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Effect of Dietary Protein on Growth, Feed Utilization and Body Composition of Silver Catfish *Schilbe intermedius* Rüppel, 1832 Fingerlings

Tossavi C.E. [1, 2], Djissou A.S.M [1]., Ouattara N.I. [2], Fiogbe E.D. [1], Micha J.C. [3]

1 Laboratoire de Recherches sur les Zones Humides, Département de Zoologie, Faculté des Sciences et Techniques, Université d'Abomey – Calavi, B.P. 526 Cotonou, Bénin

2 Laboratoire d'Hydrobiologie, UFR Biosciences, Université Félix Houphouët-Boigny, 22BP: 582 Abidjan 22, Côte d'Ivoire

3 University Namur, URBE, Bruxelles Street, 61 B-5000 Namur, Belgium

Corresponding author Email: etossavi@gmail.com

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Abstract The captive breeding of the Silver catfish *Schilbe intermedius* was envisaged to promote the aquaculture and to reduce the overfishing of this endangered species. *S. intermedius* fingerlings were fed various dietary protein levels to investigate their growth performance, feed utilization and carcass proximate composition. Fish meal and casein were the sources of protein used in the study. Six isocaloric experimental diets containing 25%~60% crud protein (CP) diet have been fed to three-replicate six groups of forty (40) fishes (mean weight: (1.640±0.015) g) for 8 weeks. Both percent weight gain and feed efficiency ratio significantly increased with increasing dietary protein levels up to 45%, while there were no significant differences for protein levels from 45 to 60%. Growth performances and nutrient utilization parameters of fingerlings fed different diets varied significantly ($p < 0.05$) and the highest growth performance and nutrient utilization were obtained with fish fed on a 45% CP diet. The second order polynomial regression between dietary protein and specific growth rate (SGR) indicated that protein requirements of *S. intermedius* fingerlings ranged from 42.5 to 53% of diet. The highest protein content of the fish carcasses was found in fish fed 45% dietary protein and there was not significantly different ($p > 0.05$) with that of fish fed 60% dietary protein. Lipid content increased with increasing dietary protein levels. The dry matter and protein content of the initial sample were significantly higher ($p > 0.05$) than the values after feeding the fish with experimental diet.

Keywords *Schilbe intermedius*; Protein requirements; Growth performance; Isocaloric experimental diets; Feed conversion ratio

Background

Schilbe intermedius (Schilbeidae) is a catfish widespread in almost all Africa, which can reach a very substantial size of 50 cm or more (Lévêque, 1994; De Vos, 1984; Paugy et al., 1999). It has good economic value and is particularly prized for the quality and fineness of its flesh (Fermon, 2010; Bills et al., 2010). This fish is abundantly caught and causes high pressure on the natural environment. Thus, many of these species of big size and high tall become more and more scarce and this is due to the rise of fishing pressure and various anthropic activities. The breeding of such species seems somehow promising and saving. Within the context of the first culture trials of this fish, their transfer, acclimatization in tank and adaptation to the culture conditions have already controlled (Tossavi et al., 2016). On the other hand, the artificial reproduction attempts of this fish have already given preliminary results including improvements allowed us perfect mastery of this technique. There is an urgent requirement to deepen our research on this fish, especially regarding its nutritional needs, to achieve rapid growth in breeding.

In aquaculture, the feed of fish accounts for 50% or more of the total production cost (Yang et al., 2002). Likewise, protein is the most expensive component of the fish feeds since it represents about 75% of the feeding cost (De Silva and Anderson, 1995; NRC, 1993). Thus, the success of intensive fish's culture depends on a large extent on adequate information on nutrient requirements, especially dietary protein. The research of the protein requirement is significant for the formulation of well-balanced and low cost feeds (Shiau and Lan, 1996). However, protein levels in fish nutrition influence the growth and body composition of various fishes and shellfishes.

Oishi et al. (2010) have pinpointed that the using of optimum protein levels in fish nutrition, enables low pollution of the fish culture environment especially in intensive fish farming or in recirculatory aquaculture systems. The fish excess supply in protein can cause deterioration of water quality in a recirculating culture system and fish ponds (Engin and Carter, 2001) by accumulation of nitrogen compounds. Therefore, determination of dietary protein requirements for fish is important to reduce or limit water quality deterioration during breeding.

Despite the fact that many works for the determination of protein requirements on various fishes, the matters of *S. intermedius* remain unknown. So, it is important to know the response of *S. intermedius* to various nutrients in order to be able to produce an effective low pollution of rearing water and low-cost feeds for the species. Thus, this study was carried out to examine the influence of dietary protein levels on growth, survival, feed utilization, protein efficiency ratio and carcass composition of African catfish, *S. intermedius* fingerlings and to estimate their protein requirement.

1 Materials and Methods

1.1 Experimental diets

Six isocaloric diets were formulated with semi-purified ingredients to contain 25%, 35%, 40%, 45%, 50% and 60% crud protein (CP). The composition of the six experimental diets and different ingredients were shown in Table 1. These protein contents were chosen based on the results of the protein requirements of other catfish species such as *Heterobranchus longifilis* (Kerdchuen, 1992), *Mystus nemurus* (Khan et al., 1993). All dry ingredients were first ground into small particle sizes in a grinder. For each diet, the various ingredients were weighed then mixed and homogenized by hand in a plastic basin. Oil and water were then added to obtain a soft dough that has been compacted into spaghetti of 2 mm diameter using a multipurpose chopper (Moulinex HV8). After drying in a lyophilizer (Eyela Dry Chamber DRC-1N), the spaghetti will be broken manually into small granules and then stored at 18°C.

1.2 Experimental fish, rearing conditions and feeding

The fishes used in this study were captured in the "Acadjas" installed on the Ouémé river in Agonlin-Lowé (N 0639' 378 ", E 00228' 571"). The average values of temperature, pH and dissolved oxygen of this environment are (27.2±0.1)°C; (6.9±0.2) and (5.8±0.1) mg/L respectively. Those fishes are acclimated in the experiment station of Research Laboratory on the Wetlands of the University of Abomey-Calavi for two weeks prior to experimentation. During this period, fingerlings were trained to accept progressively the formulated diet. A mixture of the different experimental diets (20% of each) was used as feed during this phase. After the acclimatization, fishes were distributed into tanks containing 250 liter total water volume (0.5 m radius, 0.32 m height). 40 fingerlings (mean±SD:1.640 ± 0.015 g) were stocked per tank and the six diets were assigned randomly to triplicate groups of fish. During the experience (56 days), the fishes were daily been fed manually every for hour from 08:00 am to 08:00 pm at 5% of body weight.

1.3 Water quality monitoring

In this experience, 2/3 (66.66%) of tank water were daily exchanged (every evening). Water was aerated to maintain a dissolved oxygen level of > 5 mg/L. The temperature and pH of the experimental tank waters were daily measured with clinical thermometer and pH meter (Model WTW Ph 330). Nitrite of the water was weekly measured by the colorimetric. Sampling was performed between 07.00 am and 08.00 am, before any feeding.

1.4 Chemical analysis

At the end of the experiment, five fishes from each tank were randomly sampled and sacrificed for chemical analysis. A sample of fingerlings at the start of the experiment was also used for analysis. Diets and fish whole body were analyzed for dry matter, crude protein, crude lipid and ash, in triplicate, using standard methods (AOAC, 1990).

Table 1 Formulation and proximate composition of experimental diets

Ingrédients (%)	Dietary protein					
	25%	35%	40%	45%	50%	60%
Casein[a]	8	16	21	27	34	44
Fish meal[b]	20.00	25.00	28.00	28.00	28.00	28.00
Yeast[c]	13.00	14.00	14.00	14.00	14.00	14.00
Dextrin[d]	22.50	10.00	7.00	6.00	3.50	2.00
Glucose[e]	25.00	23.50	19.50	14.50	10.00	2.00
Cod liver oil[f]	2.50	2.50	2.00	2.00	2.00	2.00
Soya oil[g]	3.00	3.00	2.50	2.50	2.50	2.00
Vitamin premix[h]	2.50	2.50	2.50	2.50	2.50	2.50
Mineral premix[i]	2.50	2.50	2.50	2.50	2.50	2.50
Carboxylméthylcellulose	1.00	1.00	1.00	1.00	1.00	1.00
Proximate composition						
Dry matter (DM, %)	81.10	81.50	84.12	85.70	87.82	87.53
Ash (% DM)	4.83	8.75	9.45	4.02	11.05	11.24
Crude protein (% DM)	25.97	35.54	41.10	45.48	50.59	57.88
Crude fat (% DM)	7.60	8.27	7.67	7.81	7.97	7.70
Gross energy (MJ/100g)	1.67	1.67	1.65	1.64	1.64	1.61
Protein / Energy (g/MJ)	15.55	21.28	24.90	27.73	30.84	35.95

Note: [a] 100% Casein complex, Scitec Nutrition (73% crude protein, 2.3% crude fat, 14.7 Kj g^{-1} gross energy, Miami, USA); [b] Ghana farming network Ltd (64% crude protein, 9.6% crude fat, 18.7 Kj g^{-1} gross energy, Accra, Ghana); [c] *Saccharomyces cervisiae*, S.I. Lesaffre (56% crude protein, 0% crude fat, 16.72 Kj g^{-1} gross energy, France); [d] Nestlé HealthCare Nutrition GmbH, D-67574 Osthofen (0.2% crude protein, 0% crude fat, 16.18 Kj.g^{-1} gross energy); [e] SIGMA-ALDRICH (0% crude protein, 0% crude fat, 15.94 Kj g^{-1} gross energy, France); [f] Setalg, France (0% crude protein, 100.0% crude fat, 37.00 Kj g^{-1} gross energy, France); [g] Songhaï center (0% crude protein, 99.9% crude fat, 37.00 Kj g^{-1} gross energy, Benin); [h] Vitamin premix contains (g 100 g– 1of premix): ascorbic acid, 50.0; D-calcium pantothenate, 5.0; choline chloride, 100.0; inositol, 5.0; menadione, 2.0; niacin, 5.0; pyridoxine HCl, 1.0; riboflavin, 3.0; thiamin HCl, 0.5; DL-alpha-tocopherol acetate (250 IU g^{-1}), 8.0; vitamin A acetate (20,000 IU g^{-1}), 5.0; vitamin micro-mix, 10.0; cellulose, 805.5. Vitamin micro-mix contains (g kg^{-1} of micro-mix): biotin, 0.5; cholecalciferol (1μg = 40 IU), 0.02; folic acid, 1.8; vitamin B_{12}, 0.02; cellulose, 97.66; [i] Mineral premix contains (g kg^{-1} of premix): calcium phosphate (monobasic) monohydrate, 136.0; calcium lactate pentahydrate, 348.49; ferrous sulfate heptahydrate, 5.0; magnesium sulfate heptahydrate, 132.0; potassium phosphate (dibasic), 240.0; sodium phosphate (monobasic) monohydrate, 88.0; sodium chloride, 45.0; aluminum chloride hexahydrate, 0.15; potassium iodide, 0.15; cupric sulfate pentahydrate, 0.50; manganese sulfate monohydrate, 0.70; cobalt chloride hexahydrate, 1.0; zinc sulfate heptahydrate, 3.0; sodium selenite, 0.011

1.5 Data processing

At the beginning and at the end of the experiment, all fishes were counted and weighed into each of 18 tanks and twenty fingerlings were randomly selected for individual weight and total length.

During the experimental period, data on growth were recorded regularly every 7 days by counting and weighing fishes in each tank. From these data, weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), survival rate (SR), Feed intake (FI), Protein intake (PI) and protein efficiency ratio (PER) were determined as follows:

Weight gain (%) = 100 x [final weight (g) − initial weight (g) / initial weight (g)]

SGR (% day^{-1}) = 100 x [Ln(final weight) – Ln(initial weight)] / culture period (days)

SR (%) = (Final Number of fish / initial Number of fish) x 100

FI (g $fish^{-1}$ 56 $days^{-1}$) = [(dry diet given – dry remaining diet recovered)/ Number of fish]

FCR = Feed intake (g) / Body weight gain (g)

PI (%) = [Protein (%) in diet x feed intake (g $fish^{-1}$ 56 $days^{-1}$)]/100

PER = Fish weight gain (g) / protein intake

1.6 Statistical analysis

Mean values were reported±standard deviation (SD). After confirming normality and homogeneity of variance (Howard and Burt, 1960), data were analyzed by one-way analysis of variance (ANOVA) by using the StatView software (version 5.0.1.0), and significance was set at $p < 0.05$. Multiple comparisons among means have been made with Duncan's tests.

The model of Brett and Grove (1979) applied to the second order polynomial regression between dietary protein and specific growth rate was used to estimate the optimum and maximum dietary protein requirements of *S. intermedius*.

2 Results

2.1 Growth performance and feed utilization

Growth performance, nutrient utilization and survival of fishes are presented in Table 2. For this experiment, the survival rate ranged from (18.33±8.81)% to (68.33±3.00)%. Apart from the fishes receiving a 40% protein diet (F3) which have presented the lowest value, the survival (%) was not significantly (p>0.05) different from the other treatments at the end of the feeding trial.

After the 56 days trial, only fishes fed F4 (CP 45%) doubled their initial body weight (Figure 1).

Table 2 Growth parameters and nutrient utilization in *Schilbe intermedius* fingerlings fed test diets for 56 days

Parameters	F 1	F 2	F 3	F 4	F 5	F 6
	25% CP	35% CP	40% CP	45% CP	50% CP	60% CP
In Wt.	1.65±0.01^{a}	1.65±0.01^{a}	1.62±0.00^{a}	1.63 ±0.00^{a}	1.64 ±0.00^{a}	1.64 ±0.00^{a}
Fn Wt.	2.01±0.05^{a}	2.47±0.05^{ab}	2.69±0.42^{b}	3.35±0.16^{c}	3.05±0.15^{b}	3.00±0.12^{b}
WG	0.011 ±0.26^{a}	20.72±1.40^{b}	18.36±7.94^{b}	62.02±3.50^{c}	58.91±7.84^{c}	52.12±4.28^{c}
SGR	0.35±0.05^{a}	0.72 ±0.04^{ab}	0.85±0.27^{b}	1.28±0.08^{c}	1.10±0.09^{b}	1.07±0.08^{b}
FI	1.46±0.22^{a}	1.46±0.05^{a}	2.72±1.23^{a}	1.68±0.06^{a}	1.61±0.02^{a}	1.66±0.06^{a}
PI	0.36±0.05^{a}	0.51±0.02^{ab}	1.09±0.49^{b}	0.75±0.02^{ab}	0.80±0.01^{ab}	0.99±0.03^{b}
FCR	4.14±0.42^{d}	1.76±0.05^{b}	2.48±0.17^{c}	1.00±0.14^{a}	1.17±0.15^{b}	1.23±0.09^{b}
PER	0.98±0.12^{a}	1.61±0.04^{b}	1.01±0.07^{a}	2.29±0.28^{c}	1.75±0.20^{b}	1.36±0.09^{ab}
SR	39.16±8.33^{a}	54.16±2.20^{acd}	18.33±8.81^{b}	50.83±4.16^{ad}	68.33±3.00^{c}	65.00±1.44^{cd}

Note: Values represent mean and standard deviation. In each line, different superscripted letters indicate significant differences between treatments (p<0.05); In wt: initial weight (g); Fn wt: final weight (g); WG: percent weight gain (%); SGR: specific growth rate (% day^{-1}); FI: feed intake (g fish^{-1} 56 days^{-1}); PI: Protein intake (g fish^{-1} 56 days^{-1}); FCR: feed conversion ratio; PER: protein efficiency ratio; PPV: protein productive value; SR: survival (%); ⁎ Values are means of triplicate groups±S.E.M. Within a row, means with the same letters are not significantly different (p>0.05)

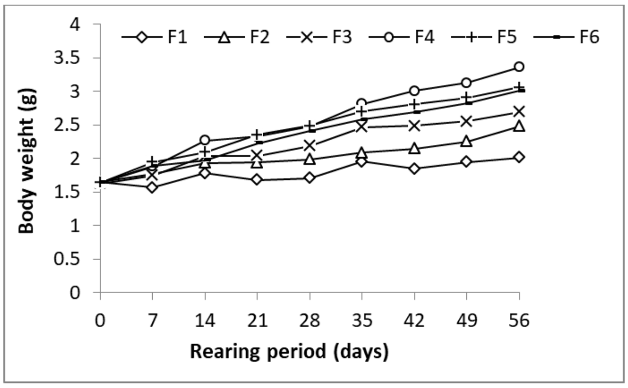

Figure 1 Effect of different dietary protein levels on the weight increment of *Schilbe intermedius* fingerlings

There was general increase of growth and feed utilization parameters according to the increasing of dietary protein levels. The final average body weight and the SGR of *S. intermedius* fed F4 (CP 45%) was significantly (p>0.05) higher than other treatments. Similarly, the best WG, FCR and PER were recorded in F4 groups (CP 45%). The WG of fish fed 25%~40% protein diets did not differ from each other, but were significantly (p<0.05) lower than those of the fish fed 45%~60% protein.

2.2 Whole body proximate composition

The whole body proximate composition of *S. intermedius* fed graded protein diets is shown in Table 3. Dry matter, ash, lipid and protein were significantly affected by dietary protein level (p<0.05). The ash content of the fish showed a decreasing trend with increasing dietary protein levels. Lipid content was significantly the lowest in fish fed diet with least protein level and increased with increasing dietary protein levels, that fish fed diet with the highest protein content retained the highest amount of lipid. The highest whole body protein was found in fish fed 45% dietary protein and there was not significantly different (p>0.05) with that of fish fed 60% dietary protein. Generally, the dry matter and protein content of the initial sample were significantly higher than the values after feeding the fish with experimental diets.

Table 3 Whole-body composition (%; on dry matter basis) for *Schilbe intermedius* fingerlings fed with diets containing different levels of protein for 56 days

Parameters	Initial	F1	F2	F3	F4	F5	F6
		25% CP	35% CP	40% CP	45% CP	50% CP	60% CP
Dry matter	90.64±0.04	88.06±0.01^a	90.09±0.02^b	90.88±0.04^c	89.16±0.06^d	89.87 ±0.01^e	91.64 ±0.03^f
Ash	12.61±0.05	13.83±0.02^a	13.50±0.05^a	12.24±0.05^b	10.69±0.28^c	10.45±0.02^{cd}	10.18±0.05^d
Lipid	12.23±0.03	11.2±0.04^a	11.49±0.00^b	12.1±0.07^c	13.7±0.02^d	14.23±0.06^e	14.62±0.01^f
Protein	73.38±0.04	65.73±0.3^{ad}	59.42 ±0.4^b	66.23±0.01^a	67.61±0.04^c	65.62±0.05^d	67.09±0.02^c

Note: Values represent mean and standard deviation. In each line, different superscripted letters indicate significant differences between treatments (p<0.05)

2.3 Estimation of protein requirement

Specific growth rate (SGR) and feed conversion ratio (FCR) values indicated that the best feed was F4 (45% CP) followed by F5 (50%CP) and F6 (60%CP). To estimate more accurately the protein requirement, the model of Brett and Grove (1979) expressing the relationship between dietary protein in diet and SGR was used. According to this model, the optimum and maximum protein requirement for better growth of *S. intermedius* fingerlings were 42.5 and 53, respectively (Figure 2).

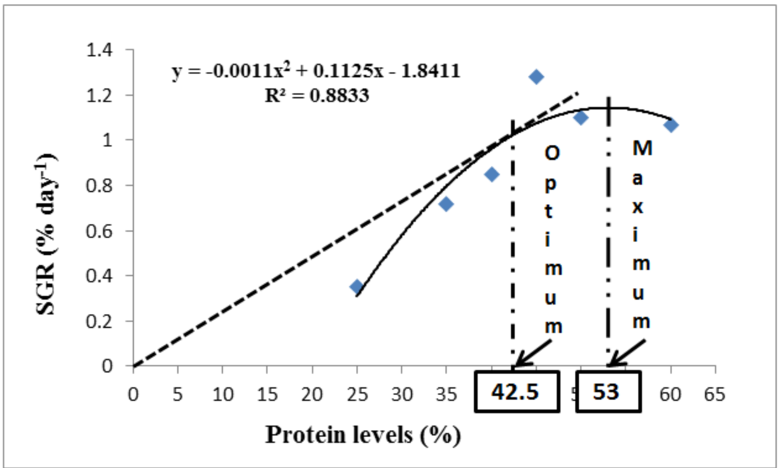

Figure 2 Relationship of SGR and dietary protein levels for *Schilbe intermedius* fingerlings fed feeds of various protein levels

2.4 Water quality

There was no difference between treatments (p>0.05) in recorded water quality indicators. Average temperature (°C) was 29.54±0.96 (26.5~31.9) and pH was 7.81±0.6 (6.17~8.98). Nitrite (NO_2^-) concentration was low during the experiment, with a slight increase with increasing dietary protein levels. Average NO_2^- (mg/L) was 0.05±0.01 (0.03~0.08).

3 Discussion

The survival rate in this study ranged between (18.33±8.81)% (F3, 40% CP) and (68.33±3.00)% (F5, 50%CP). These values are lower than those of 96 to 100% recorded by Kerdchuen (1992) with the fingerlings of *H. longifilis.* This could be justified by the difficulties of adapting to the artificial food of these fishes. Indeed, with predatory fish fingerlings, the adaptation to the artificial food affects their survival (Durville et al., 2003). The survival rates recorded in this study could be also explained by the fragility of the species (Bondombe Wa Yalokombe, 2014; Tossavi et al., 2016) and the stress resulting from handling (Maule et al., 1988; Rouger et al., 1998) since high mortalities have been recorded the first weeks of the experiment.

The results show that growth performance of the fish increases significantly with the increasing of dietary protein level up to 45% CP and then declined with further increase. Similar observation was reported in various other cultivated fingerlings as *Bidyanus bidyanus* (Yang et al., 2002), *Colossoma macropomum* (Oishi et al., 2010), *Heterotis niloticus* (Monentcham et al., 2010), *Clarias gariepinus* (Farhat and Khan, 2011) and *Parachanna obscura* (Kpogue et al., 2013). Low growth is obtained before 45% CP diet can be attributed to the fact that the fishes are not fed to satiation. Indeed, in general, low protein diets are effective when fishes are fed to satiation (Robinson, 2007). Likewise, low growth is obtained beyond 45% CP diet can be due to the fact that most of the protein is used for maintenance making it excess is unavailable for fishes growth because the excess protein may be broken down to amino acids which are deaminated to become carbohydrates (Kpogue et al., 2013). Therefore, inadequate protein levels in the diets results from a reduction of growth and loss of weight. On the other hand, insufficient dietary protein levels induce low growth performance in many fish species (Ali et al., 2014; Kim and Lee, 2005) due to insufficiency of amino acids supplied to maintain the body composition (Craig and Helfrich, 2009; Halver and Hardy, 2002).

FCR and PER are a good indicator of feed and protein utilization in aquaculture. In this study, the trends of these parameters are comparable to those reported in earlier studies on other fishes (Kerdchuen, 1992; Chaitanawisuti et al., 2010; Kpogue et al., 2013; Mohseni et al., 2014). Indeed, there is an improvement in these parameters with the increase in protein level to a maximum value from which they regress. Ahmad et al. (2012) obtained the same trend and they have shown that the feed and protein utilization parameters decrease beyond the maximal level of dietary protein. On the other hand, Al Hafedh (1999) obtained contrary trends with Nile tilapia, *Oreochromis niloticus.* Despite the similarity of trends of FCR and PER for our study with other studies, their values are lower than to those of other studies. These variations are due to the different experimental conditions, namely: fish species, size and age of fish, stocking density, protein quality, hygiene and environmental conditions, particularly temperature, which has been found to influence dietary protein requirement (Al Hafedh, 1999; Jauncey and Ross, 1982; Tung and Alfaro, 2011).

In this study, carcass lipid and protein contents of *S. intermedius* fed graded protein diets are positively correlated with dietary protein levels, while the ash content of the fishes have inverse relationship with dietary protein levels. Similar results on carcass body protein of other catfish have been reported (Kpogue et al., 2013). The similar relationship observed between the carcass lipid and dietary protein levels is also noted with *H. longifilis* (Kerdchuen, 1992) and *Epinephelus malabaricus* (Shiau and Lan, 1996). However, this observation is in contrast with that of other studies (Ali et al., 2014; Chen and Tsai, 1994; Oishi et al., 2010; Yang et al., 2002) who reported negative correlation between carcass lipid and dietary protein levels. This contradiction can be explained by the source of carbohydrate used in the various studies. Dextrin and glucose are used in this study, whereas dextrin only was used by Chen and Tsai (1994). Also, for all of our experimental diets, the ratio of glucose / dextrin is always greater than one (ratio: glucose / dextrin >1). The study of Shiau & Lin (1993) has shown that, higher body lipid was observed in tilapia fed starch diets. Yet, glucose, the majority carbohydrate of our experimental diets, is a nutrient obtained from the direct conversion of starch. This may provide an explanation for the differences in body lipid content of fish in the different studies. However, carbohydrate nutrition of *S.intermedius* has not yet been studied. The positive relationship between the carcass lipid and dietary protein levels can also be explained by the fact that the lipid content of the experimental diets are different from the beginning of the experiment. They increased with increasing dietary protein levels (Table 1). The ash contents are low in fish fed at high protein levels. This trend contradicts the results of Ali et al. (2003), who found that ash content in the fish fed diets containing in vary levels of protein were non-significant.

In this study, WG and SGR, improve with dietary protein level up to 45%, but no further improvement is observed at high protein levels, indicating that this protein level satisfied the requirement for growth of fingerlings *S.intermedius*. According to one-way ANOVA test and the model of Brett and Grove (1979) used to assess the effect of dietary protein level on SGR, protein requirements of *S.intermedius* fingerlings ranged from 42.5 to 53% of diet (Figure 2). The optimum feed protein level find out in this experiment is similar with the protein requirements reported for some other catfish species like *Mystus nemurus* (42%~44%) (Ng et al., 2001), hybrid *Hetero clarias (*50%) (Diyaware et al., 2009), *Clarias gariepinus* (43%~46%) (Farhat and Khan, 2011) and *Parachanna obscura* (42.5%~53.5%) (Kpogue et al., 2013). It is also similar to those determine for other carnivorous species fingerlings like *Perca fluviatilis* 43.6% (Fiogbe et al., 1996) and *Channa striatus* (45%) (Aliyu-Paiko et al., 2010). On the other hand, *S.intermedius* fingerlings dietary protein requirements obtained from this study are higher than 35%~40% reported for other catfish species (Kim and Lee, 2005; Kiriratnikom and Kiriratnikom, 2012; Ali et al., 2014). This can be explained by the fact that, fish species protein requirements are influenced by the size and age of fishes, diet formulation, stocking density, protein quality, hygiene and experimental conditions between various studies (NRC, 1993).

The average water temperature is 29.54°C, with a pH value of 7.81±0.6 and (0.03~0.08) mg/L Nitrite (NO_2^-). Throughout the experiment, the values recorded for the water quality can be considered low when compared with the results of water quality monitoring in striped catfish farms in the Mekong Delta (Phuong et al., 2010). Likewise, the average concentration of NO_2^- (0.05 mg/L) is similar to that recorded by Da et al. (2012) (0.06 mg/L) and low compared with the limits recommended for the management of pond fish culture (Bhatnagar and Devi, 2013). Therefore, the dietary protein levels do not significantly affect the water quality of the culture media. However, Nitrite content of the water increases proportionately with increasing of the dietary protein levels. The same trends are also observed by Yang et al. (2002) and Oishi et al. (2010). The outcome of Kaushik and Cowey (1990) on the dietary factors affecting nitrogen excretion by fish, show that, ammonia excretion rates are directly related to dietary nitrogen content and protein intake. This could explain the trend of concentration of nitrite recorded in our study.

4 Conclusion

The results of this study showed a significant variation (p <0.05) of growth performances, feed utilization and carcass composition of *S. intermedius* fingerlings fed with different dietary protein levels. The maximum WG, SGR, FER and PER were obtained with diets containing 45% protein. The second order polynomial regression was used to analyze the relationships between the dietary CP and the SGR. Based on our results, dietary CP requirements for *S. intermedius* fingerlings varied from 42.5 to 53% in formulated diets and the optimum level is 42.5%. Greater dietary protein is not only resulted in higher PER but also produced a higher lipid accumulation in the whole body of *S. intermedius* fingerlings.

Authors' contributions

TCE did work of experimental diets, system design, data collection, chemical analysis, manuscript writing; DASM did work of data collection, manuscript writing; ONI did work of experimental diets, system design, chemical analysis, manuscript writing; FED did work of experimental diets, system design, manuscript writing; MJC did work of experimental diets, manuscript writing. All authors read and approved the final manuscript.

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