumption between treatments, but gave different levels of feed utilization as seen in treatment B. This can be seen from the value of the high feed efficiency, protein efficiency ratio, protein retention, lipid retention and energy retention, compared to other treatments. This is in accordance with the opinion of Elliott (1979), stating that a minimal level of energy uptake causes the body condition of the fish to remain unchanged or to have a low growth, whereas if the level of energy uptake from the amount of feed consumed is optimal, it causes high growth and the level of feed efficiency will be maximized.

The retention of nutrients such as protein retention, lipid retention and energy retention in the body illustrates the quality of the feed given. The high value of feed retention indicates that the feed given is very good, and vice versa if the feed retention value is low, then the feed quality is also low. The protein retention value in the fish group that consumed feed B gave the highest protein retention value, of 153.19±18.62%, compared to fish groups A, B and D ($p \leq 0.05$). The highest lipid retention was obtained in fish group B, with a lipid retention value of 267.62±33.79%, followed by fish groups A (175.47±41.59%), C (164.74±22.39%), and the lowest lipid retention value was obtained in fish group D (135.13±23.01%) ($p \leq 0.05$). The highest energy retention was obtained in the fish group consuming feed B with a value of 133.55±16.55%, followed by fish groups consuming feed C, D and A ($p \leq 0.05$). The high value of nutrient retention in the fish group consuming feed B indicates that the quality of this feed is very good. Therefore, fish in group B are able to deposit protein in their body and convert it for better growth. The high lipid and energy retention values in fish group B also illustrate the high potential for building energy reserves, which will be used when energy availability is reduced. This opinion is in accordance with the opinion of Halver & Hardy (2002), which states that a high nutrient retention provides the best effect for growth and the availability of sufficient energy reserves if external energy sources (feed) are not sufficient.

The use of energy by fish group B is quite efficient. This is evident from the high energy retention value acquired by fish group B, which is 133.55%, while the remaining 16.70% is lost in the form of faeces and urine and utilized for other activities. According to Elliot (1979), the energy lost in faeces (F) and urine (U) is around 15% and 3-5%, respectively, while the remaining 80% is utilized for metabolism and growth. According to this viewpoint, faeces and urine account for 20.0% of the 36.22% of energy lost, whereas other activities account for 16.22%. The energy that remains after these activities is stored or retained in tissues and muscles. The range of energy spent for other activities was higher in the other treatments, ranging from 25.80% (C) to 33.70% (D). Feeding with increasing lipid content up to 7 g 100 g^{-1} will considerably improve *O. melanopleura* growth performance, whereas feeding with rising lipid content up to 11 g 100 g^{-1} would decrease the growth performance. *O. melanopleura* fed feed with 7 g 100 g^{-1} lipid content are better able to use feed protein sources for growth than fish fed feed C and D, which contain more lipid (9 g 100 g^{-1} and 11 g 100 g^{-1}). This suggests that the protein consumed is not always utilized for growth. According to Zonneveld et al (1991), in nature, nutrients should be available first for metabolism, then for growth, and finally for reproduction. This means that once the nutrients or energy requirements for metabolism and growth are met, excess nutrients or energy will be stored or used for reproduction. Based on growth and feed efficiency, the optimum feed lipid level for kelabau is 7 g 100 g^{-1}. This result is similar to that of Sankian et al (2017) on golden mandarin fish (*Siniperca scherzeri*), but it is lower than in other fish, such as *M. salmoides* (18.0 g 100 g^{-1}) (Guo et al 2019) and red-tailed catfish *Hemibagrus wyckioides* (10.5 g 100 g^{-1}) (Deng et al 2021). The optimal feed lipid content of 7 g 100 g^{-1} in this study was also lower than the results of Meng et al (2019) in rainbow trout (*O. mykiss*), which exhibited the highest growth and feed utilization efficiency at an optimum lipid level of 23.3 g 100 g^{-1}.

Higher results were also found in Gulf Corvina fish (*Cynoscion orthonopterus*) requiring 11 g 100 g^{-1} lipid (González-Félix et al 2015) and in topmouth culter (*Culter alburnus basilewsky*) 8 g 100 g^{-1} at 40-45 g 100 g^{-1} feed protein (Zhang et al 2015). The best growth in rohu fish (*Labeo rohita*) was observed for feed with 9 g 100 g^{-1} lipid content (Gandotra et al 2017). Chinese perch (*Siniperca chuatsi*) was able to grow well at 12 g 100 g^{-1} lipid content (Wang et al 2018). The increase in body nutrient levels during the study indicates that the feed given is able to be utilized by fish for growth. This is in line with the opinion of Zonneveld et al (1991) that growth is the result of two processes, namely a process that tends to reduce body energy and a process that begins with food intake and ends with the preparation of body elements. Body protein levels decreased with an increasing feed lipid content up to 9 g 100 g^{-1}, then increased again at higher lipid levels, of 11 g 100 g^{-1}. Body lipid content increased with increasing feed lipid content. This indicates lipid deposition in the fish body. Ash content did not differ between treatments, indicating that lipid did not play a role in increasing the minerals concentration in the body. Body FNE content decreased with an increasing feed lipid content up to 7 g 100 g^{-1}, and then it increased with an increasing feed lipid content. This indicates that in treatment B (7 g 100 g^{-1}), more energy from carbohydrates is used for fish activity.

Conclusions. The growth performance rises as the lipid content of the meal increases. In comparison to other treatments, *O. melanopleura* that were fed a diet containing 7 g 100 g^{-1} lipid demonstrated the best weight growth, relative growth, feed efficiency, protein efficiency ratio, protein retention, lipid retention, and energy retention.

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