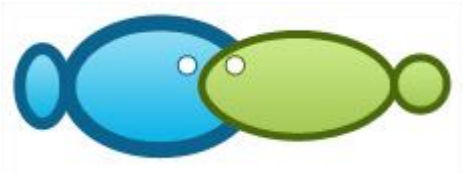

Effects of dietary protein and lipid levels on growth, feed utilization and body composition of juvenile snubnose pompano (*Trachinotus blochii*)

[1]Le Q. Viet, [1]Tran T. T. Hien, [1]Tran L. C. Tu, [1]Tran N. D. Khoa, [1]Dao T. N. Linh, [2]Nguyen T. H. Gam, [3]Viliame Waqalevu, [4]Kotani Tomonari, [4]Shunsuke Koshio, [1]Truong Q. Phu, [1]Tran N. Hai

[1] College of Aquaculture and Fisheries, Can Tho University, Cantho city, Vietnam; [2] Farmer's Union, Tan Thanh district, Long An province, Vietnam; [3] PSL Research University, EPHE-UPVD-CNRS, USR 3278 CRIOBE BP 1013, 98729 Papetoai, Moorea, French Polynesia; [4] Faculty of Fisheries, Kagoshima University, Shimoarata 4-50-20, Kagoshima 890-0056, Japan. Corresponding author: T. N. Hai, tnhai@ctu.edu.vn

Abstract. The study aimed to determine dietary protein and lipid requirements for *Trachinotus blochii* juvenile. The experiment was consisted of two factors: four protein levels (35%, 40%, 45%, 50%) and 3 lipid levels (6%, 9%, 12%). The fish were initially stocked in tanks at the density of 30 inds tank^{-1}. *T. blochii* survival was not significantly affected by dietary protein or lipid (98.3-100%). The growth increased with increasing protein levels and peaking at 50% protein. The best growth rates and feed efficiency were observed in the diet containing 9% lipid. Dietary lipid from 9 to 12% did not induce protein-sparing action. The hepatic somatic index (HSI) and the visceral somatic index (VSI) decreased with increasing dietary protein content. The results highlight that diets containing 50% protein and 9% lipids are suitable for the optimal nursing of *T. blochii* juveniles.
Key words: dietary, growth, lipid requirement, metabolism, protein requirement, snubnose pompano.

Introduction. The dietary protein plays important roles for adequate growth and maintenance of fish and this nutrient compoment is responsable for most of production cost of artificial diets (de Lemos et al 2014). Unsimilar to lipids and carbohydrates, proteins are not preserved in the fish body and excess dietary proteins are used as an energy source for intermediary metabolism or are converted to glucose or lipids as energy deposits (Dabrowski & Guderley 2002; Teles et al 2020). Moreover, nitrogen from feed and fish excretion is one of the main nutrients causing water eutrophication and negatively impact the environment (Kong et al 2020). Accordingly, protein excess could make the diet unbalanced and results in extra costs from feed, water treatment, nitrogen excretion and aquatic pollution. For economic and practical aspects , it is important to improve protein quality of diets to balance diet nutrients and to reduce feed costs and environmetal pollution (Ullah-Khan et al 2019).

However, several factors affected determination of the optimum dietary protein requirements of fish including the fish species and size, the quality of the protein source, and the amount of non-protein energy in the diet (NRC 2011; Sankian et al 2017). The dietary protein will be catabolized to supply energy when non-protein energy in the diet is insufficient (Sankian et al 2017). Thus, lipids have been used as a dietary supplementation of energy-yielding nutrients to spare or improve the efficiency of protein utilization by fish. The dietary lipid is an energy-dense nutrient that is readily metabolized by fish (NRC 1993). Supplementation with dietary lipid as an energy source has been reported to be more effective and is currently the trend in fish feed production. Therefore, the optimal dietary balance between protein and lipid is very important for achieving maximum growth and efficient feed utilization of fish species (Schuchardt et al 2008).

The snubnose pompano (*Trachinotus blochii*) is an important species for aquaculture in the Asia–Pacific region due to its fast growth, euryhaline nature, meat flavour and quality, and lack of bones (Gopakumar et al 2012). The farming of *T. blochii* has been practiced in offshore seacages, brackish water seacages and even coastal ponds in many countries (Prabu et al 2020). Pompano aquaculture is intensifying and expanding rapidly, therefore numerous studies have been directed towards the development of appropriate artificial feed and optimization of diets for this species. Many of these previous studies have highlighted the importance of protein requirements and balance between protein and non-protein energy sources for pompano varieties (Thu et al 2016; Prabu et al 2020). A similar species, *Tor putitora* has been shown to require a diet consisting of 45% protein for improved growth performance (Sunder et al 1998; Islam & Tanaka 2004). Moreover, Mohan & Basade (2005) reported that *T. putitora* fed diets having a protein to energy ratio (P/E) of 23 mg kJ^{-1} gave the best growth performance compared to fish fed diet with a P/E ratio of 26 or 19 mg kJ^{-1}. It was also observed in another similar species, *Trachinotus ovatus*, that increasing the dietary lipid level from 6.5 to 12.5% did not induce protein-sparing action, and the suitable dietary protein and lipid levels should be 45-49% and 6.5% respectively (Wang et al 2013). Riche (2009) reported the dietary lipid level for maximum growth of *Trachinotus carolinus* was 180 g kg^{-1}.

For *T. blochii*, Jayakumar et al (2014) suggested a diet containing 50% of protein for juveniles (1 g) and reduction to 30-40% protein for fingerlings. At low salinity conditions, Prabu et al (2020) reported dietary protein with a balanced level of limiting amino acids such as lysine and methionine negatively affected growth, feed utilization, body indices, and digestive enzymology of *T. blochii*. They also highlighted that the optimum dietary protein levels should be in the range of 395.3-426.7 g kg^{-1} (with lipid levels at 10%) for maximum growth of *T. blochii* fingerlings (16-20 g) (Prabu et al 2020). The objective of the present study is to determine the optimal dietary protein and lipid levels with respect to growth, feed conversion ratio, nitrogen retention, and carcass composition of juvenile *T. blochii*. Results obtained from this study could assist in the fomulation of diets, which are cost-effective and nutritionally practical, for *T. blochii* nursery.

Material and Method

Experimental diets. The experiment lasted 56 days (from March to April 2020) and was conducted in a 4 (protein levels) x 3 (lipid levels) factorial protocol in quadruplicate. The four dietary protein levels (35, 40, 45, and 50%) were tested. Also, the three dietary lipid levels (6, 9, and 12%) were included. The treatments were labeled as 35P-6L, 40P-6L, 45P-6L, 50P-6L, 35P-9L, 40P-9L, 45P-9L, 50P-9L, 35P-12L, 40P-12L, 45P-12L and 50P-12L. The experimental diets were formulated based on common ingredients as fishmeal, soybean meal, cassava meal, fish oil, soybean oil, shrimp extract, premix, and binder, presented in Table 1. Ingredients were finely ground, added 30% of water, pelleted with a diameter of 2 mm, dried in an oven at 45ºC for 12 hours to reach a humidity of about 10%. All diets, after being processed, were stored in the freezer at the temperature of -20ºC during the experiment. The chemical compositions (including amino acids) of all diet treatments are presented in Table 2.

Table 1

Amounts (%) of ingredients used in the experimental diets

Lipid (%)	*Protein (%)*	*Ingredients*							
		Fish meal	*Soybean meal*	*Cassava*	*Fish oil*	*Soybean oil*	*Premix**	*Binder*	*Shrimp extract*
6	35	26.7	30.0	34.5	1.5	2.9	2.0	1.0	1.5
	40	34.0	30.0	27.7	1.0	2.9	2.0	1.0	1.5
	45	41.3	30.0	20.8	0.6	2.9	2.0	1.0	1.5
	50	48.6	30.0	13.9	0.2	2.9	2.0	1.0	1.5
9	35	26.7	30.0	31.5	3.0	4.4	2.0	1.0	1.5
	40	34.0	30.0	24.6	2.5	4.4	2.0	1.0	1.5
	45	41.3	30.0	17.7	2.1	4.4	2.0	1.0	1.5
	50	48.6	30.0	10.9	1.7	4.4	2.0	1.0	1.5
12	35	26.7	30.0	28.5	4.5	5.9	2.0	1.0	1.5
	40	34.0	30.0	21.6	4.0	5.9	2.0	1.0	1.5
	45	41.3	30.0	14.7	3.6	5.9	2.0	1.0	1.5
	50	48.6	30.0	7.8	3.2	5.9	2.0	1.0	1.5

Ca Mau Fishmeal, Argentina soybean meal, *Premix: Bio-premix C-1 AG: vitamin A (6.000.000 IU), vitamin D3 (2000.000 IU), vitamin E (50.000 mg), vitamin K_3 (6000 mg), vitamin B1 (11.000 mg), vitamin B2 (7000 mg), vitamin B6 (8000 mg), vitamin C Stay (50.000 mg), inositol (5000 mg), folic acid (3000 mg), biotin (500 mg), pantothenic acid (35.000 mg), niacine (60.000 mg), Cu (34.000 mg), Fe (50.000 mg), Mn (12.000 mg), Zn (125.000 mg), I (500 mg), Co (250 mg), Se (200 mg).

Table 2

Chemical compositions of experimental diets (%, as dry matter basis)

	35P-6L	*40P-6L*	*45P-6L*	*50P-6L*	*35P-9L*	*40P-9L*	*45P-9L*	*50P-9L*	*35P-12L*	*40P-12L*	*45P-12L*	*50P-12L*
P	35.4	40.3	45.4	50.3	35.2	40.3	45.3	50.4	35.3	40.1	45.3	50.4
L	6.27	6.24	6.48	6.50	9.25	9.39	9.47	9.56	12.3	12.4	12.5	12.5
Ash	10.8	11.2	13.1	13.9	10.5	11.6	13.4	14.9	10.3	11.6	13.4	14.6
E	19.2	19.4	19.5	19.6	19.9	20.0	20.1	20.1	20.6	20.7	20.7	20.8
P/E ratio	18.4	20.8	23.4	25.6	17.7	20.1	22.6	25.0	17.1	19.4	21.9	24.2
						Amino acids (%)						
Met	0.75	0.89	1.04	1.18	0.75	0.89	1.04	1.18	0.75	0.89	1.04	1.18
Cys	0.40	0.44	0.49	0.54	0.40	0.44	0.49	0.54	0.40	0.44	0.49	0.54
Met+ Cys	1.16	1.35	1.55	1.74	1.16	1.35	1.55	1.74	1.16	1.35	1.55	1.74
Lys	2.48	2.88	3.28	3.68	2.48	2.88	3.28	3.68	2.48	2.88	3.28	3.68
Thr	1.43	1.65	1.86	2.08	1.43	1.65	1.86	2.08	1.43	1.65	1.86	2.08
Tryp	0.43	0.48	0.54	0.60	0.43	0.48	0.54	0.60	0.43	0.48	0.54	0.60
Arg	2.33	2.64	2.94	3.24	2.34	2.64	2.94	3.24	2.34	2.64	2.94	3.24
Ile	1.59	1.82	2.05	2.28	1.59	1.82	2.05	2.28	1.60	1.82	2.05	2.28
Leu	2.70	3.10	3.49	3.88	2.70	3.10	3.49	3.88	2.71	3.10	3.49	3.89
Val	1.75	2.01	2.27	2.54	1.75	2.01	2.28	2.54	1.75	2.01	2.28	2.54
His	0.89	1.02	1.14	1.27	0.89	1.02	1.14	1.27	0.89	1.02	1.14	1.27
Phe	1.61	1.83	2.04	2.25	1.62	1.83	2.04	2.25	1.62	1.83	2.04	2.25

Note: P = protein; L = lipid; E = energy (KJ g^{-1}).

Experimental system and animals. Snubnose pompano juveniles with weight ranging between 3.8 and 4.1 g/individual (8 weeks post-hatch) were collected from a hatchery in Khanh Hoa – Nha Trang, Viet Nam and transported to the Wetlab of the College of Aquaculture and Fisheries, Can Tho University. The fish were acclimatized to the experimental conditions for a period of 2 weeks in 2 m^3-tanks with a salinity of 30 ‰. During the acclimation period, the fish were fed commercial feed with 55% protein and 9% lipid.

T. blochii juveniles were stocked in 48 100 L tanks which were supplied with continuous aeration. Each 100 L tank were randomly stocked with 30 fish. Each diet treatment was replicated four times. Salinity was maintained at 30 ‰ and a water refreshment rate of 300% day^{-1} was used. Water quality was checked daily and maintained for temperature (28-31 °C), pH (7-8), oxygen concentration (higher than 5.2

ppm), alkalinity (100-120 mg $CaCO_3$ L^{-1}). Total ammonia nitrogen TAN (0.1-0.3 mg L^{-1}) and NO_2-N (0-0.02 ppm) were measured and monitored weekly. The rearing experiment was conducted in a recirculating system with a 12 hour light and 12 hour dark photoperiod regimen adopted.

Experimental procedure and sample analysis. During the experimental period, the fish were fed *ad libitum* with the twelve experimental diets four times daily (07:00, 10:00, 13:00, 16:00). The amount of feed fed was recorded and the uneaten pellets were collected 30 minutes after feeding. The unconsumed feed were dried in the oven at 45ºC for 8 hours, weighed, and recorded.

During pelleting, ingredient samples were taken and during the experiment, about 5 g of each experimental diet was sampled weekly. For body composition analysis, the initial compositions of fish at stocking for all treatments were determined using 30 fish. After 56 days of culture, 5 fishes in each tank were sampled to analyze body compositions. Prior to collecting the body composition samples, the fish were dissected to collect liver, intestine and total body was weighed to determine hepatosomatic index (HSI), and viscerosomatic index (VSI). All samples were ground by a coffee blender and stored in the freezer until analysis. The chemical analyses were done in triplicates. According to standard laboratory methods (AOAC 2000), the dry matter (DM) content was determined by drying in the oven at 105°C until constant weight; crude protein (N × 6.25) content was measured following the Kjeldahl method; mineral (ash) content by placing in the furnace at 560°C for 4 hours; and crude fat content by solvent (diethyl ether) extraction. The carbohydrate (CHO) content in the sample on a dry matter basis was calculated as 1000 – (crude protein + crude ash + crude fat). The gross energy (kJ g^{-1}) was calculated as [(crude protein × 23.6) + (crude fat × 39.5) + (CHO × 17.2)] / 1000. The amino acids analysis of ingredients was done by UpScience Company, Vietnam.

Calculations. The initial mean weight (Wi) and final mean weight (Wf) of individual fish were determined before and after the experiment. The survival rate (SR, %), daily weight gain (DWG), feed intake (FI), feed conversion ratio (FCR), the protein efficiency ratio (PER), and net protein utilization (NPU), hepatosomatic index (HSI), and viscerosomatic index (VSI) were measured as follows (where t = time in days):

$$SR\ (\%) = (\text{number of fish at the end of experiment})/(\text{number of initial fish}) \times 100$$

$$DWG\ (g\ day^{-1}) = (Wf - Wi)/t$$

$$FI\ (\%\ fish^{-1}\ day^{-1}) = \text{consumed feed}/(((Wf \times Wi)/2) \times t)$$

$$FCR = \text{amount of consumed feed in dry matter}/\text{weight gain}$$

$$PER = (Wf - Wi)/\text{protein intake}$$

$$NPU\ (\%) = (\text{protein of final fish} - \text{protein of initial fish}) / \text{protein intake}$$

$$HSI = \text{liver weight (g)}/\text{total body weight (g)}$$

$$VSI = \text{viscera weight (g)}/\text{total body weight (g)}$$

Statistical analysis. The mean values of growth and feed efficiency and standard deviation were calculated by the Microsoft Excell 2010. Statistical differences in means between dietary treatments was analyzed via two-way Analysis of Variance (ANOVA) followed by a Duncan Multiple Range Test (MRT) post hoc test at a significance level of 0.05, using SPSS program 16.0 (SPSS for Windows 2007, Chicago, SPSS Inc.).

Results

Survival rate, growth, and feed utilization of the experimental fish. The survival rate of *T. blochii* was between 98.3 and 100%. There was no interaction between dietary protein and dietary lipid levels observed. There were also no significant differences ($p > 0.05$) observed between each treatment in any factor (Table 3).

Prior to the experiment the initial mean weight range was from 3.83±0.13 to 4.09±0.16 g $fish^{-1}$ and after 56 days of culturing, all treatments reached a mean weight of 26.4±1.00-35.4±1.91 g $fish^{-1}$, and the growth rate (DWG) 0.40±0.02-0.56±0.03 g day^{-1} (Table 3). The interaction between the dietary protein and lipid was shown in the

final mean weight and the growth rate ($p < 0.05$). The highest final weight and the growth rates were found in the treatment 50P-9L, while the lowest final weight and growth rates were in the treatment 35P-6L (35.4±1.91g fish^{-1}, 0.56±0.03 g day^{-1}, and 26.4±1.00 g fish^{-1}, 0.40±0.02 g day^{-1}, respectively) (Table 3). Fish in the treatments with 9% lipid in the diet displayed significantly higher growth rates ($p < 0.05$) than those in the 6% and 12% treatments.

Table 3

The mean weight (g fish^{-1}), growth rate (g day^{-1}), and survival rate (%) of experimental fish

Treatment		*Initial mean weight - W_0*	*Final mean weight - Wt*	*Growth rate - DWG*	*Survival rate*
Protein	*Lipid*				
35	6	3.93±0.09	26.4±1.00^{a}	0.40±0.02^{a}	98.3±1.92
40	6	4.08±0.09	29.3±1.63^{bc}	0.45±0.03^{bc}	99.2±1.67
45	6	3.83±0.20	30.0±0.62^{cd}	0.47±0.01^{cde}	99.2±1.67
50	6	3.98±0.08	32.0±2.42^{de}	0.50±0.04^{def}	100±0.00
35	9	3.83±0.13	27.5±2.13^{ab}	0.42±0.04^{ab}	100±0.00
40	9	3.89±0.24	30.3±0.79^{cd}	0.47±0.01^{cde}	100±0.00
45	9	4.00±0.11	33.1±2.20^{e}	0.52±0.04^{f}	100±0.00
50	9	3.91±0.14	35.4±1.91^{f}	0.56±0.03^{g}	99.2±1.67
35	12	4.04±0.12	28.6±0.41^{abc}	0.44±0.01^{abc}	98.3±1.67
40	12	3.95±0.18	29.1±1.64^{bc}	0.45±0.03^{bc}	99.2±1.92
45	12	3.95±0.17	32.3±1.56^{de}	0.51±0.03^{ef}	99.2±1.67
50	12	4.09±0.16	30.1±1.03^{cd}	0.46±0.02^{bcd}	100±0.00
p values					
Protein		0.285	< 0.001	< 0.001	0.699
Lipid		0.218	0.001	< 0.001	0.321
Protein x lipid		0.325	0.004	0.003	0.440

Values were represented as mean±standard deviation. Different letters in the same column represent a significant difference ($p < 0.05$).

Significant interaction between dietary protein and dietary lipid was also observed ($p < 0.05$) in the feed intake, FCR, PER, and NPU (Table 4). The lowest feed intake and FCR ($p < 0.05$) were expressed in the treatment 50P-9L (3.89±0.08 and 1.36±0.03, respectively). While the highest values of PER ($p < 0.05$) were shown in the 35% protein treatments (with the dietary lipid levels 6, 9, 12% as 1.76±0.05, 1.80±0.03, and 1.84±0.04). The highest NPU was in 35P-12L (28.1±1.12) and the lowest NPU was in 50P-12L (17.9±0.72).

Table 4

The feed intake (FI, % day^{-1}), feed conversion ratio (FCR), protein efficiency ratio (PER), and net protein utilization (NPU, %)

Treatments		*FI*	*FCR*	*PER*	*NPU*
Protein	*Lipid*				
35	6	4.24±0.09^{defg}	1.60±0.05^{e}	1.76±0.05^{f}	25.7±0.99^{de}
40	6	4.38±0.05^{fg}	1.62±0.01^{e}	1.53±0.01^{cd}	22.7±1.01^{bc}
45	6	4.04±0.04^{abc}	1.46±0.03^{bc}	1.50±0.03^{cd}	22.5±0.60^{bc}
50	6	4.22±0.13^{def}	1.52±0.05^{cd}	1.31±0.04^{b}	19.1±0.40^{a}
35	9	4.26±0.16^{defg}	1.58±0.08^{de}	1.80±0.03^{f}	26.1±2.22^{e}
40	9	4.12±0.07^{bcd}	1.49±0.04^{bc}	1.66±0.08^{e}	25.9±2.77^{e}
45	9	4.00±0.11^{ab}	1.43±0.07^{b}	1.54±0.08^{cd}	21.9±0.68^{b}
50	9	3.89±0.08^{a}	1.36±0.03^{a}	1.46±0.03^{c}	23.0±1.28^{cd}
35	12	4.18±0.07^{cde}	1.54±0.03^{cde}	1.84±0.04^{f}	28.1±1.12^{f}
40	12	4.35±0.14^{efg}	1.61±0.09^{e}	1.55±0.08^{d}	24.0±0.68^{cd}
45	12	4.20±0.16^{cde}	1.51±0.07^{bcd}	1.47±0.07^{cd}	22.7±0.70^{bc}
50	12	4.40±0.09^{g}	1.62±0.03^{e}	1.23±0.03^{a}	17.9±0.72^{a}
p values					
Protein		< 0.001	< 0.001	< 0.001	< 0.001
Lipid		< 0.001	< 0.001	< 0.001	0.001
Protein × lipid		< 0.001	< 0.001	< 0.001	< 0.001

Values were represented as mean±standard deviation. Different letters in the same column represent a significant difference ($p < 0.05$).

The hepatosomatic index (HSI), viscerosomatic index (VSI), and the chemical compositions of the experimental fish body. Significant interaction between the dietary protein and lipid ($p < 0.05$) was also observed in the HSI and VSI of the experimental fish (Table 5). The HSI and VSI values reduced with the increase of dietary protein levels ($p < 0.05$). The lowest HSI and VSI ($p < 0.05$) were found in the treatment 50P-6L.

Table 5

Hepatosomatic index (HSI) and viscerosomatic index (VSI)

Treatments		*HSI*	*VSI*
Protein	*Lipid*		
35	6	0.019 ± 0.004^{e}	0.087 ± 0.005^{cd}
40	6	0.018 ± 0.003^{de}	0.080 ± 0.007^{bc}
45	6	0.017 ± 0.002^{cde}	0.079 ± 0.006^{bc}
50	6	0.011 ± 0.002^{a}	0.066 ± 0.003^{a}
35	9	0.016 ± 0.001^{bcd}	0.078 ± 0.009^{b}
40	9	0.014 ± 0.002^{abc}	0.083 ± 0.004^{bcd}
45	9	0.013 ± 0.002^{ab}	0.076 ± 0.005^{b}
50	9	0.013 ± 0.001^{ab}	0.077 ± 0.006^{b}
35	12	0.016 ± 0.001^{bcd}	0.091 ± 0.005^{d}
40	12	0.014 ± 0.001^{abc}	0.084 ± 0.002^{bcd}
45	12	0.013 ± 0.001^{ab}	0.083 ± 0.002^{bcd}
50	12	0.013 ± 0.001^{ab}	0.080 ± 0.002^{bc}
p values			
Protein		<0.001	<0.001
Lipid		0.001	0.001
Protein × lipid		0.012	0.018

Values were represented as mean±standard deviation. Different letters in the same column represent a significant difference ($p < 0.05$).

The chemical compositions of the whole fish body of the experimental fish. Significant differences in the dietary protein and lipid ($p < 0.05$) was also observed in the lipid and ash content of the whole-body samples (Table 6). While the moisture and protein content did not show any significant differences in dietary protein and lipid ($p > 0.05$). Moisture content increased significantly ($p < 0.05$) with the increase of dietary protein. Lipid content linearly decreased significantly ($p < 0.001$) with the increase of the P:E ratio (Table 6). The highest lipid content was in the treatment 35P-12L (12.3±0.17%) and the lowest one was in 50P-9L (10.6±0.19%). The lowest ash content (3.66±0.03%) was observed in the 35P-6L treatment (Table 6).

Table 6

The chemical compositions (%) of the experimental whole-body fish

Treatments		*Moisture (%)*	*Protein (%)*	*Lipid (%)*	*Ash (%)*
Protein	*Lipid*				
Initial fish		70.4	15.3	7.13	4.98
Final fish					
35	6	68.8±0.20	15.0±0.35	12.1 ± 0.60^{cde}	3.66 ± 0.03^{a}
40	6	68.2±0.86	15.2±0.64	12.2 ± 0.46^{e}	4.06 ± 0.23^{abc}
45	6	69.0±0.55	15.2±0.42	11.5 ± 0.12^{bc}	3.90 ± 0.26^{ab}
50	6	69.7±0.67	14.9±0.34	11.1 ± 0.40^{ab}	4.02 ± 0.36^{ab}
35	9	68.4±0.94	14.9±1.12	12.1 ± 0.46^{de}	4.14 ± 0.06^{bc}
40	9	68.1±1.66	15.8±1.15	11.4 ± 0.31^{b}	4.19 ± 0.44^{bc}
45	9	69.7±0.99	14.6±0.52	11.6 ± 0.47^{bcd}	3.93 ± 0.13^{ab}
50	9	69.1±0.85	15.9±0.67	10.6 ± 0.19^{a}	3.99 ± 0.30^{ab}
35	12	68.8±0.96	15.7±0.56	12.3 ± 0.17^{e}	4.47 ± 0.20^{c}
40	12	68.3±0.72	15.7±0.56	11.2 ± 0.36^{b}	3.94 ± 0.21^{ab}
45	12	68.3±1.29	15.7±0.84	11.6 ± 0.26^{bcd}	4.10 ± 0.31^{bc}
50	12	69.0±0.46	15.0±0.36	11.5 ± 0.17^{bc}	4.12 ± 0.21^{bc}

p values				
Protein	0.015	0.377	<0.001	0.756
Lipid	0.239	0.215	0.092	0.037
Protein × lipid	0.174	0.067	0.002	0.029

Values were represented as mean±standard deviation. Different letters in the same column represent a significant difference ($p < 0.05$).

Discussion. High survival rates of *T. blochii* were observed in this study (98-100%, Table 3) and it was also shown to not be affected by the dietary treatments. Similar results have also been reported in studies by Huyen (2014) and Hung et al (2013a, b). The growth rates of *T. blochii* increased with increasing levels of dietary protein dietary lipids (Table 3). These results allude that this species requires a high protein level in the diet. Similar findings have been observed in almost all carnivorous fish species, with dietary protein requirements higher than 45% (Wang et al 2013). For instance, the dietary protein requirement of rockfish *Sebastes schlegeli* (Kim et al 2004) was 50%, 48-50% for Malabar grouper *Epinephelus malabaricus* (Chen & Tsai 1994; Shiau & Lan 1996), 45-50% for juvenile flounder (Kim et al 2005), 45-46% for cuneate drum *Nibea miichthioides* (Wang et al 2006), 45% for spotted sand bass *Paralabrax maculatofasciatus* (Alvarez-Gonzalez et al 2001), 44.5% for cobia *Rachycentron canadum*, and Pacific bluefin Tuna *Thunnus orientalis* juvenile 61.9% (Chou et al 2001).

In this study, the best growth rates, the lowest feed intake, and the lowest FCR were found in the treatment 50P-9L (0.56±0.03 g day^{-1}, 3.89±0.08, 1.36±0.03, respectively) compared to other treatments with lower dietary protein levels (Tables 3 and 4). It suggested that 50% dietary protein is efficient for *T. blochii* at nursery phase. As the pompano is a saline carnivorous species, its metabolism requirements for cruising and feeding activities could be high (Tutman et al 2004). Some studies on the dietary protein requirements of pompano species reported 43% for 25 g golden pompano (*Trachinotus ovatus*) (Liu et al 2011), 45-50% for 4.5-6.3 g Florida pompano (Lazo et al 1998; Riche 2009). Alternatively, fish fed with excess of dietary protein results in the non-protein energy limiting growth and is also wasteful (Hossain et al 1998). This could possibly explain why there is a reduction of growth rates at 50P-12L in the present study (Table 3).

The FCR coefficient is known to be influenced by dietary protein and lipid content and this has been reported by many researchers (de Lemos et al 2014; Sankian et al 2017; Ullah-Khan et al 2019). When the dietary protein and lipid content is appropriate, it assists in the reduction of the FCR coefficient and improves the efficiency of feed use. When the diet has a low energy level, the protein source is used to convert to energy to maintain the fish activities, therefore the protein usage index is low. Manh (2015) said that after hatching *T. blochii* it was observed that if feed intake increased, the FCR also increased. In our experimental results, the treatment 50P-9L showed the lowest feed intake and the lowest FCR (Table 4). Similarly, *Trachinotus ovatus* fingerlings fed diets containing of 33-49% protein, 6.5 and 12.5% lipid, achieved FCR of 1.08-1.65 (Wang et al 2013). In this study, the diet at 50% protein and 12% lipid gave the highest NPU because the diet met the requirements of the pompano, protein intake, digestion and absorption.

Liver and visceral index of experimental fish tended to decrease with increasing dietary protein. At the same level of dietary protein, the VSI index increase with increase in dietary lipid level. Similar results were observed in the golden croaker *Nibea japonica* (Chai et al 2013) where increases in dietary protein was inversely related to the liver and visceral index. It suggests that the dietary protein and lipid levels can affect body composition of *T. blochii.*

Conclusions. Snubnose pompano (*Trachinotus blochii*) juveniles utilized high dietary protein content rather than high dietary lipid content. Elevating dietary lipid levels from 9 to 12 % could not induce protein-sparing action. The suitable dietary protein and lipid levels for juvenile snubnose pompano should be 50% protein and 9% lipid, coinciding with the protein:energy ratio (P:E) 25 mg KJ^{-1}.

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Conflict of interest. The authors declare that there is no conflict of interest.

References

Alvarez-González C. A., Civera-Cerecedo R., Ortiz-Galindo J. L., Dumas S., Moreno-Legorreta M., Grayeb-Del Alamo T., 2001 Effect of dietary protein level on growth and body composition of juvenile spotted sand bass, *Paralabrax maculatofasciatus*, fed practical diets. Aquaculture 194(1-2):151-159.

AOAC (Association of Official Analytical Chemists), 2000 Moisture of animal feed (934.01). In: Official Methods of Analysis of AOAC International, 17th Edn. Association of Official Analytical Chemists International. Gaithersburg, MD, USA

Chai X. J., Ji W. X., Han H., Dai Y. X., Wang Y., 2013 Growth, feed utilization, body composition and swimming performance of giant croaker, *Nibea japonica* Temminck and Schlegel, fed at different dietary protein and lipid levels. Aquaculture Nutrition 19(6):928-935.

Chen H. Y., Tsai J. C., 1994 Optimal dietary protein level for the growth of juvenile grouper, *Epinephelus malabaricus*, fed semipurified diets. Aquaculture 119(2-3): 265-271.

Chou R. L., Su M. S., Chen H. Y., 2001 Optimal dietary protein and lipid levels for juvenile cobia *Rachycentron canadum*. Aquaculture 193(1-2):81-89.

Dabrowski K., Guderley H., 2002 Intermediary metabolism. In: Fish Nutrition (ed. by J. Halver & R. Hardy). Academic Press, San Diego, CA, USA, 309–365 pp.

de Lemos M. V. A., Arantes T. Q., Souto C. N., Martins G. P., Araújo J. G., Guimarães I. G., 2014 Effects of digestible protein to energy ratios on growth and carcass chemical composition of siamese fighting fish (*Betta splendens*). Ciência e Agrotecnologia 38(1):76-84.

Gopakumar G., Nazar A. K. A., Jayakumar R., Tamilmani G., Kalidas, C., Sakthivel M., Rameshkumar P., Rao G. H., Premjothi R., Balamurugan V., Ramkumar B., Jayasingh M., Rao G. S., 2012 Broodstock development through regulation of photoperiod and controlled breeding of silver pompano, *Trachinotus blochii* (Lacepede, 1801) in India. Ind. J. Fish. 59, 53–57.

Hossain M. A., Begum S., Islam M. N., Shah A. K. M. A., 1998 Studies on the optimum protein to energy ratio of African catfish (*Clarias gariepinus* Burchell). Bangladesh Journal of Fisheries Research 2(1):47-54.

Hung L. V., Thu H. T., Dung T. V., Trang T. T. L., Khanh P. T., 2013a [Effects of vitamin D3 levels on growth and survival rate of snub-nose pompano juvenile (*Trachinotus blochii* Lacepède, 1801)]. Tạp chí Khoa học và Công nghệ Biển 13(4):390-396. [in Vietnamese]

Hung L. V., Trang T. T. L., Dung T. V., Thu H. T., 2013b [Effects of lipid content on growth and survival rate of snub-nose pompano juvenile (*Trachinotus blochii* Lacepède, 1801)]. Tạp chí Khoa học và Công nghệ Biển 8:30-36. [in Vietnamese]

Huyen N. T., 2014 [Study on the effects of protein and energy levels on growth, feed efficiency and digestibility of snub-nose pompano juvenile (*Trachinotus blochii* Lacepède, 1801)]. Master thesis of Aquaculture, Vinh University, Thai Nguyen province, Vietnam, 55 pp. [in Vietnamese]

Islam M. S., Tanaka M., 2004 Optimization of dietary protein requirement for pond-reared mahseer *Tor putitora* Hamilton (Cypriniformes: Cyprinidae). Aquaculture Research 35(13):1270-1276.

Jayakumar R., Nazar A. K. A., Tamilmani G., Sakthivel M., Kalidas C., Rameshkumar P., Hanumantarao G., Gopakumar G., 2014 Evaluation of growth and production performance of hatchery produced silver pompano *Trachinotus blochii* (Lacépède, 1801) fingerlings under brackishwater pond farming in India. Indian Journal of Fisheries 61(3):58-62.

Kim K. W., Wang X., Han K., Bai S. C., Kang J. C., 2004 Optimum dietary protein level and protein-to-energy ratio for growth of juvenile Korean rockfish *Sebastes schlegeli*. Journal of the World Aquaculture Society 35(3):305-314.
Kim K. W., Kang Y. J., Choi S. M., Wang X., Choi Y. H., Bai S. C., Jo J. Y., Lee J. Y., 2005 Optimum dietary protein levels and protein to energy ratios in olive flounder *Paralichthys olivaceus*. Journal of the World Aquaculture Society 36(2):165-178.
Kong W., Huang S., Yang Z., Shi F., Feng Y., Khatoon Z., 2020 Fish feed quality is a key factor in impacting aquaculture water environment: evidence from incubator experiments. Scientific Reports 10:187.
Lazo J. P., Davis D. A., Arnold C. R., 1998 The effects of dietary protein level on growth, feed efficiency and survival of juvenile Florida pompano (*Trachinotus carolinus*). Aquaculture 169(3-4):225-232.
Liu X., Wang H., Zhang H., Xu D., 2011 Optimum dietary protein to energy ratio in juvenile pompano, *Trachinotus ovatus*. Fisheries Science 30(3):136-139.
Manh N. V., 2015 Study on the effects of technical solutions on egg and larval quality and nursery efficiency of snub-nose pompano juvenile (*Trachinotus blochii* Lacepède, 1801). Master thesis of Aquaculture, Nha Trang University, Khanh Hoa province, Vietnam. [in Vietnamese]
Mohan M., Basade Y., 2005 Effects of available diets with different protein to energy ratios on growth, nutrient utilization and body composition of juvenile Himalayan golden mahseer *Tor putitora* (Hamilton). Asian Fisheries Science 18:275-283.
NRC (National Research Council), 1993 Nutrient requirements of fish. National Academy Press, Washington DC, 128 pp.
NRC (National Research Council), 2011 Nutrient Requirements of Fish. National Academy Press, Washington, DC, USA, 392 pp.
Prabu D. L., Ebeneezar S., Chandrasekar S., Tejpal C. S., Kavitha M., Sayooj P., Vijayagopal P., 2020 Influence of graded level of dietary protein with equated level of limiting amino acids on growth, feed utilization, body indices and nutritive profile of snubnose pompano, *Trachinotus blochii* (Lacepede, 1801) reared in low saline water. Animal Feed Science and Technology 269:114685.
Riche M., 2009 Evaluation of digestible energy and protein for growth and nitrogen retention in juvenile Florida pompano, *Trachinotus carolinus*. Journal of the World Aquaculture Society 40(1):45-57.
Sankian Z., Khosravi S., Kim Y. O., Lee S. M., 2017 Effect of dietary protein and lipid level on growth, feed utilization, and muscle composition in golden mandarin fish *Siniperca scherzeri*. Fisheries and Aquatic Sciences 20:7.
Schuchardt D., Vergara J. M., Fernández-Palacios H., Kalinowski C. T., Hernández-Cruz C. M., Izquierdo M. S., Robaina L., 2008 Effects of different dietary protein and lipid levels on growth, feed utilization and body composition of red porgy (*Pagrus pagrus*) fingerlings. Aquaculture Nutrition 14(1):1-9.
Shiau S. Y., Lan C. W., 1996 Optimum dietary protein level and protein to energy ratio for growth of grouper (*Epinephelus malabaricus*). Aquaculture 145(1-4):259-266.
Sunder S., Raina H. S., Nulia U., 1998 Preliminary feeding trials on juveniles of golden mahseer, *Tor putitora* (Ham.) at different stocking densities with artificial dry pellet feeds. Indian Journal of Animal Sciences 68(4):410-416.
Teles A. O., Couto A., Enes P., Peres H., 2020 Dietary protein requirements of fish – a meta-analysis. Reviews in Aquaculture 12(3):1445-1477.
Thu T. T. N., Ninh N. H., Muu T. T, Hieu, T. T. T., Dat N. T., 2016 Apparent Digestibility of Some Commercial Feeds for Short Fin Pompano (*Trachinotus ovatus). Tạp chí KH Nông nghiệp Việt Nam 2016, Vol. 14, No. 8: 1185-1189* [in Vietnamese].
Tutman P., Glavić N., Kožul V., Skaramuca B., Glamuzina B., 2004 Preliminary information on feeding and growth of pompano, *Trachinotus ovatus* (Linnaeus, 1758) (Pisces; Carangidae) in captivity. Aquaculture International 12(4):387-393.
Ullah-Khan K., Tellechea-Rodrigues A., Menegasso-Mansano C. F., de Almeida Queiroz D. M., Kazue-Sakomura N., de Souza Romaneli R., Do Nascimento T. M. T., Kochenborger-Fernandes J. B., 2019 Dietary protein quality and proper protein to energy ratios: a bioeconomic approach in aquaculture feeding practices. Latin American Journal of Aquatic Research 47(2): 232-239.

Wang F., Han H., Wang Y., Ma X., 2013 Growth, feed utilization and body composition of juvenile golden pompano *Trachinotus ovatus* fed at different dietary protein and lipid levels. Aquaculture Nutrition 19(3):360-367.
Wang Y., Guo J. L., Li K., Bureau D. P., 2006 Effects of dietary protein and energy levels on growth, feed utilization and body composition of cuneate drum (*Nibea miichthioides*). Aquaculture 252(2-4):421-428.

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Authors:
Le Quoc Viet, College of Aquaculture and Fisheries, Can Tho University, Campus II, 3/2 street, 94100 Can Tho city, Vietnam, e-mail: quocviet@ctu.edu.vn
Tran Thi Thanh Hien, College of Aquaculture and Fisheries, Can Tho University, Campus II, 3/2 street, 94100 Can Tho city, Vietnam, e-mail: ttthien@ctu.edu.vn
Tran Le Cam Tu, College of Aquaculture and Fisheries, Can Tho University, Campus II, 3/2 street, 94100 Can Tho city, Vietnam, e-mail: tlctu@ctu.edu.vn
Tran Nguyen Duy Khoa, College of Aquaculture and Fisheries, Can Tho University, Campus II, 3/2 street, 94100 Can Tho city, Vietnam, e-mail: tndkhoa@ctu.edu.vn
Dao Thi Ngoc Linh, College of Aquaculture and Fisheries, Can Tho University, Campus II, 3/2 street, 94100 Can Tho city, Vietnam, e-mail: dtnlinh@ctu.edu.vn
Nguyen Thi Hong Gam, Farmer's Union, Tan Thanh district, Long An province, Vietnam, e-mail: honggam@gmail.com
Viliame Waqalevu, PSL Research University: EPHE-UPVD-CNRS, USR 3278 CRIOBE BP 1013, 98729 Papetoai, Moorea, French Polynesia, e-mail: vwaqalevu@hotmail.com
Kotani Tomonari, Faculty of Fisheries, Kagoshima University, Shimoarata 4-50-20, Kagoshima 890-0056, Japan, e-mail: kotani@fish.kagoshima-u.ac.jp
Shunsuke Koshio, Faculty of Fisheries, Kagoshima University, Shimoarata 4-50-20, Kagoshima 890-0056, Japan, e-mail: koshio@fish.kagoshima-u.ac.jp
Truong Quoc Phu, College of Aquaculture and Fisheries, Can Tho University, Campus II, 3/2 street, 94100 Can Tho city, Vietnam, e-mail: tqphu@ctu.edu.vn
Tran Ngoc Hai, College of Aquaculture and Fisheries, Can Tho University, Campus II, 3/2 street, 94100 Can Tho city, Vietnam, e-mail: tnhai@ctu.edu.vn

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