Asian Fisheries Science **31**(2018):32–44

ISSN 0116-6514
E-ISSN 2073-3720
https://doi.org/10.33997/j.afs.2018.31.1.003

Asian Fisheries Science
The Journal of the Asian Fisheries Society

Growth Performance of Catfish *Clarias gariepinus* (Burchell 1822) Juveniles Fed Processed Toad Meal Based Diets

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Abstract

The growth performance of African catfish *Clarias gariepinus* (Burchell 1822) juveniles fed differently processed toad meal based diets was investigated in this study. Toads were collected, gutted, washed and processed into meals using four different methods, namely: oven drying at 60 ^{o}C (treatment 1); oven drying at 100 ^{o}C (treatment 2); removal of the skin and parotid gland before oven drying at 60 ^{o}C (treatment 3); and fermentation for 3 days before oven drying at 60 ^{o}C (treatment 4). Five isonitrogenous diets of 35 % crude protein were formulated with inclusions of the processed toad meals (treatments 1, 2, 3 and 4) and a control diet with inclusion of fish meal (treatment 5). These were fed to juveniles of *C. gariepinus* (mean weight 13.08 ± 0.01 g) for 56 days. The results reveal that treatment 3 gave the best growth parameters, even more than the control diet with inclusion of fishmeal. This is further supported by the result of carcass analysis which revealed a similar trend. The cost analysis also confirms the superiority of treatment 3 over the other treatments due to its ability to produce 1 kg of fish with far less money than the other diets. The least growth indices, carcass protein and cost effectiveness were observed with dietary inclusions of fermented toad meal (treatment 4). It was therefore concluded that dietary inclusions of skinned and deglanded toad meal improves performance and production characteristics of the African catfish.

Keywords: toad meal, fishmeal, *Clarias gariepinus*, skinning and deglanding

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Introduction

Aquaculture, which involves the farming of aquatic organisms, implies some form of intervention in the rearing process of the aquatic animals to enhance production. One of such means is through feeding of the animals under culture. Feed accounts for up to 70 % of the variable cost of commercial aquaculture operation for many fish species (FAO 2007). Fish meal is the most preferred protein source that contributes significantly to the variable production cost in the aquaculture industry (Naylor et al. 2000). The supply of fishmeal is not adequate to sustain the current rate of growth of aquaculture in addition to the demand from other animal feed industries, and continued exploitation of this natural resource will ultimately become both environmentally and economically unsustainable (Mondal et al. 2008).

Several studies have been directed towards alternative protein feed ingredients of both plant and animal origin that can supply comparable nutritional value at less cost. In the choice of these alternative feed ingredients, availability, nutrient composition, easy accessibility and lack of competition with other consumers are key factors. Several studies on alternative protein feedstuffs of animal origin such as termite, locust, earthworm, grasshopper, lizard *Agama agama* (Linnaeus 1758) and maggot have been reported (Alegbeleye et al. 2012; Aniebo et al. 2009; Balogun 2011; Olele 2011; Solomon et al. 2007; Tiamiyu et al. 2013).

Toad meal processed from African common toads *Sclerophrys regularis* (Reuss 1833) of the Bufonid family has been reported to have good prospects as an unconventional protein feedstuff (Bekibele et al. 1995; Jimmy et al. 2015). Aside from their abundance (especially during the rainy seasons when they can be picked at street corners, behind houses, bushes and stagnant waters), they have no competition for human requirement and very few animals are known to prey on them. Despite these advantages, there are very few studies on their use as meal for fish diets (Annune 1990; Fagbenro et al. 1993; Bekibele et al. 1995). This apparent lack of interest stems from the fact that toads of the bufonid family have poison glands containing toxic substances.

However, processing methods used in most feed preparation are aimed at detoxification and deactivation of toxins and anti-nutrients in those ingredients. This could be done by boiling/cooking, fermenting with/without enzymes, soaking, heating, roasting, blanching and extruding among other methods (Akpodiete and Okagbare 1999; Isikwenu and Bratte 1999; Obun et al. 2005; Tiamiyu et al. 2007). Therefore, there is a need to access various methods of processing toad meal in order to eliminate these toxic substances, so as to render it fit for use in fish diets and subsequently replacing fishmeal. This work is aimed at investigating the growth performance of *Clarias gariepinus* (Burchell 1822) juveniles fed differently processed toad meal based diets.

Materials and Methods

Juveniles (mean weight 13.08±0.01 g) of *C. gariepinus* were obtained from Tidoo fish farm, Makurdi, Benue state, Nigeria. They were acclimatised for 2 weeks before stocking in plastic bowls at 20 fish per bowl. The plastic bowls were of the same size (110 L), shape (round) and colour (black), and were filled to a volume of 60 L. The experiment was carried out in the indoor hatchery of the Department of Fisheries and Aquaculture, University of Agriculture, Makurdi.

Procurement and processing of ingredients

The feed ingredients such as fishmeal, vitamins and mineral premixes were purchased from a livestock feed shop in Makurdi while soybean and yellow maize were purchased, processed and pulverised into powdered forms for proper mixing. Toads *S. regularis* were harvested, wearing hand gloves from streams along the international market road, Makurdi.

Processing of toad meal

Wearing hand gloves and other protective apparatus, the toads collected were killed using a club to knock them on the head to unconsciousness, and pithing as described by AVMA (2013), before processing through four different methods as follows:

Treatment 1: Whole toads were gutted, washed and oven-dried at 60 ^{o}C to a constant weight.

Treatment 2: Whole toads were gutted, washed and oven-dried at 100 ^{o}C to a constant weight.

Treatment 3: Whole toads were gutted, skinned and the parotid glands removed. The processed toads were then washed and oven-dried at 60 ^{o}C to a constant weight.

Treatment 4: Whole toads were gutted, washed and fermented in airtight containers for 3 days. The fermented toads were then oven-dried at 60 ^{o}C to a constant weight.

Diet formulation

The experimental diets were formulated using Pearson's square method with 35 % crude protein to meet the requirement for *C. gariepinus* juveniles. The biochemical composition of the toad meals used for this formulation was as reported by Jimmy et al. (2015) as shown in Table 1.

The ingredients were ground, weighed, mixed, pelleted and sundried into individual diets. The experiment lasted for 8 weeks and had 5 experimental diets containing treatments 1, 2, 3 and 4 in diets 1, 2, 3 and 4 respectively. Diet 5, which served as the control experiment, was formulated and produced using fishmeal. The diets were composed of ingredients as shown in Table 2. Five bowls were stocked randomly with twenty juveniles in each bowl for this experiment.

Table 1. Proximate composition of the differently processed *Sclerophrys regularis* meals (source: Jimmy et al. 2015)

Parameters	**TRT 1**	**TRT 2**	**TRT 3**	**TRT 4**	**LSD**
Crude protein (%)	48.90±0.55^{b}	57.96±0.06^{c}	58.22±0.67^{c}	43.56± 0.17^{a}	1.72
Ether extract (%)	4.07±0.14^{b}	5.02±0.08^{c}	5.09±0.27^{c}	1.81±0.12^{a}	0.65
Ash (%)	23.95±0.05^{b}	23.03±0.42^{b}	23.59± 0.74^{b}	15.32±0.56^{a}	2.00
Crude fibre (%)	1.19±0.06^{c}	0.57±0.02^{ab}	0.36±0.05^{a}	0.80±0.14^{b}	0.32
Moisture (%)	3.75±0.05^{b}	2.59±0.07^{a}	2.55±0.05^{a}	3.56± 0.13^{b}	0.31
NFE (%)	18.15±0.06^{b}	10.85±0.37^{a}	10.20±1.67^{a}	34.96±1.21^{c}	4.12

Means on the same row with different superscripts are significantly different (P<0.05)

Key: TRT 1 = Treatment 1 (toads processed by oven-drying at 60 ºC); TRT 2 = Treatment 2 (toads processed by oven-drying at 100 ºC); TRT 3 = Treatment 3 (toads processed by skinning and removal of the parotid glands before oven-drying at 60 ºC); TRT 4 = Treatment 4 (toads processed by fermenting before oven drying at 60 ºC).

Table 2. Gross composition (g.kg^{-1}) of experimental diets containing differently processed *Sclerophrys regularis* meal

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Fish meal	0.00	0.00	0.00	0.00	300.00
Toad meal	300.00	300.00	300.00	300.00	0.00
Soybean meal	478.60	391.30	388.80	530.10	256.00
Maize meal	141.40	228.70	231.20	89.90	364.00
Vitamin and mineral premix	5.00	5.00	5.00	5.00	5.00
Salt	5.00	5.00	5.00	5.00	5.00
Soya oil	30.00	30.00	30.00	30.00	30.00
Starch (as binder)	40.00	40.00	40.00	40.00	40.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00

Key: Diet 1 was produced using toads of treatment 1(toads processed by oven-drying at 60 ºC); Diet 2 was produced using toads of treatment 2 (toads processed by oven-drying at 100 ºC); Diet 3 was produced using toads of treatment 3 (toads processed by skinning and removal of the parotid glands before oven-drying at 60 ºC); Diet 4 was produced using toads of treatment 4 (toads processed by fermenting before oven drying at 60 ºC); Diet 5 was produced using fish meal.

Experimental design, set-up and management

The experimental design used was a completely randomized design. The dietary treatments were assigned to groups at random in a completely randomized design and each treatment was in triplicate. Experimental fish were cultured in bowls which were covered with nets to prevent fish from jumping out as described by Ejere et al. (2014). The daily feed rations were divided into two portions and fed to the fish in the morning (0700–0800 h) and evening (1600–1700 h) at 5 % body weight as described by Olele (2011). The fish were weighed weekly to determine weight gain and the quantity of feed was adjusted accordingly.

Analyses of proximate composition

The analyses of the proximate composition of the differently processed toad meals, experimental diets and samples of fish carcasses fed experimental diets at the start of the feeding trial and at the end of the experiment were carried out using the AOAC (2005) standard method.

Cost analysis

Cost analysis was done by computing the cost of each diet estimated from the quantity of feedstuffs used. The cost of producing 1 kg of fish flesh was determined by multiplying the cost of producing 1 kg of each formulated diet by the corresponding value of FCR at the end of the feeding trial (Solomon et al. 2017).

Determination of water quality

Water quality parameters such as temperature, total dissolved solids, conductivity and pH were determined using a Hanna waterproof tester H198129 and dissolved oxygen (DO) was measured using a Lutron DO meter DO5509.

Measurement of growth parameters

Growth parameters measured were mean weight gain, percentage weight gain, specific growth rate, food conversion ratio, protein efficiency ratio, apparent net protein utilization and survival rate, and were calculated as follows:

$$\text{Mean weight gain (MWG)} = \text{Mean final weight (MFW)} - \text{Mean initial weight (MIW)}$$

$$\text{Percentage mean weight gain (\% MWG)} = \frac{\text{Mean weight gain (MWG)}}{\text{Mean initial weight (MIW)}} \times 100$$

$$\text{Specific growth rate (SGR)} = \frac{\ln \text{MFW} - \ln \text{MIW}}{\text{T}} \times 100$$

where ln = Natural logarithm; MFW = Mean final weight; MIW= Mean initial weight; and T = Period of experiment in days.

$$\text{Food conversion ratio (FCR)} = \frac{\text{Weight of feed consumed (dry)in grams}}{\text{Weight gain of fish produced (wet)in grams}}$$

$$\text{Protein efficiency ratio (PER)} = \frac{\text{Mean weight gain of fish produced (wet)in grams}}{\text{Weight of protein in feed (dry)in grams}}$$

where Mean weight gain = Mean final weight – Mean initial weight.

$$\text{Weight of protein} = \frac{\%\ \text{Protein in diet} \times \text{Total feed consumed}}{100}$$

$$\text{Apparent net protein utilisation} = \frac{\text{Protein gained}}{\text{Protein consumed}} \times 100$$

$$\text{Survival rate (\%)} = \frac{\text{Number of fish that survived}}{\text{Number of fish stocked}} \times 100$$

Data analysis of the various experiments

Data collected from the various experiments were analyzed using descriptive statistics and are presented as means and standard error of means. All data were also subjected to a one-way analysis of variance (ANOVA) where the means were separated using least significant differences (LSD) at 95% confidence level (P<0.05) with the aid of Genstat package edition 12.

Results

Table 3 depicts the proximate composition of the experimental diets. The result reveals that crude protein content of all the differently processed toad meal based diets did not differ statistically (P>0.05). Ether extract of the differently processed toad meal based diets differed significantly (P<0.05) ranging from 8.88±0.23 in diet 3 to 9.41±0.25 in diet 2. Crude fibre of the differently processed toad meal based diets varied significantly (P<0.05) with diet 5 (9.05±0.18) recording the highest value and diet 4 (6.03±0.10) recording the lowest.

Table 3. Proximate composition of the differently processed *Sclerophrys regularis* meal based diets

Parameter	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	p-Value
Crude protein (%)	35.71±0.19^{a}	35.39±0.19^{a}	35.90±0.17^{a}	36.18±0.20^{a}	35.67±0.43^{a}	0.16
Ether extract (%)	8.99±0.02^{a}	9.41±0.25^{a}	8.88±0.23^{a}	9.36±0.40^{a}	9.19±0.13^{a}	0.08
Ash (%)	10.86±0.15^{b}	13.43±0.55^{c}	9.73±0.23^{a}	10.97±0.06^{b}	10.35±0.15^{ab}	0.03
Crude fibre (%)	8.04±0.12^{b}	8.55±0.18^{c}	7.925±0.09^{b}	6.03±0.10^{a}	9.05±0.18^{d}	0.03
Moisture (%)	3.66±0.11^{b}	2.61±0.07^{a}	4.93±0.09^{d}	4.48±0.03^{c}	4.22±0.09^{c}	0.04
NFE (%)	32.74±0.06^{ab}	30.62±0.23^{a}	32.45±0.95^{ab}	33.17±0.63^{b}	31.52±0.62^{ab}	0.03

Means on the same row with different superscripts are significantly different (P<0.05)

Table 4 shows the growth performance of *C. gariepinus* juveniles fed differently processed toad meal based diets. The result reveals that the mean initial weights (MIW) of *C. gariepinus* juveniles fed the different experimental diets did not differ significantly (P>0.05). Mean final weight (MFW) differed significantly (P<0.05), ranging from 21.12±0.86 g in diet 4 to 64.06±1.26 g in diet 3.

Table 4. Growth performance of *Clarias gariepinus* juveniles fed differently processed *Sclerophrys regularis* meal based diets

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	p-Value
MIW (g)	13.09±0.03^{a}	13.07±0.05^{a}	13.09±0.03^{a}	13.11±0.01^{a}	13.05±0.05^{a}	0.090
MFW (g)	30.76±3.75^{b}	36.86±3.14^{bc}	64.06±1.26^{d}	21.12±0.86^{a}	45.06±0.18^{c}	0.006
MWG (g)	17.68±3.78^{b}	23.77±3.09^{bc}	50.98±1.23^{d}	8.05±0.85^{a}	32.01±0.13^{c}	0.007
MWG %	135.20±29.20^{b}	181.70±22.92^{b}	389.60±8.49^{d}	61.43±6.41^{a}	245.3±0.05^{c}	0.003
SGR (%.day^{-1})	1.51±0.22^{b}	1.84±0.15^{bc}	2.84±0.03^{d}	0.85±0.07^{a}	2.21±0.01^{c}	0.010
FCR	2.80±0.46^{b}	2.18±0.21^{ab}	1.46±0.02^{a}	4.82±0.46^{c}	1.84±0.02^{ab}	0.013
PER	1.16±0.19^{b}	1.43±0.14^{b}	1.84±0.01^{c}	0.57±0.05^{a}	1.42±0.01^{b}	0.020
ANPU	17.54±4.97^{a}	25.14±1.01^{ab}	30.25±0.37^{b}	15.69±3.95^{a}	28.93±0.06^{b}	0.015
Survival %	92.50±7.50^{a}	90.00±2.50^{a}	92.50±2.50^{a}	87.50±5.00^{a}	92.50±7.50^{a}	0.060

Means on the same row with different superscripts are significantly different (P<0.05). Key: MIW = Mean initial weight; MFW = Mean final weight; MWG = Mean weight gain; % MWG = Percent mean weight gain; SGR = Specific growth rate; FCR = Food conversion ratio; PER = Protein efficiency Ratio; ANPU = Apparent net protein utilization

Similarly, the mean weight gain (MWG) differed significantly (P<0.05), with diet 3 (50.98±1.23 g) recording the highest value and diet 4 (8.05±0.85 g) recording the lowest value. Specific growth rate (SGR) of *C. gariepinus* juveniles fed differently processed toad meal based diets differed significantly (P<0.05), ranging from 0.85 %.day^{-1}±0.07 (diet 4) to 2.84 %.day^{-1}±0.03 (diet 3). Food conversion ratio (FCR) also differed significantly (P<0.05) ranging from 1.46±0.02 (diet 3) to 4.82±0.46 (diet 4).

Table 5 shows carcass analysis of *C. gariepinus* fed differently processed toad meal based diets. The results indicate that there was significant difference (P<0.05) between the initial carcass analysis and the final carcass analyses of all the treatments for all the parameters. Among the various diets, crude protein content of the carcass of *C. gariepinus* fed differently processed toad meal based diets differed significantly (P<0.05), ranging from 14.70±0.04 in diet 4 to 19.63±0.36 in diet 3. Table 6 shows the cost analysis of the experimental diets. The results reveal that diet 3 had the least cost (₦165.24) of production while diet 4 had the highest cost (₦ 613.63).

The mean water quality parameters measured during the experimental feeding of *C. gariepinus* juveniles with differently processed toad meal based diets indicated that the parameters were within acceptable limits. Dissolved oxygen was within the range of 4.00±0.05 to 4.29±0.01. Temperature ranged from 25.65±0.05 to 25.98±0.28. pH was within the range of 8.71±0.05 to 8.72±0.06. Total dissolved solids ranged from 339.50±15.00 to 401.50±27.00. Conductivity was in the range of 679.20±29.75 to 804.20±55.25. The results revealed that there were no significant differences (P>0.05) among the different treatments for all parameters tested.

Table 5. Carcass analysis of *Clarias gariepinus* fed differently processed *Sclerophrys regularis* meal based diets

Parameters	Initial	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	p-Value
Crude protein (%)	12.47±0.55^{a}	15.07±0.07^{b}	17.01±0.12^{c}	19.63±0.36^{e}	14.70±0.04^{b}	18.00±0.46^{d}	0.010
Ether extract (%)	6.07±0.01^{a}	7.49±0.13^{b}	6.43±0.11^{a}	8.89±0.16^{c}	7.54±0.04^{b}	11.21±0.27^{d}	0.012
Ash (%)	2.23±0.14^{a}	3.76±0.04^{d}	3.50±0.01^{c}	3.67±0.02^{d}	3.44±0.05^{c}	2.998±0.01^{b}	0.018
Crude fibre (%)	0.88±0.04^{a}	1.21±0.02^{b}	1.61±0.02^{d}	1.89±0.02^{e}	1.34±0.02^{c}	1.18±0.05^{b}	0.021
Moisture (%)	72.35±0.16^{c}	68.63±0.25^{b}	68.74±0.13^{b}	64.14±0.48^{a}	67.89±0.89^{b}	63.63±0.83^{a}	0.040
NFE (%)	6.00±0.50^{c}	3.85±0.11^{b}	2.70±0.14^{ab}	1.48±0.02^{a}	5.09±0.88^{bc}	1.96±0.04^{a}	0.030

Means on the same row with different superscripts are significantly different (P<0.05)

Table 6. Cost analysis (in Nigerian Naira) of experimental diets produced using differently processed toad meal for *Clarias gariepinus* juveniles

Ingredients	Unit cost per kg [a]	Equivalent cost of feeds as used in the diet (₦)[b]				
		Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Fish meal	700.00	0.00	0.00	0.00	0.00	210
Toad meal	0.00	0.00	0.00	0.00	0.00	0.00
Soybean meal	200.00	95.72	78.26	77.76	106.02	51.20
Maize meal	100.00	14.14	22.87	23.12	8.99	36.4
Vitamin and mineral premix	1000.00	5.00	5.00	5.00	5.00	5.00
Salt	100.00	0.50	0.50	0.50	0.50	0.50
Soya oil	200.00	6.00	6.00	6.00	6.00	6.00
Starch (as binder)	20.00	0.80	0.80	0.80	0.80	0.80
Cost of compounded feed.kg^{-1} [c]		122.16	113.43	113.18	127.31	309.90
FCR		2.80	2.18	1.46	4.82	1.84
Cost of feed to produce a kg of fish [d]		342.05	247.28	165.24	613.63	570.22

[a] Unit cost of ingredients per kg: This was determined as ingredients were purchased in the feed store.

[b] Equivalent cost of feeds as used in the diet: this is the product of quantity of feedstuff incorporated in each diet (as shown in Table 2) and its corresponding unit cost per kg (i.e 1000 g).

[c] Cost of compound feed per kg is the sum of equivalent costs of feedstuffs in each diet.

[d] Cost of feed to produce 1 kg fish was estimated by multiplying FCR by cost of compound feed per kg.

Discussion

The results of this work revealed that diet 3 (which contained toads that were skinned and deglanded) gave the best growth performance parameters even outweighing the fishmeal diet. The result from carcass analysis also concurs with this as fish fed diet 3 gained the highest crude protein in their carcasses. In line with this, the cost analysis further highlights the cost effectiveness of diet 3 due to its ability to produce 1 kg of fish with far less money than the other diets. The high growth indices of fish fed diet 3 suggest that the removal of the sources of toxin (parotid gland and skin) in toads may have eliminated the toxin, rendering the meal fit for inclusion in fish diet. This result is similar to that of a study by Robinson et al. (1984) who reported that the removal of the gossypol gland which secretes an anti-nutritional factor called gossypol rendered cotton seed fit as an adequate protein source for use in channel catfish diets.

Diet 2 (containing toads processed at 100 ^{o}C) gave lower growth performance indices than fishmeal; however, the values were still within acceptable limits (Tiamiyu et al. 2013; Oso and Iwalaye 2014). This is in contrast to the reports of Bekibele et al. (1995) who reported that diets of toad meal processed thermally at 103 ^{o}C (which is close to the temperature of 100 ^{o}C used for diet 2 in the present work) gave slightly better growth performance indices than fishmeal diets.

Diet 4 (fermented toad meal) gave the lowest growth parameters. This could have been due to degradation and depletion of protein by microorganisms causing fermentation which resulted in low quality protein of fermented toad meal, leading to lower growth indices of fish fed fermented toad meal diet. Degradation of protein in fermented products has been attributed mainly to the actions of catalytic enzymes and microbes (Taorem and Sarojnalini 2012). Survival was slightly lower in diet 4, although this difference was not statistically significant. The highest cost of production also incurred in diet 4 due to its high FCR which implies that more feed and hence more money was required to produce 1 kg of fish.

Against popular expectations, diet 1 (containing toads only processed by oven drying at 60 ^{o}C) gave fair growth performance parameters although lower than those of diet 3, diet 5 and diet 2. It would have been expected that the use of this toad meal should be deleterious to fish growth and survival due to the effects of the toxin; however, the results were just the opposite.

Similarly, Falaye et al. (2012), in a study involving replacement of fishmeal with toad meal processed at 70 ^{o}C in diets of *C. gariepinus*, observed and recommended that 100 % toad meal diet gave good growth performance parameters closely following those of the fishmeal diet. In line with this, Annune (1990) in his work on suitability of toad meal in the diets of *Clarias lazera* Valenciennes 1840 (syn. of *C. gariepinus*) concluded that fish fed whole toad meal grew favourably without exhibiting any symptoms of ill effects. He even observed that fish fed toad meal inclusion of 30 % and 40 % gave better growth parameters than the control (0 % toad meal).

This result is not peculiar to fish alone as whole toad meal has also been included in diets of other livestock with good results. Aradanas and Ulep (1989) and Esonu (2002) included toad meal in the diets of broiler chicks and concluded that birds on 10 % dietary levels of toad meal had better growth than the control (0 % toad meal).

The fair growth performance obtained from diet 1 may be attributed to processes involved in feed production (such as pelleting and oven drying) which may have somewhat affected and reduced the toxin or may be due to the ability of fish to tolerate the toxin. It is reported that some catfishes of the order siluriformes, eels, various species of killifish and the rock flagtail, *Kuhlia rupestris* (Lacépède 1802) are among those animals capable of eating toads without being affected by their toxins (Tyler 1989). Other animals such as freshwater crayfish *Cherax* spp., *Euastacus hystricosus* Riek 1951, *Euastacus suttoni* Clark 1941 and *Euastacus valentulus* Riek 1951, crabs *Holthuisana* spp. as well as adult dytiscid diving beetles *Cybister godeffroyi* (Wehncke 1876), *Hydaticus vittatus* (Fabricius 1775), *Sandracottus bakewelli* (Clark 1864) and dragonfly larvae *Trapezostigma* sp., *Hemianax papuensis* Burmeister 1839 have been reported to feed on cane toads without adverse effects (Hutchings 1979; Crossland 1998; Crossland and Alford 1998). Some species of ibis (subfamily Threskiornithinae), whistling kite *Haliastur sphenurus* (Vieillot 1818), rakali *Hydromys chrysogaster* É. Geoffroy 1804, black rat *Rattus rattus* (Linnaeus 1758), water monitor *Varanus salvator* (Laurenti 1768), tawny frogmouth (*Podargus strigoides* (Latham 1802), Papuan frogmouth *Podargus papuensis* Quoy and Gaimard 1830, bullet ants *Paraponera clavata* (Fabricius 1775) and meat ants (genus *Iridomyrmex*) prey on toads and do not exhibit symptoms associated with toad toxin poisoning (Tyler 1989; Clerke and Williamson 1992; Angus 1994; Ward-Fear et al. 2009).

However, toad toxin has been documented to cause ventricular fibrillation, vasoconstriction, dyspnea and weakened respiration, paralysis and seizure, salivation and vomiting, cyanosis, hallucinations and death in animals such as dogs and even in humans (Chen and Kovarikova 1967; Perry and Bracegirdle 1973; Palumbo et al. 1975; Emboden 1979; Smith 1982; Hitt and Ettinger 1986).

Conclusion

The use of toads in feed production will not only serve as an alternative cheap protein-rich source for fish feed production but will help reduce and control toad biomass especially in areas where some species of toads are considered as pests. Toad meal processed by skinning and deglanding gave the best growth indices and can be used to completely replace fish meal without adverse effects on the fish and with better growth indices than fish meal. It also proves to be cheaper than fishmeal, thus increasing profit margin. Thermally processed toad meal may also be good replacements for fishmeal because its growth indices were only a little lower than that of fishmeal. However, further investigation on the toxin contents of these toad meals is recommended to ascertain if these processing methods have reduced or eliminated the toad toxin, before recommendation to fish farmers.

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Received: 06/05/2017; Accepted: 03/02/2018; (AFSJ-2017-0048)