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Effect of Mealworm (*Ternebrio molitor*) Meal in Practical Diets on Growth Performance, Feed Utilization and Carcass Composition of Climbing Perch Fingerlings (*Anabas testudineus*)

W. Nalinanon[1*], S. Lerdsuwan[2] and D. Pisuttharachai[1]

[1]*Program of Fishery Science and Aquatic Resources, King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus, Thailand*

[2]*Program of Animal Science, King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus, Thailand*

Abstract: The Climbing Perch (*Anabas testudineus*), a tropical freshwater fish, was chosen as a candidate for commercial inland aquaculture. Two separate 12-week feeding trials were conducted to evaluate the use of mealworm, *Tenebrio molitor*, as an alternative protein source for *A. testudineus*. In Experiment 1, fingerlings of *A. testudineus* 8.6 $\pm$ 0.1 g were acclimated to laboratory conditions for a period of 2 weeks. Five isonitrogenous (30% crude protein) and isoenergetic (4,000 Kcal/Kg) practical diets were formulated. The fish meal component of the diets was progressively substituted at 0, 12.5, 25, 37.5, and 50% with mealworm meal. The diets were fed to triplicate groups of 20 fish twice a day to apparent satiation. Growth performance and feed utilization efficiency of *A. testudineus* fed diets with up to 25% replacement of fish meal with worm meal were not significantly different ($P>0.05$) in FCR, PER and NPU as 1.51±0.09, 2.22±0.14 and 34.06±1.05% respectively compared to fish fed the control diet. Worm meal in the experimental diets of caused a significant ($p<0.05$) increase in whole body lipid and decrease in moisture at all levels of worm meal incorporation. Treatment 4 (37.5% worm meal) was the highest in whole body lipid as 9.50±0.82 % and treatment 5 (50% worm meal) was the lowest in moisture as 70.45±1.76 %. In Experiment 2, fingerlings of *A. testudineus* 15.2$\pm$0.12 g were acclimated to laboratory conditions for a period of 2 weeks. The nutritive value of mealworms was compared with a commercial catfish pellet. Five dietary treatments consisting of fish fed catfish pellets only, mealworms (25) /catfish pellet (75) combination, mealworms (50) /catfish pellet (50) combination, mealworms (75) /catfish pellet (25) combination and mealworms only were tested. *A. testudineus* fed mealworms (50) /catfish pellet (50) combination displayed the best in specific growth rate as 2.61±0.10 than *A. testudineus* fed catfish pellets only.

Keywords: Mealworm, growth performance, feed utilization, *Anabas testudineus*

Introduction

In formulating a nutritive diet of cultured fish, fish meal is used as the main dietary protein source because of its nutritional quality and palatability properties (Hardy and Tacon, 2002). The increased demand in fishmeal especially in the commercial fish diet industry has resulted in a supply shortage in concomitant price increase (Abd Rahman Jabir et al.,2012). Fishmeal will not be able to supply the aquaculture feed industry with a continuous source of cheap protein indefinitely. It is crucial to reduce the use of fishmeal in fish diet by replacing it with alternative protein sources because total dependence can affect the whole operation of aquaculture systems. Unconventional protein sources such as insect meal have been used to replace fishmeal. These studies indicate a reduction in feed cost and increased profitability, without compromising performance (Abd Rahman Jabir et al.,2012). Mealworm, the larvae of the beetle, Tenebrio molitor, is a potential protein source and widely used as a feed supplement for birds and fish (Ebeling, 1975) and is a favorable candidate for insect rearing due to its high protein content, well-balanced amino acid profile (Rumpold and Schlüter, 2013), efficient feed conversion rate (Oonincx et al., 2015), low greenhouse gas emissions (Oonincx and de Boer,

Corresponding Author: *warrapong.na@kmitl.ac.th*

2012), ability to live on organic by-products (Van Broekhoven et al., 2015) and available mass production technology (Cortes Ortiz et al., 2016). Meal worm larvae had a proximate composition of 64.1% moisture, 13.8% lipid, 17.6% protein, 1.5% ash, and 3.1% carbohydrate, or on a dry weight basis, 38.3% lipid, 49.1% protein, 4.1% ash, and 8.5% carbohydrate (Changqi et al., 2020). Mealworm based diet is the most promising project to evaluate whether it can give similar growth performances of fish as fishmeal based diet. Climbing Perch (*Anabas testudineus*), a tropical freshwater fish, was chosen as a candidate for commercial inland aquaculture in Thailand. This is due to its good growth rate, resistance to pathogens and favorite for consuming in Thailand.

The aim of this study was to evaluate the growth performance, feed utilization and carcass composition in juvenile of the Climbing Perch (*Anabas testudineus*) when fishmeal was replaced with mealworm and a commercial catfish pellet was replaced with fresh worm meals in combination diets.

Material and Method

Diet Formulation and Preparation

Experiment 1, the experimental design was a completely randomized design with 5 treatments and 3 replications for each treatment. The formulations of the experimental diets for the fishmeal replacement study are shown in Table 1. Mealworms were purchased from a local pet shop Chumphon, Thailand, dried in hot air oven (Memmert Model 110 UF) in 60 ºC for 36 hours, and ground into powder using an electric blender (Philips HR 2225) (Ng et al., 2001). The mealworm meal (WM) so obtained contained, on a dry weight basis, 51.93% crude protein, 28.6% lipid, 4.69% ash and 7.20% crude fiber (Bovera et. al., 2015). After passing through a 550 mm mesh sieve (Sieve Shaker Model MVS-1N), the WM was used at 12.5, 25, 37.5, and 50% replacement of the dietary fish meal component in the experimental diets. Control diet (WM0), which did not contain any worm meal. All diets were formulated to be isonitrogenous (30% crude protein) and isoenergetic (4,000 kcal/kg diet). The experimental diets were prepared following the procedure described by Nalinanon and Lerdsuwan, (2018).

In Experiment 2, the experimental design was a completely randomized design with 5 treatments and 3 replications for each treatment. A commercial catfish pellet (KT Feed, Thailand) and live mealworms were used as experimental feeds. The floating catfish pellet contained, on a dry weight basis, 34.0% crude protein, 4.5% lipid, 6.6% ash, 4.7% crude fiber and 50.1% nitrogen-free extract. The pelleted catfish feed had a moisture content of 4.5%, compared to 61.0% for whole mealworms. Five dietary treatments were tested; catfish pellets only, mixed feed proportion 25:75, 50:50, 75:25 (mealworms and catfish pellets) and mealworms only.

Experimental procedure

Juvenile climbing perch (*Anabas testudineus*) was provided by The Chumphon Aquaculture Genetics Research and Development Center, Chumphon Thailand. Prior to study, The fish were maintained in indoor oxygenated (1,500 L) tank in the Inland Aquaculture Laboratory, King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus (KMITL PCC), Chumphon, Thailand. A domesticated strain of climbing perch was used in this study. The experimental fish were fed a commercial catfish feed (30% crude protein, Asian Feed, Thailand) during the 2-week acclimatization period (Ng et al., 2001). Prior to the start of Experiment 1, all experimental fish were acclimated to the control diet (WM0) for one week.

At the start at the experiment, 20 juvenile climbing perch (mean weight 8.6 + 0.1 g) in a recirculation aquaculture tanks (RAT) for Experiment 1 and 10 fish (mean weight 15.2 + 0.1 g) in Experiment 2 were stocked into each tank. The RAT was integrated into a single system of 15 (200-L) rearing tanks (Nalinanon and Lerdsuwan, 2018). From the outlet of the fish tanks the water flows to a multilayer fiber filter and further on to a biological filter before it is aerated and stripped of carbon dioxide and returned to the fish tanks. Each raring tank was supplied with 8 L/min of treated, constant temperature (28 C) and constant DO (6.0 mg/L). Integrating into one system permitted uniformity of water conditions in all tanks and allowed us to remove blocking effect and execute a completely random experimental design. The five dietary treatments of mealworm meal levels in Experiment 1, and the five dietary treatments of different feed combinations in Experiment 2, were fed to randomly assigned triplicate groups of fish. The both of the Experiment fish were fed to apparent satiation, twice a day. Live mealworms were cut into small pieces prior to feeding. Climbing perch on the mixed feed regime were fed mealworms in the morning (07.30 am) and the commercial catfish pellet in the evening (16.30 pm). Fish were batch-weighed by tank once every two weeks and the daily ration adjusted accordingly. Experiments 1 and 2 were both conducted for 12 weeks.

Table 1 Formulation of experimental diets (g/100g dry diet) and proximate composition of experimental diets (% dry matter)

Ingredient	Meal worm %				
	0	12.5	25	37.5	50
Fish meal	24.50	21.44	18.38	15.31	12.25
Mealworm meal	0	3.06	6.13	9.19	12.25
Rice bran	10.00	10.00	10.00	10.00	10.00
Corn starch	14.00	14.00	14.00	14.00	14.00
Cassava starch	23.50	23.00	22.40	21.80	21.20
Soybean meal	26.00	26.50	27.10	27.70	28.30
Premix1	1.00	1.00	1.00	1.00	1.00
NaCl	1.00	1.00	1.00	1.00	1.00
Total (g)	100	100	100	100	100
Component					
Moisture (%)	10.02	9.96	10.11	10.69	10.52
Crude protein (%)	30.05	30.02	30.02	30.03	30.04
Crude fat (%)	11.31	11.45	11.23	11.82	12.08
Fiber (%)	15.02	15.86	16.11	16.05	16.20
Ash (%)	12.43	11.76	11.65	11.08	10.56
NFE	21.17	20.95	20.88	20.33	20.60
GE (Kcal/Kg)	4,160.25	4,135.57	4,111.54	4,087.53	4,063.53

1Vitamin-mineral premix provides per kg of diet : vitamin A 15,000 IU; vitamin D3 3,000 IU; vitamin E 25 IU ; vitamin K30.5 g; vitamin B1 2.5 mg; vitamin B2 7 mg; vitamin B6 4.5 mg; vitamin B12 0.025 mg; pantothenic acid 35 mg; nicotinic acid 35 mg; choline chloride 0.25 g; biotin 0.025 mg; Cu 1.6 mg; folic acid 0.5 mg; Mn0.06 g; Se 0.15 mg; Fe 0.08 g; I 0.4 mg and Zn 0.045 g.

2NFE = Nitrogen-free extract = 100 - (protein + lipid + fiber + ash).

Sample collection and chemical analysis

At the start of each experiment, 50 fish were sacrificed, weighed, measured length and kept frozen at -20 °C for subsequent initial whole body composition analysis. At the end of feeding trial of each experiment, 15 fish per treatment (5 fish per replicate) were randomly chosen, starved for 24 h, weighed, measured length, killed and dissected. Liver, gut and flesh were weighed to determine Hepatosomatic (HSI) and Viscerosomatic (VSI) indexes and Flesh ratio (FR) as described in Nalinanon and Lerdsuwan (2018). Fish carcasses were then pooled, blended, dried and ground into powder before proximate analysis.

Analysis of crude protein, crude fat, fiber, ash, moisture, NFE and DE contents of the test diets and fish samples followed the methods of the Association of Official Analytical Chemists (1997).

Calculations and statistical analysis

Growth, survival rate, feed utilization, and some physical qualities were calculated according to the following equations (Pichet et al., 2014; Nalinanon and Lerdsuwan, 2018).

(1) MW = [sum of body weight / number of fish]; where MW is the mean weight measured in grams.

(2) WG = Wf – Wi; where WG is the weight gain, Wi and Wf are the initial and final mean body weights.

(3) LG = Lf – Li; where Li and Lf are the initial and final mean body lengths; where LG is length gain.

(4) ML = [sum of standard length / number of fish]; where ML is the mean length measured in centimeters.

(5) SGR = [100 × [(ln(FW) – ln(IW)] /day]; where SGR is the specific growth rate measured in percent per day and IW is the initial weight and FW the final weight both measured in grams.

(6) ADG = [Wf – Wi]/ day; where Wi and Wf are the initial and final mean body weights.

(7) SR = [100 × (remaining number of fish)/ (initial number of fish)];where SR is the survival rate measured in percent.

(8) FI = [100 × (sum of dried diet consumed/ (mean of initial and final body weight) / day];where FI is the feed intake measured in percent.

(9) FCR = [sum of dried diet consumed /weight gain];where FCR is the feed conversion ratio.

(10) PER = wet weight gain (g)/total protein intake (g) ; where PER is the protein efficiency ratio

(11) NPU = 100 × (final - initial fish body protein)/total protein intake ; where NPU is the net protein utilization (%)

(12) FR = [100 × flesh weight / total body weight]; where FR is the flesh ratio measured in percent.

(13) HSI = [100 × liver weight / total body weight]; where HIS is the hepato-somatic index measured in percent.

(14) VSI = [100 × visceral mass weight / total body weight]; where VSI is the viscero-somatic index measured in percent.

All data were calculated as mean ±SD and were subjected to one-way analysis of variance. Duncan's new multiple range test was used to test for significant differences at the ($P < 0.05$) level.

Results

In experiment 1, The experimental diets were well accepted by climbing perch and all feeds were consumed without loss throughout the duration of the experiment. The analysis proximate composition of the diets (Table 1) was as expected from the ingredient formulations used. All fish were active and appeared healthy until the end of the experiment, and no fish dead throughout the duration of the experiment (Table 2).

Climbing perch fed all experimental diets did not show any significant (p>0.05) reduction in growth performance on the all parameters compared to fish fed the control diet without worm meal. Climbing perch fed experimental diets in which 25% of the fish meal was substituted with mealworms meal showed not significantly different (P>0.05) in growth performance compared to fish fed the control diet. Fish fed experimental diets with up to 50% replacement of fish meal with a mealworm meal (dietsWM50) showed the decreasing trend of growth.

Feed conversion ratio (FCR), protein utilization efficiencies (PER and NPU) of the climbing perch were affected by the different levels of worm meal in the diets (Table 2). Replacement of dietary fish meal with a worm meal at 37.5% or higher significantly (p<0.05) reduced feed conversion ratio and protein utilization efficiencies of the climbing perch. Feed conversion ratio and protein utilization efficiencies of climbing perch fed diets with up to 25% replacement of fish meal with worm meal were not significant differences (p>0.05) from those of fish fed the control diet.

Table 2 Growth performance, survival rate and feed utilization of climbing perch fed with meal worm level in experimental diets

Growth and feed utilization	Meal worm (%)[1/]					
	0	12.5	25	37.5	50	p-value
Initial MW (g/fish)^{ns}	8.59±1.49	8.54±1.44	8.55±1.36	8.59±1.45	8.64±1.47	1.000
Final MW (g/fish)^{ns}	45.64±8.16	41.90±2.78	41.67±5.92	39.84±2.69	35.71±4.67	0.299
WG (g/fish)^{ns}	37.04±6.77	33.36±2.14	33.12±4.60	31.25±1.31	27.06±3.66	0.132
ADG (g/fish/day)^{ns}	0.53±0.10	0.48±0.03	0.47±0.06	0.45±0.02	0.39±0.05	0.132
Initial ML (cm)^{ns}	7.03±0.06	7.03±0.06	7.13±0.23	7.17±0.15	7.10±0.26	0.732
Final ML (cm)^{ns}	14.50±1.76	13.87±0.61	13.93±1.47	13.07±0.50	12.47±1.10	0.318
LG (cm)^{ns}	7.47±0.92	6.84±0.34	6.80± 0.85	5.90 ±0.33	5.37 ±0.68	0.201
SGR(%/day)^{ns}	2.38±0.09	2.28±0.19	2.26±0.05	2.20±0.14	2.03±0.15	0.082
SR (%)^{ns}	100±0.00	100±0.00	100±0.00	100±0.00	100±0.00	-
FI (g/fish/day)^{ns}	0.86±0.18	0.80±0.03	0.84±0.20	0.83±0.06	0.82±0.08	0.710
FCR	1.39±0.04^{c}	1.44±0.05^{bc}	1.51±0.09^{abc}	1.57±0.13^{ab}	1.66±0.07^{a}	0.021
PER	2.39±0.07^{a}	2.31±0.09^{ab}	2.22±0.14^{abc}	2.13±0.18^{bc}	2.01±0.08^{c}	0.023
NPU (%)	35.20±1.12^{a}	34.82±0.81^{ab}	34.06±1.05^{ab}	32.84±1.14^{c}	30.12±1.06^{d}	0.015

[1/]Means in the row sharing the same superscript letter are not significantly different (p>0.05). MW = Mean weight; WG = Weight gain; ADG = Average daily gain; ML = Mean length; LG = Length gain; SGR = Specific growth rate; SR = Survival rate; FI = Feed intake; FCR = Feed conversion ratio; FER = Feed efficiency ratio; PER = Protein efficiency ratio; NPU = Net Protein Utilization.

Climbing perch fed all experimental diets did not show any significant (p>0.05) different in carcass quality on the basis of flesh ratio, hepato-somatic index and viscero-somatic index compared to fish fed the control diet without worm meal. Worm meal in the experimental diets of caused a significant (p<0.05) increase in whole body lipid concentrations at all levels of worm meal incorporation (Table 3). Moisture and crude protein levels in fish fed 0, 12.5 and 25% dietary replacement of fish meal with worm meal showed significantly (p<0.05) higher moisture and whole body protein content compared to fish fed dietary concentrations of 37.5 and 50% replacement.

Table 3 Carcass quality and whole body composition (% wet weight basis) of climbing perch fed diets with increasing percentage replacement of fish meal with mealworm meal (WM)1

Carcass and whole body composition	Meal worm (%)[1/]					
	0	12.5	25	37.5	50	p-value
FR (%)[ns]	51.23±2.59	53.16±1.56	52.85±2.36	53.21±1.92	51.78±2.47	0.840
HSI (%)[ns]	2.62±0.77	2.47±0.19	2.37±0.13	2.14±0.14	3.14±0.16	0.185
VSI (%)[ns]	14.94±2.83	13.98±2.72	16.54±3.64	16.87±2.92	16.89±3.06	0.604
Moisture	73.65±1.66[a]	71.43±1.26[ab]	71.61±1.60[ab]	70.23±1.42[b]	70.45±1.76[b]	0.031
Crude lipid	7.31±0.60[b]	8.65±0.69[a]	9.14±0.35[a]	9.50±0.82[a]	9.25±0.63[a]	0.014
Crude protein	15.46±0.71[ab]	15.90±0.36[a]	15.53±0.23[ab]	15.13±0.12[b]	14.83±0.19[b]	0.024
Ash[ns]	3.08±0.10	3.01±0.05	3.03±0.06	3.0±0.08	3.05±0.05	0.155

[1/]Means in the row sharing the same superscript letter are not significantly different ($p>0.05$). FR= Flesh ratio; VSI= Viscero somatic index; HSI =Hepato somatic index.

In experiment 2, At the end of the study (12 weeks), There was no mortality and all fish appeared healthy. Climbing perch in all groups consumed their feed vigorously after an acclimatize to the environment. Fish fed the experimental diets (commercial catfish pellet, mealworms (25) /catfish pellet (75) combination, mealworms (50) /catfish pellet (50) combination, mealworms (75) /catfish pellet (25) combination or mealworms only, exhibited good growth and feed utilization efficiency (Table 4). Climbing perch fed diets in which mealworms (50) /catfish pellet (50) combination showed the highest specific growth rate significant different ($p<0.05$) with mealworms (75) /catfish pellet (25) combination and mealworms only group. Although there was no significant difference ($p>0.05$) between fish fed the experimental diets on the parameters of their growth performance, fish fed the mealworms (50) /catfish pellet (50) combination displayed the highest absolute growth in terms of final mean weight and weight gain.

The feed conversion ratio and protein utilization efficiency (PER and NPU) of fish fed the commercial catfish ration was significantly ($p<0.05$) higher compared to fish fed the mealworms (50) /catfish pellet (50) combination, the mealworms (75) /catfish pellet (25) combination and mealworms only, but was not significantly different compared to fish fed the mealworms (25) /catfish pellet (75) combination (Table 4).

Climbing perch fed the mealworm ration (the mealworms (75) /catfish pellet (25) combination and mealworms only) had an increased trend in whole body lipid content significant different ($p<0.05$) with fish fed commercial catfish pellets only. Whole body protein content and ash did not vary between dietary treatments.

Table 4 Growth performance, feed utilization and body composition of climbing perch fed commercial catfish pellets, a combination of mealworms and catfish pellets in proportion 25:75, 50:50, 75:25 or mealworms only

Parameter	Feed type[1/]					
	commercial	25:75	50:50	75:25	mealworms	p-value
Initial MW (g/fish)[ns]	15.20±0.10	15.21±0.12	15.21±0.10	15.19±0.15	15.20±0.12	0.984
Final MW (g/fish)[ns]	60.62±4.77	62.07±3.19	62.37±5.23	57.40±6.14	54.84±7.16	0.085
WG (g/fish)[ns]	45.54±3.13	46.78±2.82	47.16±2.60	42.37±3.02	39.89±4.46	0.064
SGR(%/day)	2.43±0.12[ab]	2.54±0.16[a]	2.61±0.10[a]	2.23±0.10[b]	2.15±0.12[b]	0.031
SR (%)[ns]	100±0.0	100±0.0	100±0.0	100±0.0	100±0.0	-
FCR	1.26±0.05[c]	1.38±0.16[bc]	1.53±0.03[b]	1.68±0.12[ab]	1.83±0.10[a]	0.024
PER	2.56±0.07[a]	2.48±0.10[ab]	2.31±0.05[b]	2.12±0.16[bc]	1.98±0.08[c]	0.015
NPU (%)	39.10±1.32[a]	36.70±2.12[ab]	33.53±1.82[b]	30.11±1.58[c]	28.02±2.36[cd]	0.042
Body composition						
Moisture	74.82±1.96[a]	72.91±1.78[ab]	71.15±1.06[b]	70.75±1.66[b]	70.16±1.66[b]	0.030
Crude lipid	7.63±0.91[b]	9.34±0.86[ab]	9.63±0.73[ab]	10.13±1.13[a]	10.52±1.02[a]	0.016
Crude protein[ns]	15.86±0.26	15.60±0.51	15.81±0.56	15.34±0.60	15.18±0.62	0.086
Ash[ns]	3.12±0.11	3.17±0.10	3.06±0.16	3.06±0.15	3.0±0.18	0.094

[1/]Means in the row sharing the same superscript letter are not significantly different ($p>0.05$).

Discussion

The results of the present study indicate that the larvae of mealworm (*Ternebrio molitor*), whether used as live feed or as a meal, are a potential protein source for the Climbing perch *(Anabas testudineus*). The mealworm meal could replace up to 25% of the fish meal component in practical diets for Climbing perch without any significant reduction in growth performance and feed utilization. Climbing perch fed a combination diet of mealworms (50) /catfish pellet (50) grew better than fish fed solely on commercial catfish pellets and mealworms only. The reduced weight gain, average daily gain and specific growth rate as observed when mealworm content in the diet was higher than 37.5%, suggests that the high mealworms level led to growth reduction. Ng et al. (2000) reported that the depression of growth performance and of feed utilization in catfish fed high levels of mealworms meal or solely on mealworms may be due to the presence of chitin found in the exoskeletons of worms. Chitin is a polymer of glucosamine and is insoluble in common solvents **(**Ng et al., 2001**).** Shiau & Yu (1999**)** reported that tilapia fed diets with chitin as low as 2**%** exhibited depressed growth and feed efficiency ratios. However, Kono et al. (1987) did not find any growth depression in red sea bream *(Pagrus major*), Japanese eel (*Anguilla japonica*) and yellowtail (*Seriola quinqueradiata)* when these fish were fed diets containing 10% dietary chitin. The problem of poor growth and variation in size can be explained by riboflavin deficiency may be due to limiting amino acid content (Nengas et al., 1999; Murai and Andrews, 1978). Moreover, The poor conversion ratio, reported in fish fed 37.5 and 50% (fishmeal replacement with mealworms meal) may be attributed to the feeding management, culture system, experimental condition, improper balance of amino acids, high carbohydrates and reduction in pellet quality (Ovie, 2007). Another consequence of using mealworms in place of fish meal is the lipids contributed by mealworms may result in diets having a less favourable n-3/n-6 ratio for the Climbing perch as its fatty acid profile may not match that present in fish oil (Ng et al., 2001). There were other worm-based diets as a dietary protein source for fish, such as Nandeesha et al. (1988) reported that the excellent growth results with catla-rohu hybrids (*Catla catla x Labeo rohita*) when these carps were fed diets with high levels of silkworm pupae meal. The growth response of catfish, *Clarias batrachus*, fingerlings fed diets containing 100% replacement of fish meal with silkworm pupae meal was similar to fish fed the control diet, which had no silkworm pupae meal (Habib et al., 1994). In accordance with Abd Rahman Jabir et al. (2012) reported that can be replaced fishmeal with a super worm meal up to 25% by without any adverse effect on feed utilization and body composition, but also did find the decrease in weight gain and other growth associated parameters was observed with higher replacement. In contrast, Rainbow trout fed 100% worm meal protein were reported to display little growth over the duration of the feeding trial and slightly lower growth response in rainbow trout fed diets in which worm meal (E. foetida) replaced 50% of dietary herring meal protein compared to fish fed the control diet (Tacon et al., 1983).

The carcass quality of climbing perch indicated that the flesh ratio, hepato somatic index a viscero somatic index were not affected by incorporation of 50% mealworm meal. Similar results have been reported for hybrid clarias catfish by Jantrarotai et al., (1998) and silver perch (Yang et al., 2002).

Measures of body composition significantly different between treatments, where worm meal in the experimental diets of caused a significant ($p<0.05$) increase in whole body lipid concentrations at all levels of worm meal incorporation. These results are in agreement with the previous study in tilapia recorded by Metwalli, (2013) and sunshine bass (Rawles et al., 2011)

Worms as live feeds have an important role in fish culture. This present study shown that a combination diet of mealworms (50) /catfish pellet (50) grew better than fish fed solely on commercial catfish pellets and mealworms only. Strictly carnivorous fish larvae have been known to refuse artificial feed and high mortality rates have been reported when artificial diets were used. The importance of using live aquatic oligochaete worms and earthworms in the culture of the carnivorous snakehead fish *(Channa* spp.) has been reported by De Silva (1988). Knights (1996) recommended the use of tubificid worms and *E. foetida* preparations to encourage the first feeding of glass eels, *Anguilla anguilla.*

In conclusion, the study indicates that 25% meal worm can be included within a 30% crude protein diet in climbing perch (*Anabas testudineus*) fingerlings and are suitable for growth and feed utilization. However, for higher substitution levels of fish meal, growth and feed utilization were adversely affected. Moreover, a combination diet of mealworms (50) /catfish pellet (50) grew better than fish fed solely on commercial catfish pellets and mealworms only. However, substitution fishmeal with mealworm had some effect of body composition such as moisture and body lipid. Thus, mealworm could be used as an alternative protein source in the diet of Climbing perch (*Anabas testudineus*).

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