Effects of organic and commercial feed meals on water quality and growth of *Barbonymus schwanenfeldii* juvenile

[1]Omran Mansour, [1]Mushrifah Idris, [1]Noorashikin M. Noor, [1]Muhammad S. B. Ruslan, [1,2]Simon K. Das

[1] School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, National University of Malaysia, 43600 Bangi, Selangor, Malaysia; [2] Marine Ecosystem Research Centre (EKOMAR), Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, D.E., Malaysia. Corresponding authors: M. Idris, mush@ukm.edu.my; S. K. Das, simon@ukm.edu.my

Abstract. The effects of organic and commercial feed meals on water quality and growth of *Barbonymus schwanenfeldii* (lampam fish) were studied. Experiments were carried out using organic and commercial feed for 16 weeks. During the experimental period, water quality which includes dissolved oxygen (DO), pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), ammonia (NH_3), nitrate (NO_3), total suspended solids (TSS) and water quality index (WQI) were measured. The growth performance measured included the fish body weight, total length, specific growth rate (SGR), feed conversion ratio (FCR) and survival rate (SR). The fish weights, length and SGR in commercially fed group were higher ($p < 0.05$) than the organic fed group. Meanwhile, significantly lower FCR was observed in the commercial fed group. No mortality was observed between both groups. Conversely, the commercial fed group had significantly lower DO, COD, pH and TSS concentrations and significantly higher ($p < 0.05$) WQI, BOD, NH_3, and NO_3, than organic fed group. From the results, it is suggested that better water quality was observed when *B. schwanenfeldii* was fed with commercial feed than organic feed which lead to better growth performance.

Key Words: *B. schwanenfeldii*, growth, feed type, water quality parameter.

Introduction. Water quality has influenced fish survival and can be divided into physical and compound parameters (Idris et al 2003). Physical environment incorporates aquarium size, water temperature, and length. Chemical components incorporate chlorine, chloramine, carbonate hardness, pH, oxygen, carbon dioxide, phosphate, and nitrogenous waste levels (Howard 1998). Nitrogenous waste can be separated into ammonia (NH_3), nitrite (NO_2), and nitrate (NO_3). These elements interface influence the particular nature of the water (Boyd 1990). The variations in dissolved oxygen (DO), pH, temperature, chemical oxygen demand (COD), biochemical oxygen demand (BOD), NH_3, NO_3 and total suspended solids (TSS) have an impact on fish development in length and weight (TVA 2010; Chezhian et al 2012). Any alterations in these parameters can cause significant fish mortality and stunted growth (Rahman et al 2016).

The type of feed meal is well established to positively influence fish growth performance which, in turn, may or may not affect water quality parameters (Tidwell et al 1996). Proteinous rich feed meal is considered, in addition to amino acid source, to be a moderately rich source of vitamins of the B-complex especially cobalamine (B12), niacin, choline, pantothenic acid, and riboflavin. The natural cycle of fish is when the feed meal is digested within a certain period of time and produces less ammonia (NH_3). NH_3 can be produced naturally when there is a breakdown of organic matter excreted by fish as a nitrogenous waste product (Crab et al 2007; Amirkolaie 2011). In fish, NH_3 is produced as a by-product of protein metabolism and it is primarily excreted within the gill membranes, the NH_3 produced can be eliminated by certain bacteria to nitrite and nitrate (Randall & Tsui 2002). This nitrate can be used by crops and algae and it is known to be harmless to any kind of fish in most fresh water (Fabricius et al 2005). NH_3 is a toxic compound which can adversely affect the health of fish. The nature and degree of toxicity depend on many factors, including the chemical form of ammonia, the pH as well as the temperature of the water, the length of exposure, and the life stage of the exposed fish (Randall & Tsui 2002). Alteration in any water quality parameters influences fish performance, survival, and physiology in their natural environment (Yerel & Ankara 2012). This may adversely affect the groups of fish including *Barbonymus schwanenfeldii* (Alabaster & Llyod 2013). These water quality parameters commonly studied in fish include pH, DO, temperature, and TSS (Idris et al 2003).

The data on the effects of feed meals on the growth of *B. schwanenfeldii* is scarce. Also, information on the effect of feed meals on water quality parameters is poorly reported. Therefore, the objective of this study was to compare the water quality and growth performance of *B. schwanenfeldii* fed with commercial and organic feed meals.

Material and Method. A total of 60 tails of juvenile *B. schwanenfeldii* fish (Lampam) were acquired from local commercial aquarium shop and was first acclimatized in a stocking tank (1200 L) for one week prior to experiment. The fish were then transferred into 18 experimental tanks (40 L capacity) at the greenhouse of Universiti Kebangsaan Malaysia (UKM). Each tank contained eight fish with an average weight of 4.5±0.5 g. The experimental tanks were then categorized into two groups with triplicates; fish fed with organic meal and fish fed with commercial meal (Table 1). The amount of feed meal was about 5% of fish weight. The total experiment was conducted for 16 weeks from January-April 2014.

Table 1

Description of experimental diet

	Feed type	*Ingredients*	*Features*
1	Organic	Wheat Germ, White Fish Meal Spirulina, Soybean Meal, Dried Sour Whey, Dehydrated Alfalfa, Brewers, Dried Yeast Minerals, Vitamins - A,B complex, C, and E.	Ocean free high standard wheat germ feed ensures all out the freshness and effortlessly digestion for your fish. Enzymes help to minimize water contamination from fish waste. All the crucial vitamins and minerals are incorporated to give balance meal for your fish. Provides development to your kois/fishes even in outside conditions. Ingredients like meat, protein, wheat germ and digestive enzymes will promote growth and beautify overall shape of fish.
2	Commercial	Fish meal, wheat, yeast. Germ meal, shrimp meal. Vitamin and mineral supplements	Fish sustenance is skimming pellet and won't cloud the water. Fish sustenance is produced from select fixings under strict quality control.

Determination of water quality parameters*.* The physical parameters measured were pH, DO and TSS while the chemical parameters include COD, ammonia, nitrite, and BOD. The pH and temperature of each aquarium were measured and recorded on a daily basis. The pH and temperature were measured using pH meter and thermometer respectively. The DO was measured using dissolved oxygen meter (YSI 5000). Fish body weight (BW) was measured and recorded using digital balance (A & D, Model-GR-200) (Simon et al 2008).

The TSS was determined gravimetrically (TM, 1999), and ammonia nitrogen (NH_3-N), and nitrate (NO_3) were determined individually using Cadmium Reduction Method (Nessler 2014). The COD and BOD were measured separately using Colorimetric Lr method (Idris et al 2003).

Water Quality Index (WQI)*.* Six parameters including DO, pH, BOD, COD, ammonia nitrite, and TSS are used for the evaluation of the overall status of the aquaria waters. WQI was calculated based on these six parameters (Al-Mamun & Idris 2008). The WQI equation comprises of the sub-indices which were calculated according to the best-fit relations given in Equation. The formula used in the WQI calculation is:

$$WQI = 0.22SIDO + 0.19SIBOD + 0.16SICOD + 0.16SISS + 0.15SIAN + 0.12SI\ pH \quad (1)$$

where: WQI = Water quality index; SIDO = Sub-index of DO; SIBOD = Sub-index of BOD; SICOD = Sub-index of COD; SIAN = Sub-index of AN; SISS = Sub-index of TSS; SIpH = Sub-index of pH.

Statistical analysis*.* All data interpretation and analysis were carried out using statistical SAS software version 9.4) (SAS Institute Inc., Cary, NC, USA). Water quality data were tested by subjecting the data to different multivariate statistical analyses. The difference between the means was compared using Tukey. The $p < 0.05$ was considered statistically significance.

Determination of fish growth performance*.* The fish lengths were measured using tape meter. The feed conversion ratio and survival rate were calculated on two weeks interval using body weight gain (BWG), feed intake (FI), and mortality records. The following formulae were used:

$$\text{Feed conversion ratio (FCR)} = \frac{\text{feed intake (g feed on as fed basis)}}{\text{Body weight gain (g)}}$$

(Lupatsch et al 2010)

$$\text{Survival Rate (\%)} = \frac{\text{Number of live fish (live fry – dead fry)}}{\text{Initial number of total fish}} \times 100$$

(Ahmadi et al 2011)

Specific growth rate (SGR) was calculated according to the following equation:

$$\text{SGR (\%body wt. gain/day)} = \frac{(\text{Log}_n \text{ Final fish wt.} - \text{Log}_n \text{ Initial fish wt.})}{\text{Time interval}} \times 100$$

where: wt = weight; Log_n = natural logarithm (Cook et al 2000).

Results and Discussion. The weight of *B. schwanenfeldii* fed with organic and commercial feed is presented in Figure 1. During the experimental period, the *B. schwanenfeldii* fed with commercial feed had significantly ($p < 0.05$) higher body weight than the organic fed group starting from the third month (week 12) until the end of the experimental period. This might due to the ingredients of the commercial feed which consisted of fish meal. Similarly, this could be observed in rainbow trout *Oncorhynchus mykiss* whereby the body weight is significantly increased in fish supplemented with fish meal (Hauptman et al 2014).

The length of fish treated with commercial feed were significantly ($p < 0.05$) increased (Figure 2). The significantly increased length was observed during the third month (week 12) onwards. This pattern followed the increase of body weight as previously showed. A study by Overturf et al (2013) reported that the presence of fish meal significantly increased the length of rainbow trout *O. mykiss* as the author suggest the fish meal supplied the fish with protein that contributed to the length of the fish as well as the growth performance.

The results of the SGR on commercial fed and organic fed groups were represented in Figure 3. The SGR was significantly ($p < 0.05$) increased in the commercial fed group than the organic fed group. This was observed starting from the third month (12 weeks) in linear with the body weight and body length of the fish. A different SGR was noted in pool barb, *Puntius sophore* fed with different supplementary feed where the highest fish meal content group results in a higher SGR (Ahammad et al 2009). However, the present result did not agree with results by Wee & Ngamsnal (1978) where a much lower SGR values was obtained in *P. gonionotus* fed with higher dietary protein levels.

The FCR was greatly ($p < 0.05$) declined in fish fed with commercial diet compared to organic fed group (Figure 4). Past study by Christensen (1994) indicated that FCR of *B. schwanenfeldii* was 2.8 when the fish were fed with pellet which was higher than with the results obtained in the present study. This might be due to the lower protein content in the pellet used. Osofero et al (2009) showed FCR of 1.56 in tilapia, *Oreochromis niloticus* when it was fed with high protein content feed compared to 2.21 when fed with low protein content feed. Also, no mortality was observed between the organic and commercial fed group during the experimental period. This was supported by the study by which presented that the feed type affect the growth performance but did not affect the survival rate in rainbow trout, *O. mykiss* juvenile (Overturf et al 2013).

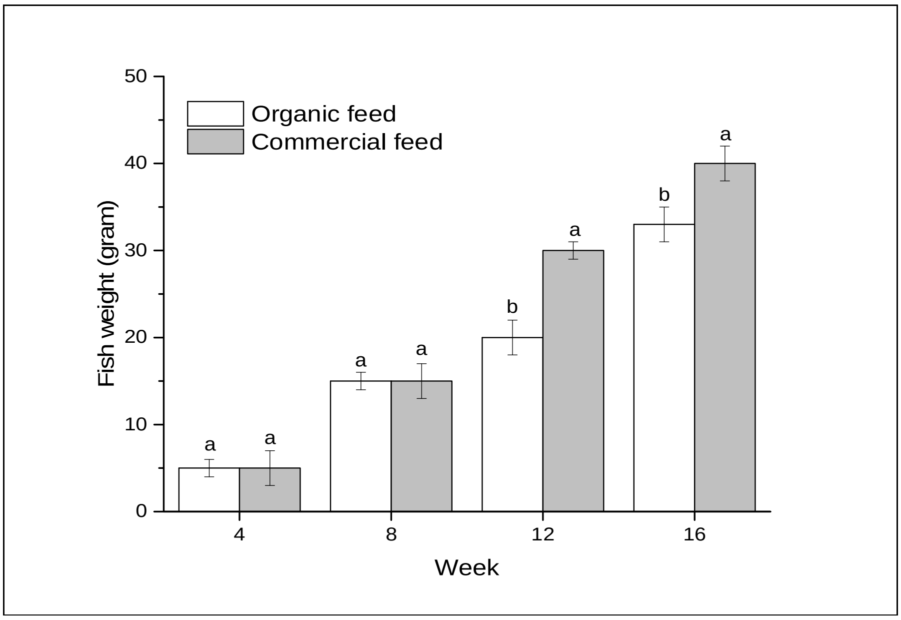

Figure 1. Body weight (g) observed in the organic and commercial fed group during the experimental period for *B. schwanenfeldii*. Different small letters on the bar graph shows the significant difference ($p < 0.05$) between groups in the same time.

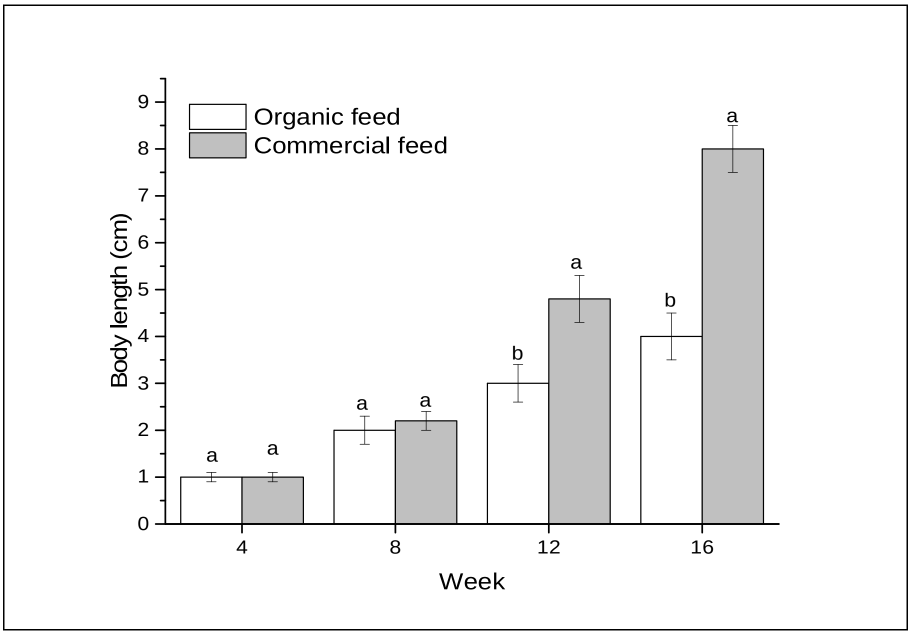

Figure 2. Body length (cm) observed in the organic and commercial fed group during the experimental period for *B. schwanenfeldii*. Different small letters on the bar graph shows the significant difference ($p < 0.05$) between groups in the same time.

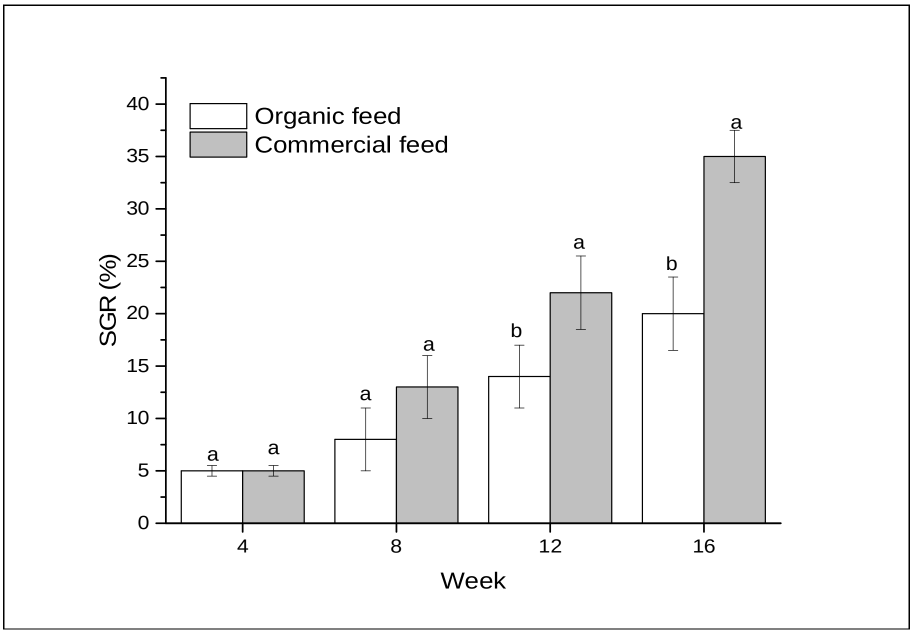

Figure 3. SGR (%) observed in the organic and commercial fed group during the experimental period for *B. schwanenfeldii*. Different small letters on the bar graph shows the significant difference ($p < 0.05$) between groups in the same time.

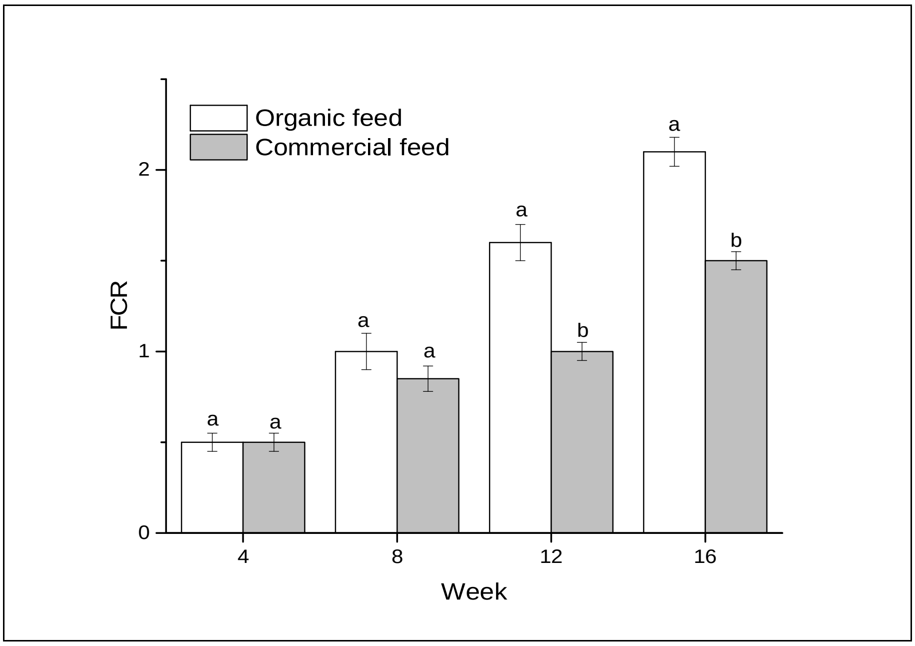

Figure 4. FCR observed in the organic and commercial fed group during the experimental period for *B. schwanenfeldii*. Different small letters on the bar graph shows the significant difference ($p < 0.05$) between groups in the same time.

The dissolved oxygen (DO) in the first and second month showed no significant differences in both organic and commercial fed group (Figure 5). However, the DO significantly decreased in organic fed group compared to the commercial fed group after three months of culturing. The amount of oxygen in water shows its overall health. If the oxygen level is high, the pressure of the polluted level is low (Chezhian et al 2012). Equally, when the oxygen level is low, pressure has high oxygen demand, and the body of water is not an optimal health. In this study, it is observed that the organic fed group has lower DO due to the excessive algae and plankton in the experimental tanks.

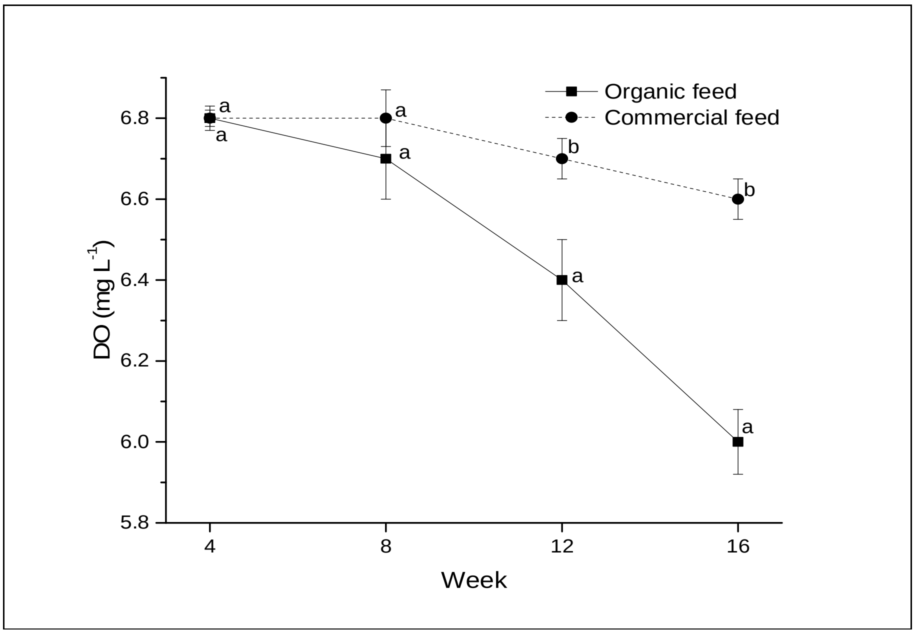

Figure 5. DO observed in the organic and commercial fed group during the experimental period for *B. schwanenfeldii*. Different small letters on the bar graph shows the significant difference ($p < 0.05$) between groups in the same time.

The results of chemical oxygen demand (COD) of *B. schwanenfeldii* fed with organic and commercial feed were shown in Figure 6. The COD level of the organic fed group was significantly ($p < 0.05$) decreased when compared commercial fed group. This was observed form the third months until the end of the experimental period. The increase in feed output increases the DO level, thus providing a greater value of COD and vice versa. The lower value of COD observed in organic fed group may attributed with the excessive algae and plankton which lower the DO (Sasi 2011). The COD of organic pollutants are commonly consumed by microorganisms which result in depletion of the oxygen content of the water. This depletion has adverse effects on the balance of natural ecosystems if the oxygen content drops below the level crucial to support aquatic life (Rahman et al 2016).

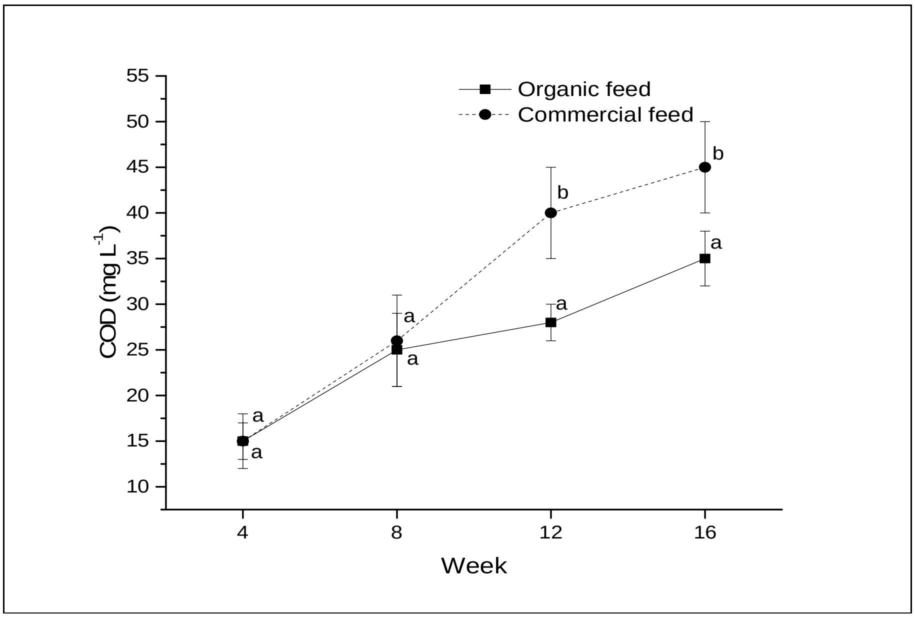

Figure 6. COD observed in the organic and commercial fed group during the experimental period for *B. schwanenfeldii*. Different small letters on the bar graph shows the significant difference ($p < 0.05$) between groups in the same time.

The Biological Oxygen Demand (BOD) values of organic and commercial fed group were displayed in Figure 7. The BOD level of the organic fed group was significantly ($p < 0.05$) higher than the commercial fed group from the third month onwards. No significant differences were observed on the first two months. According to Faizul & Christianus (2013), BOD is an amount of oxygen consumed by the organism while decomposing under aerobic conditions. A high BOD indicates that organisms are persistently breaking down excessive organic contaminants, as indicated by the present results. Oxygen is used up in this process and results in a decrease in DO and BOD increases when the breaking down process is complete (Faizul & Christianus 2013). It is clear that a reverse proportional relationship between DO and BOD existed as shown by the current results. This was agreement with the results obtained by Faizul & Christianus (2013).

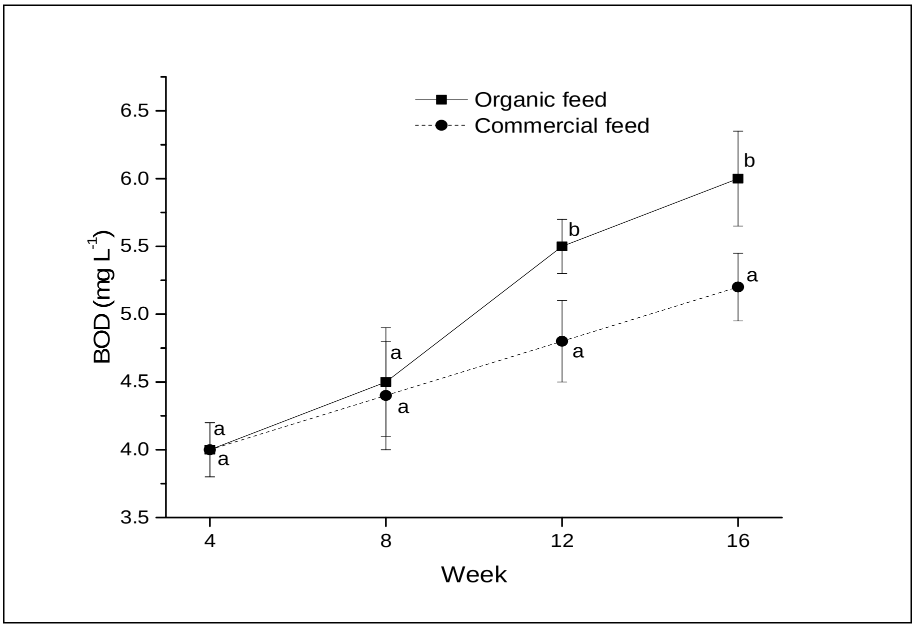

Figure 7. BOD observed in the organic and commercial fed group during the experimental period for *B. schwanenfeldii*. Different small letters on the bar graph shows the significant difference ($p < 0.05$) between groups in the same time.

The pH level of the organic and commercial fed groups were shown in Figure 8. pH of the *B. schwanenfeldii* fed with the commercial diet had a higher pH than the one fed with the organic diet from the third month onwards. This might be due to increased amount of algae. Lower pH may cause acidic environment and can be toxic to the fish (Howerton 2001).

The effects of ammonia (NH_3) level when *B. schwanenfeldii* was fed with organic and commercial feed were presented in Figure 9. *B. schwanenfeldii* fed with commercial feed produced significantly ($p < 0.05$) higher NH_3 from the third month than those fed with organic feed. The organic feed group indicated lesser NH_3 due to the presence of algae and plankton activities. NH_3 is a crucial constraint in an intensive system as it determines the psychical health of the fish (Svobodova et al 1993). The decrease in ammonia in an environment may promote bacterial infections and cause poor growth. However, extremely high level of NH_3 is toxic to the fish. NH_3 is a by-product of fish metabolism such as faeces and therefore accumulates naturally in the aquatic environment (Svobodova et al 1993). NH_3 level may also increase especially if overfeeding is prevalent (Abdullah 1994).

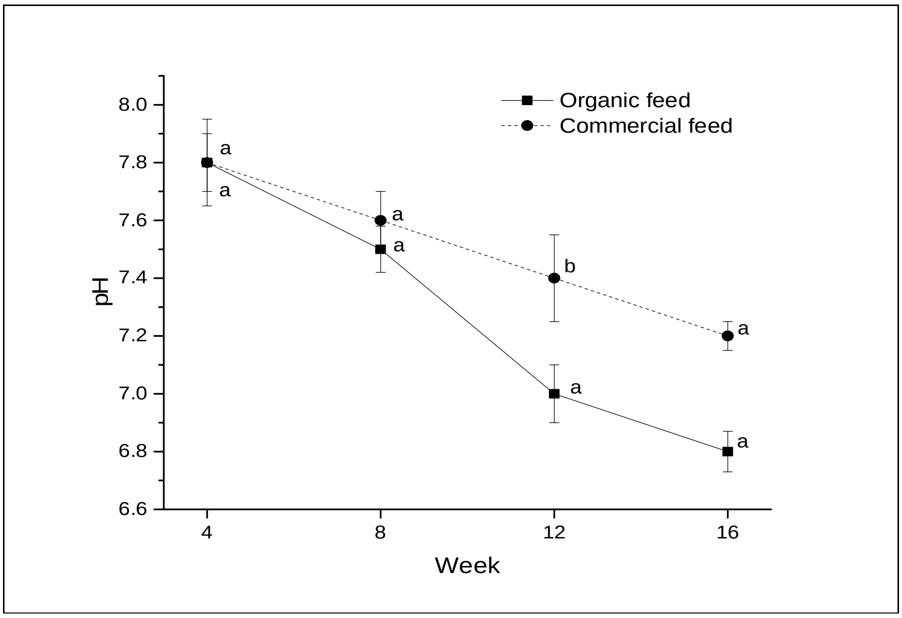

Figure 8. pH observed in the organic and commercial fed group during the experimental period for *B. schwanenfeldii*. Different small letters on the bar graph shows the significant difference ($p < 0.05$) between groups in the same time.

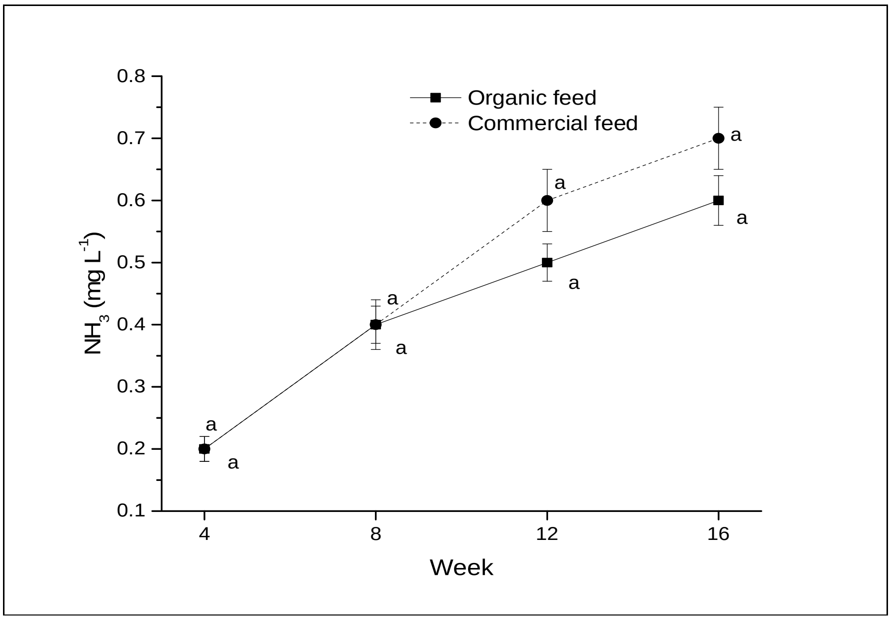

Figure 9. NH_3 observed in the organic and commercial fed group during the experimental period for *B. schwanenfeldii*. Different small letters on the bar graph shows the significant difference ($p < 0.05$) between groups in the same time.

The results of nitrate of both groups are shown in Figure 10. The nitrate (NO_3) in commercially fed group increased significantly ($p < 0.05$) compared to organic fed group at the third month (12 weeks) until the fourth month (16 weeks). This is due to the high nitrogen (N_2) content in the organic feed compared to the commercial feed (Chezhian et al 2012). Ammonia is the nitrogen cycle that broken by *Nitrosomonas* bacteria to produce nitrite then broken down the beneficial bacteria nitrate. The goal is zero detectable nitrites. Zero readable nitrites can be toxic (Svobodova et al 1993). Tips to reduce this toxic action includes increasing the biological filtration, avoiding overfeed, avoiding aquarium overstock, increasing water exchanges and daily monitoring for dying fish (Faizul & Christianus 2013). The NO_3 levels in the organically fed aquaria were lesser than commercial ones.

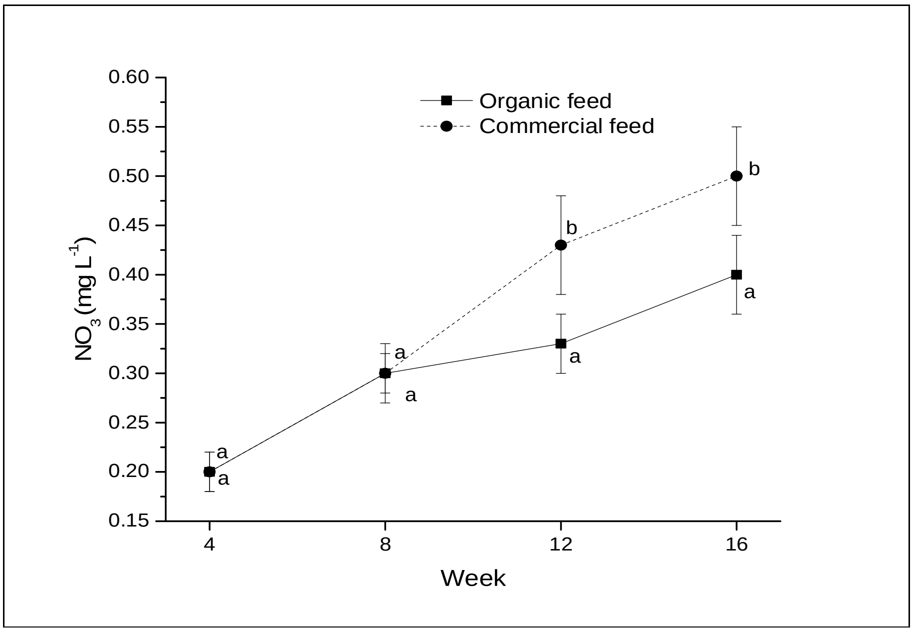

Figure 10. NO_3 observed in the organic and commercial fed group during the experimental period for *B. schwanenfeldii*. Different small letters on the bar graph shows the significant difference ($p < 0.05$) between groups in the same time.

The results of total suspended solids (TSS) of the fish fed with organic or commercial feed are shown in Figure 11. In the first three months, there was no significant difference observed in both groups. However, in the last month, significantly ($p < 0.05$) higher TSS level was observed in the organic feed group. This can be attributed to the plentiful of algae and plankton distributions that came from the feed type which was supported by study by Abdullah (1994). As less oxygen is produced by plants and algae, there is a further drop in DO levels which would lead to higher TSS level. It was also observed that the water became cloudy in the organic fed group due to the higher levels of the TSS. Water with TSS concentration less than 20 to 40 mg/l tends to be clear while water with TSS levels between 40 to 80 mg L^{-1} appears cloudy, while water with concentrations over 150(mg/l) appears dirty (TVA 2010).

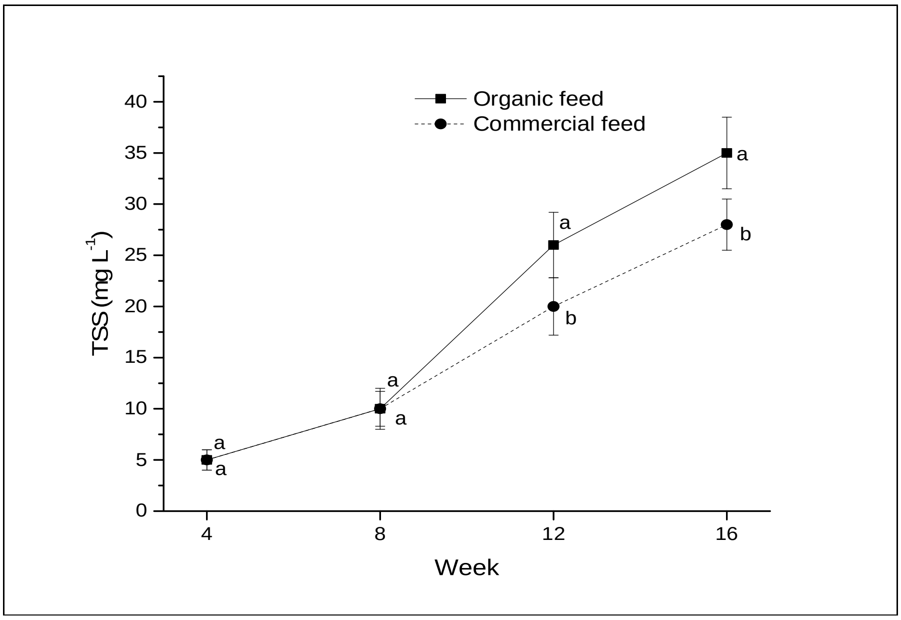

Figure 11. TSS observed in the organic and commercial fed group during the experimental period for *B. schwanenfeldii.* Different small letters on the bar graph shows the significant difference ($p < 0.05$) between groups in the same time.

The results of Water Quality Index (WQI) of organic and commercial fed group were presented in Table 2. The commercial fed group had significantly ($p < 0.05$) higher WQI than organic fed group. This study was supported by the findings in rainbow trout, *O. mykiss* where significantly higher WQI of the cultured water when the fish was fed with pellet supplemented with higher fish meal content (Overturf et al 2013). Higher WQI supported the better growth performance observed in fish that was fed with commercial diet.

Table 2

Water Quality Index (WQI) of the organic and commercial fed groups

Group	*Mean WQI ± SD*
Organic fed	32.7 ± 23.0^{a}
Commercial fed	75.5 ± 17.0^{b}

SD: standard deviation of the mean; different superscript letters indicated significance ($p < 0.05$) difference among treatments.

Conclusions. From the study, it can be concluded that the commercial fed group resulted significantly improved ($p > 0.05$) growth and water quality compared to the organic fed group. Thus, it is suggested to use commercial feed as the diet for *B. schwanenfeldii* for better water quality and eventually the growth performance. This study would be useful for the feed management of *B. schwanenfeldii* among the aquaculturist.

Acknowledgements. The authors wish to thank School of Environmental and Natural Resource Sciences, Universiti Kebangsaan Malaysia for all facilities offered. The principal researcher would also like to thank the Libyan Ministry of Higher Education and Bani Waleed University for the PhD sponsorship and study leave respectively. Thanks to Universiti Kebangsaan Malaysia for the financial support through the University Research Grant GUP-2015-025.

References

Abdullah S. Z., 1994 Studies on the morphology of *Tifelohanellus* sp., and the effects of water quality and rainfall on its prevalence in *Puntius gonionotus* (Bleeker). Master Thesis, Universiti Pertanian Malaysia, pp. 26-28.

Ahammad A. K. S., Khan M. M. R., Hossain M. A., Parvez I., 2009 Nursery rearing of Thai sarpunti, *Barbonymus gonionotus* larvae using three different supplementary feeds. Journal of the Bangladesh Agricultural University 7(1):139-144.

Ahmadi M. R., Mahmoudzadeh H., Babaei M., Shamsaei M. M., 2011 Prediction of survival rate in European white fish (*Coregonus lavaretus*) fry on three different feeding regimes. Iranian Journal of Fisheries Sciences 10(2):188-202.

Alabaster J. S., Lloyd R. S., 2013 Water quality criteria for freshwater fish (No. 3117). Elsevier, London, pp. 352-360.

Al-Mamun A., Idris A., 2008 Revised water quality indices for the protection of rivers in Malaysia. Twelfth International Water Technology Conference, IWTC12 2008, Alexandria, Egypt, pp. 1687-1698.

Amirkolaie A. K., 2011 Reduction in the environmental impact of waste discharged by fish farms through feed and feeding. Reviews in Aquaculture 3(1):19-26.

Boyd C. E., 1990 Water quality in ponds for aquaculture. 2nd edition, Alabama Agricultural Experiment Station, Auburn University, Auburn, AL, USA, 482 pp.

Chezhian A., Senthamilselvan D., Kabilan N., 2012 Histological changes induced by ammonia and pH on the gills of fresh water fish *Cyprinus carpio* var. *communis* (Linnaeus). Asian Journal of Animal Veterinary Advances 7(7):588-596.

Christensen M. S., 1994 Growth of tinfoil barb, *Barbonymus schwanenfeldii*, fed various feeds, including fresh chicken manure, in floating cages. Asian Fisheries Science 7:29-34.

Cook J. T., McNiven M. A., Richardson G. F., Sutterlin A. M., 2000 Growth rate, body composition and feed digestibility/conversion of growth-enhanced transgenic Atlantic salmon (*Salmo salar*). Aquaculture 188:15-32.
Crab R., Avnimelech Y., Defoirdt T., Bossier P., Verstraete W., 2007 Nitrogen removal techniques in aquaculture for a sustainable production. Aquaculture 270(1):1-14.
Fabricius K., De'ath G., McCook L., Turak E., Williams D. M., 2005 Changes in algal, coral and fish assemblages along water quality gradients on the inshore Great Barrier Reef. Marine Pollution Bulletin 51:384-398.
Faizul M. I. M., Christianus A., 2013 Salinity and stocking density effect on growth and survival of *Barbodes gonionotus* (Bleeker, 1850) fry. Journal of Fisheries and Aquatic Science 8(2):419-424.
Hauptman B. S., Barrows F. T., Block S. S., Gaylord T. G., Paterson J. A., Rawles S. D., Sealey W. M., 2014 Evaluation of grain distillers dried yeast as a fish meal substitute in practical-type diets of juvenile rainbow trout, *Oncorhynchus mykiss*. Aquaculture 432:7-14.
Howard A. G., 1998 Aquatic environmental chemistry. Oxford University Press, Oxford, 90 pp.
Howerton R., 2001 Best management practices for Hawaiian aquaculture. Center for Tropical Aquaculture, Publication No. 148, 32 pp.
Idris A., Al-Mamun A., Amin M., Soom, Noor W. A., 2003 Review of water quality standards and practices in Malaysia. Pollution Research 22(2):145-155.
Lupatsch I., Santos G. A., Schrama J. W., Verreth J. A. J., 2010 Effect of stocking density and feeding level on energy expenditure and stress responsiveness in European sea bass *Dicentrarchus labrax*. Aquaculture 298:245-250.
Nessler M., 2014 Nitrogen-Ammonia (2.50 mg/L). Hach Company/Hach Lange GmbH, Edition 8.
Osofero S. A., Otubusin S. O., Daramola J. A., 2009 Effect of stocking density on tilapia (*Oreochromis niloticus* Linnaeus 1757) growth and survival in bamboo-net cages trial. African Journal of Biotechnology 8:1322-1325.
Overturf K., Barrows F. T., Hardy R. W., 2013 Effect and interaction of rainbow trout strain (*Oncorhynchus mykiss*) and diet type on growth and nutrient retention. Aquaculture Research 44(4):604-611.
Rahman M. K., Sheriff M. A., Azmathullah N. M., 2016 Potential use of the freshwater teleost, *Labeo rohita* (Hamilton, 1882) as a bio-indicator of zinc toxicity. International Journal of Life Sciences Scientific Research 2(4):376-384.
Randall D. J.,Tsui T. K. N., 2002 Ammonia toxicity in fish. Marine Pollution Bulletin 45(1):17-23.
Sasi H., 2011 A review and new locality of threatened fish, *Pseudophoxinus anatolicus* (Hanko, 1924) (Cyprinidae) from Anatolia. Asian Journal of Animal Veterinary Advances 6:238-241.
Simon K. D., Mazlan A. G., Cob Z. C., Samat A., Arshad A., 2008 Age determination of archer fishes (*Toxotes jaculatrix* and *Toxotes chatareus*) inhabiting Malaysian estuaries. Journal of Biological Sciences 8(6):1096-1099.
Svobodova Z., Lloyd R., Machova J., Vykusova B., 1993 Water quality and fish health. EIFAC Technical Paper, No. 54, Rome, FAO, 59 pp.
Tidwell J. H., Webster C. D., Coyle S. D., 1996 Effects of dietary protein level on second year growth and water quality for largemouth bass (*Micropterus salmoides*) raised in ponds. Aquaculture 145(1-4):213-223.
TVA, 2010 Standard operating procedure for total suspended solids determination using vacuum filtration and oven drying TVA-KIF-SOP-49. Prepared by Jacobs Engineering Group, Inc., 10 pp.
Wee K. L., Ngamsnal D., 1978 Production of *Puntius gonionotus* (Bleeker) in ponds. Indian Journal of Fisheries 21(2):77-83.
Yerel S., Ankara H., 2012 Application of multivariate statistical techniques in the assessment of water quality in Sakarya River, Turkey. Journal Geological Society of India 79:89-93.

Received: 15 August 2017. Accepted: 08 September 2017. Published online: 14 September 2017.
Authors:
Omran Mansour, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, National University of Malaysia, 43600 Bangi, Selangor, Malaysia, e-mail: omranmansor@yahoo.com
Musrifah Idris, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, National University of Malaysia, 43600 Bangi, Selangor, Malaysia, e-mail: mush@ukm.edu.my
Noorashikin Md. Noor, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, National University of Malaysia, 43600 Bangi, Selangor, Malaysia, e-mail: kk_shikin@yahoo.com
Muhammad Shafiq Bun Ruslan, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, National University of Malaysia, 43600 Bangi, Selangor, Malaysia, e-mail: msr@ukm.edu.my
Simon Kumar Das, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, University Kebangsaan Malaysia, 43600 UKM Bangi Selangor, D.E., Malaysia; Marine Ecosystem Research Centre, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor D. E., Malaysia, e-mail: skdas_maa@yahoo.com; simon@ukm.edu.my

How to cite this article:
Mansour O., Idris M., Noor N. M., Ruslan M. S. B., Das S. K., 2017 Effects of organic and commercial feed meals on water quality and growth of *Barbonymus schwanenfeldii* juvenile. AACL Bioflux 10(5):1037-1048.