

Original Research Article

Growth ~~response performance~~ and nutrient utilization of *Clarias gariepinus* juvenile fed *Bombyx mori* (Mulberry silkworm) ~~diet meal~~ as partial replacement of fish meal protein ~~source~~.

ABSTRACT

A 56-day (Eight weeks) trial was carried out to determine the growth performance and nutrient utilization of *Clarias gariepinus* juveniles fed *Bombyx mori* meal (BMM) as a replacement for fishmeal. Five experimental diets were formulated which included 100% fishmeal, 25% BMM inclusion, 50% BMM inclusion, 75% BMM inclusion and 100% BMM inclusion designated diets A, B, C, D and E respectively with the fish fed at 5% body weight. The effect of the diets on the growth, feed utilization, carcass and mineral compositions of the fish were evaluated. The results showed that mean weight gain, specific growth rate and protein efficiency ratio of fish fed the experimental diets differed significantly ($P > 0.05$) when compared with the control. In this study, replacement of 25% fishmeal gave the best result while 100%, 75% and 50% gave better result than the control. Also, carcass yield and mineral depositions differed marginally in the fishes fed the various diets. It can be inferred from this study that *B. mori* larvae have the potential to be used as a protein source and can replace and elicit better growth trends in fish more than the conventional fish meal without any problem with growth.

Keywords: Growth response, Nutrient utilization, Bombyx mori, *Clarias gariepinus*

INTRODUCTION

The rapid world-wide expansion of aquaculture to meet up with the global demand of fish is a strong indicator that crisis will be precipitated in the aqua feed industries in the near future. Since many fisheries are overfished ~~or heading towards depletion~~, aquaculture is recognized as the only feasible option to meet the increasing demands for aquatic foods (Allan, 2004; Chebbaki *et al.*, 2010). Feed is one of the major inputs in aquaculture production, and fish feed technology is one of the least development sector of aquaculture particularly in Africa and other developing countries of the world (Gabriel *et al.*, 2007). It was reported by Ahmad and Diab (2008) that the

Comment [KBW1]: Please revise this for 100% replacement for fish meal

Comment [KBW2]: May be better to put in alphabetical order

Formatted: Space After: 8 pt

Comment [KBW3]: Please rewrite it

32 feeding cost in aquaculture represents over 50% of the operation cost of fish farming. Fishmeal
33 as a raw material is the choice in aquaculture due to its high quality protein with balanced amino
34 acid profile (Gatlin *et al.*, 2007). ~~and a~~ According to Goytortu'a, (2006), the production of
35 fishmeal has been relatively stable in the last two decades but the increasing demand could not
36 be matched in the present world due to increased aquaculture. Moreover, the cost of fishmeal is
37 increasing ~~day by day~~ which renders the use of alternative protein source which are local, cheap
38 and unsuitable for direct human consumption inevitable to make up for the shortage of fishmeal
39 and secure the stable supply for commercial feeds (Hardy, 2005).

40 Many works have been done on the nutritional value of ~~many alternative feed ingredients other~~
41 ~~source of raw materials~~ to supplement the dietary fishmeal-based diets. ~~Several Researches~~
42 ~~have~~ shown that alternative protein sources derived from grains such as corn, wheat, barley,
43 soya bean, cotton seed, fishmeal, and animal rendering products such as mechanically deboned
44 meal, poultry by-product meal, meat and bone meal, maggot, Bambara groundnut, etc. ~~and~~ can
45 be used to formulate nutritious aquaculture feed at various levels of inclusions in different feeds.
46 ~~Among animal and plant protein sources, For instance~~ Yang (2006) reported that diets with 20%
47 of fishmeal replaced by meat- and- bone meals produced growth equivalent to the control diet in
48 *Gibel carp*. Kasper *et al.* (2007) ~~also reported concluded~~ that up to 47.6% of the fishmeal could
49 be replaced with soy bean meal in the diets of yellow perch (*Perca flavescens*) without affecting
50 the feed consumption, weight gain, feed efficiency or survival of the fish. Toledo *et al.* (1986 &
51 ? 1987) ~~also reported that partially replaced~~ 15% of fishmeal with shrimp head meal in
52 *Oreochromis aureus* feed ~~resulted a normal growth performance and feed utilization efficiency~~
53 ~~without any adverse effect on feed and growth efficiency~~. *Nibea miichthioides* and *Carassius*
54 *auratus gibelio* grew well on diets with 50% of the fishmeal replaced by poultry- by- product
55 meal (Wang, 2006; Yang, 2004). Also, Oso *et al.* (2013) ~~in a study~~ showed that *Clarias*
56 *gariepinus* fingerlings fed up to 75% inclusion of Bambara groundnut in fish feed was
57 satisfactorily acceptable without affecting growth and feed utilization.

58
59 ~~Moreover, In~~ insects are important source of food to many animal species including man (Adedire
60 and Aiyesanmi, 1999). Their larvae may constitute a cheaper source of essential nutrients that are
61 easily available and affordable to the natives within the localities where the insect larvae are

62 found and could form a base for new food products of considerable nutritive value (Ekpo and
63 Onigbinde, 2007). *Bombyx mori* can be used for the production of silk and are also proteinaceous
64 in nature. These worms originated from China with four developmental stages and undergo
65 complete metamorphosis (Krishmawami, 2005). The larvae undergo spinning, vomiting the silk
66 fibre into liquid substance form around themselves to form cocoon so that they will not emerge
67 out and develop into adult stage called moth. The dead larvae in the cocoon are removed by
68 riling machine and the silk is separated while the dead larvae are used for production of fish feed.
69 The objective of this study is therefore, to determine the optimum level of fishmeal replacement
70 with *Bombyx mori* as protein source in the diet of *Clarias gariepinus*. The aim is to evaluate the
71 response in terms of growth performance of *Clarias gariepinus* juvenile fed *Bombyx mori* as a
72 protein source at different levels of inclusion so as to make cheaper and qualitative
73 supplementary feeds available to culture fish species with a view to bridging the gap between
74 protein supply and consumption through reduction in cost of production in the aquaculture
75 sector.

76 77 MATERIALS AND METHODS

78 79 Feed Preparation:

80 The feed ingredients used for this study were fishmeal, *Bombyx mori*, maize, salt, soya bean,
81 groundnut cake, vitamin, premix, lysine and methionine. Except *Bombyx mori* which was
82 purchased from kiti State Sericulture Project were all ~~The feed ingredients were purchased from~~
83 ~~Metro Vet Consultant Limited in Ekiti State, while the *Bombyx mori* used were purchased from~~
84 ~~Ekiti State Sericulture Project.~~ The larvae were killed during the process of cooking so that they
85 will not emerge out of the cocoon and to avoid not to damage ~~to~~ the silk. Inside the cocoon, the
86 larvae were oven dried at 65°C, and then were later removed from the cocoon. Later it was,
87 pulverized and analyzed for proximate composition according to the procedure of APHA (2006)
88 as shown in table 1. Feed ingredients were finely ground and mixed together in appropriate
89 proportions after which the mixture was pelleted into small sizes and then sun dried.

Comment [KBW4]: Take it after the next portion (subtitle)

Formatted: Font: Not Italic

Comment [KBW5]: As you have more than two different sizes of pellet, could you mention the different sizes and why?

91 | **Experimental Site-** The experiment was carried out at the postgraduate research laboratory of
92 | Zoology Department, Ekiti State University, Ado- Ekiti for a period of 56 days (eight weeks).
93 | Sixteen plastic bowls of 20 litres water holding capacity were used for the experiment. Water
94 | was maintained at 17 litres level throughout the experiment and a mosquito mesh was used to
95 | cover the bowls to preclude predators from entering into the bowls and fish jumping out as well.

96 |
97 | **Experimental Fish-** *Clarias gariepinus* juvenile were used for the experiment. One hundred and
98 | fifty mixed sex juvenile with average weight of 7.20g were obtained from a hatchery in Ado-
99 | Ekiti. The fish were acclimatized for two days in a plastic bowl during which they were not fed
100 | in order to empty their gut and prepare their appetite for the new feed. The fish were randomly
101 | stocked at the rate of ten (10) juveniles per bowl. The initial mean body weight of fish in each
102 | bowl was taken and recorded. Fish were fed at 5% of their body weight twice on daily basis, that
103 | is, morning ~~from~~ (08:00 – 09:00 am) and evening ~~from~~ (17:00 – 18:00 pm). Subsequent weight
104 | and standard length measurements were taken every week and the rations of the feed were
105 | adjusted accordingly to fish weight gain. ~~General observations were made daily for m~~Mortality
106 | of the fish was recorded daily. In addition, and also movement and the behavior of fish were
107 | were observed on daily based, monitored. Water in the experiment bowls was renewed totally on
108 | daily basis to remove unconsumed food particles and faecal materials and thus better water
109 | quality parameters were maintained. to prevent poor water quality.

Comment [KBW6]: It is expected to include in discussion part as you observed behavior of the fish

110 |
111 | **Experimental Design and Diets** – The experiment consisted of five treatments with three (3)
112 | replicates, ~~representing each treatment including control.~~ Each of the five experimental treatment
113 | diet contained *Bombyx mori* as fishmeal substitute except the control. ~~All the experimental four~~
114 | diets were formulated to contain commen basal diets and different proportion varying percentage
115 | of *Bombyx mori* fortified ~~with different ingredients~~ as shown in Table 2. Each of the diets was
116 | analyzed to determine the proximate composition. The various diets were ~~designated formulated~~
117 | as follows at varying levels of to contain Bombyx mori inclusion: 0%, 25%, 50%, 75% and 100%
118 | Bombyx mori for and level as D diets A (control), B, C, D and E respectively.

119 |

Data collection and analysis

~~Sampling-~~ All the fish were sampled every weekly sampling was carried out to measure their body weight determine the new growth rate and survival using manual weighing balance. Body length was also measured using... Mortality of the fish was also redistared daily. In addition, physico-chemical parameters of water such as temperature, pH, and dissolved oxygen were monitored during the experiment in daily based or weekly based or....

Based on the data collected, growth performance, feed utilization efficiency and survival rate of the fish were calculated as:

~~Physico-chemical Parameter of Water~~ The following parameters were monitored during the experiment: temperature, pH, and dissolved oxygen.

~~Feed Evaluation Parameters~~ The initial and weekly mean weights were recorded per treatment.

Weight gain (WG) = Final weight of fish – Initial weight of fish

Percentage weight gain (%WG) = [(Final weight – Initial weight)/ Initial weight)] x 100

~~Percentage weight gain (%WG) = Final weight – Initial weight x 100~~
~~Initial weight~~

Percentage specific growth rate (%SGR) = (Log W₂ – Log W₁) x 100
T₂ – T₁

Where:

W₂ = Weight of fish at time T₂ (final)

W₁ = Weight of fish at time T₁ (initial)

T = Period of experiment in days

Comment [KBW7]: Please do the same as above or any other alternatives for all your formulae as the current are not good

148

149 Feed conversion ratio (FRC) = $\frac{\text{Dry weight of feed}}{\text{Total weight gained by fish}}$
150
151

152 Protein efficiency ratio (PER) = $\frac{\text{Total weight gained by fish}}{\text{Protein intake}}$
153
154

155 Statistical Analysis

156 The growth performance and feed utilization parameters were analyzed by univariate analysis
157 using SPSS version 17. Univariate analysis is able to analyze two parameters simultaneously to
158 see if there are strong and meaningful links between them. The significant difference used was at
159 the 0.05 level.

160

161 RESULTS

162 ~~The mean values of Table 3 shows mean~~ growth rate, feed conversion ratio and protein
163 efficiency ratio of *Clarias gariepinus* juveniles fed the five ~~different experimental~~ diets (A, B, C,
164 D and E) for eight weeks ~~were calculated and summarized in Table 3~~. The result shows ~~that the~~
165 weight gain, % weight gain, the specific growth rate (SGR), protein efficiency ratio and food
166 conversion ratio ~~were significantly affected by the type of feed provided for the fish~~. The highest
167 weight gain was recorded in fish fed with diet B (3.05) followed by diet E (2.85) while the
168 ~~lowest least~~ value was recorded in diet C (2.33). Fish fed with diet B had the highest increase in
169 percentage body weight gain (45.05) followed by diet E (38.41). The lowest value of 31.14 was
170 recorded in diet A. A similar trend was observed for the specific growth rate and protein
171 efficiency ratio in which the highest mean of 2.00 and 0.086 was recorded with diet B followed
172 by diet E (1.76 and 0.080). Fish fed with diet A ~~revealed gave~~ the least S-G-R. and protein
173 efficiency ratio (1.47 and 0.064) respectively. The highest value of 4.35 was achieved with the
174 fish fed diet D followed by diet C (3.84) in feed conversion ratio. The lowest value (2.79) was
175 recorded with diet E.

176 Proximate composition of experimental feed is shown in table 4. The ash content was very high
177 in diet A and low in diet D with 11.95 and 9.84 respectively while the percentage fat was high in
178 diet E (3.70) and low in diet A (3.563). The highest and ~~lowest east~~ crude protein was recorded
179 in diet A (37.70) while 35.46 was recorded for both diet D and E. Diet C and B gave the highest

(7.37, 6.74) and ~~lowest~~ (6.40, 6.42) for moisture content and percentage fibre respectively. The percentage soluble carbohydrate was high in diet B (37.73) and low in diet A (35.21).

The proximate composition of *Clarias gariepinus* juvenile flesh is shown in table 5. The highest ash content was recorded in diet D (16.44) and the ~~lowest~~ in diet E (15.49) while the highest moisture content was recorded in diet A (11.41) and ~~lowest~~ in diet D (10.26). Diet E ~~gave~~ had the highest crude protein (67.54) while the ~~lowest~~ was recorded in diet D (66.34). The highest and ~~lowest~~ percentage fat was recorded in diet E and C with 5.76 and 5.39 respectively. The percentage soluble carbohydrate was very high in diet C (1.80) and low in diet D (0.42). The experimental fish showed little weight gain. ~~Low mortality was also observed in~~ all the treatments throughout the period of the experiment.

Comment [KBW8]: Clarify or delete

Table 1: Proximate Composition of *Bombyx mori* larva

Components	% in larva
% dry matter	87.50
% crude protein	69.52
% crude fibre	5.01
% ether extracts	11.12
% ash	7.88

Table 2: Gross Composition of Experimental Diets (Kg)

INGREDIENTS	DIET A Control 0%	DIET B 25% <i>B- mori</i>	DIET C 50% <i>B- mori</i>	DIET D 75% <i>B- mori</i>	DIET E 100% <i>B- mori</i>
Fish meal 72	10	7.5	5	2.5	–
<i>B. mori</i>	–	2.5	5	7.5	10
Maize	11	11	11	11	11
Rice bran	7	7	7	7	7
Fish meal 65	16	16	16	16	16
Soya bean	15	15	15	15	15
Groundnut	38	38	38	38	38
Bone meal	1	1	1	1	1
Salt	1.33	1.33	1.33	1.33	1.33
Lysine	0.37	0.37	0.37	0.37	0.37
Methionine	0.1	0.1	0.1	0.1	0.1
Vitamin C	0.1	0.1	0.1	0.1	0.1
Vit premix	0.1	0.1	0.1	0.1	0.1
Total	100	100	100	100	100

Comment [KBW9]: It is not 100% replacement of fish meal as you have fish meal 65 in all the diets

Table 3: Mean Growth Performance Rate and Feed Utilization Efficiency Conversion Ratio of *Clarias gariepinus* Juvenile.

Parameters	Diet A	Diet B	Diet C	Diet D	Diet E
Initial weight	7.29 ^a	6.77 ^b	7.17 ^a	7.33 ^a	7.42 ^a
Final weight	9.56 ^b	9.82 ^{ab}	9.50 ^b	9.77 ^{ab}	10.27 ^a
Weight gain	2.27 ^{de}	3.05 ^a	2.33 ^d	2.44 ^c	2.85 ^b
% Weight gain	31.14 ^d	45.05 ^a	32.50 ^{cd}	33.29 ^c	38.41 ^b
Specific growth rate	1.47 ^d	2.00 ^a	1.53 ^{bc}	1.56 ^{bc}	1.76 ^b
Protein efficiency					
Ratio	0.064 ^c	0.086 ^a	0.065 ^c	0.068 ^c	0.080 ^{ab}
Feed conversion ratio	3.55 ^c	3.12 ^d	3.84 ^b	4.35 ^a	2.79 ^e

Means with the same alphabet across columns are not significantly different at P< 0.05

Table 4: Proximate Composition of Experimental Feed

Parameters	Diet A	Diet B	Diet C	Diet D	Diet E
Ash	11.95 ^a	10.24 ^b	11.35 ^{ab}	9.84 ^c	10.23 ^b
Moisture	6.54 ^d	6.40 ^e	7.37 ^a	6.86 ^c	7.22 ^b
Crude protein	35.70 ^a	35.60 ^b	35.50 ^c	35.46 ^d	35.46 ^d
Fat	3.53 ^c	3.63 ^b	3.58 ^b	3.60 ^b	3.70 ^a
Fibre	6.54 ^b	6.42 ^c	6.74 ^a	6.64 ^{ab}	6.57 ^b
CHO	35.21 ^d	37.73 ^a	35.76 ^c	36.25 ^b	37.72 ^a

Table 5: Proximate Composition of Experimental Fish

Parameters	Diet A	Diet B	Diet C	Diet D	Diet E
Ash	15.35 ^c	16.39 ^a	15.35 ^c	16.44 ^a	15.49 ^b
Moisture	11.41 ^a	11.38 ^a	10.64 ^{ab}	10.26 ^b	10.69 ^{ab}
Crude protein	66.49 ^c	66.79 ^b	66.62 ^b	66.34 ^d	67.54 ^a
Fat	5.59 ^b	5.42 ^c	5.39 ^c	5.57 ^b	5.76 ^a
CHO	0.86 ^b	0.41 ^d	1.80 ^a	0.42 ^d	0.53 ^c

DISCUSSION AND CONCLUSION

In the present study, fish fed the various diets showed increase in growth performance weight without any external sign of nutritional deficiency because growth performances of fish fed the *Bombyx mori* diets with up to 100% replacement were similar and even better in terms of weight gain, % weight gain, specific growth rate and protein efficiency ratio when compared with the control. This shows the possibility of using *B. mori* as alternative protein source in the diet of *C. gariepinus* as it contains all the necessary nutrients that are required for growth. Orilogbon *et al* (2011) reported that insect meals have a higher level of methionine, lysine and valine compared to soybean meal. The present study showed significant differences ($P < 0.05$) in the growth performance of *Clarias gariepinus* fed the experimental diet at various inclusion of *B. mori* as diet B, E, D and C were shown to be more significant in decreasing order than diet A (control) in terms of weight gain, percentage weight gain, specific growth rate and protein efficiency ratio. This result contradicts the work done by Oyegoke (2006) on dietary potentials of the edible larvae of *Cirina forda* (westwood) as poultry feed; he stated that there were no significant differences between the growth performances of the broiler chicks as better results were obtained

Comment [KBW10]: Table three shows a significant growth performance of the fish fed with verity of feed, but you said here similar performance. How?

Comment [KBW11]: This comparison is not good as they are extreme group of animals,

295 | from fish fed with the experimental diet. The best performance of fish was ~~observed gotten~~ from
296 | 25% inclusion of BMM. This supports the work of Sogbesan (2006) that replacement of fishmeal
297 | with 25% maggot meal gave the best performance in the fish. Also, more than 25% BMM
298 | inclusion gave a better growth performance when compared with control. This contradicts the
299 | report made by Sogbesan (2006) that higher replacement levels than 25% magmeal gave a lower
300 | growth.

301 | The *Clarias gariepinus* juvenile fed diet D (i.e. 75% inclusion of *Bombyx mori*) showed superior
302 | feed conversion ratio. This agreed with the findings of Davies & Gouveia (2010) who worked
303 | on the dietary nitrogen utilization in African cat fish fed oil seed meal diets under sub-optimal
304 | growth condition consistent with a restricted regime. It was stated that fish fed the experimental
305 | diets showed superior feed conversion ratio. The result of the proximate composition of carcass
306 | of fish fed experimental diets showed significant difference at various levels of *B. mori*
307 | inclusion. This however, disagreed with the work done by Nwanna (2003) where he reported no
308 | significant difference ($P<0.05$) in the carcass composition and mineral deposition of *Clarias*
309 | *gariepinus* fed chemically preserved shrimp head waste silage diets. Also, the higher lipid
310 | deposits in the carcass of fish fed experimental diets showed better growth in terms of weight
311 | which may be due to lipid rather than crude protein gain as this supports the report of Adeparusi
312 | and Agbede (2004) that better performance in growth, nutrient utilization and carcass crude
313 | protein deposit in *O. niloticus* fed diets with leaf protein cake showed that leaf proteins made
314 | from *Gliricidia* and *Leucaena* could be viable means of improving fish feed especially for
315 | herbivorous fish like *O. niloticus*.

316 |
317 | Also, the result of this study showed the preference of *Clarias gariepinus* juvenile for small
318 | amount of lipids in their diet for growth because the highest ~~weight-growth performance~~ was
319 | observed in fish fed diet B. This may be attributed to the fact that the lipids of animal origin such
320 | as silkworm have shorter chain and lower degree of fatty acids rather than Omega 6-fatty acid in
321 | contrast to terrestrial animal which require long chain of omega 6- fatty acids (Kanazawa, 1993).

322 |
323 | ~~As conclusion, It can be concluded from the present study that~~ 25%, 100%, 75% and 50% of
324 | ~~replacement of fish meal protein by~~ *Bombyx mori* ~~respectively could replace fish meal protein in~~
325 | the diet of *Clarias gariepinus* juvenile ~~as it was satisfactorily is~~ acceptable to the fish without

Comment [KBW12]: Too long make short

326 affecting the growth and feed utilization. This will ultimately reduce the cost of fish meal to be
327 included in the diet and consequently reduce the cost of fish production. It can be said that
328 whatever was responsible for a drop in weight gain and feed utilization of fish fed diet C (50% *B.*
329 *mori* inclusion) could be taken care of by using a better processing method. Moreover, *B. mori*
330 replacement can be tested on later stage of the fish to make a general conclusion~~other fish~~
331 ~~species, poultry and any other animal diets.~~

332 REFERENCES

- 333 Adedire C. O. and Aiyesanmi A. F. (1999). Proximate and mineral composition of the adult and
334 immature forms of the variegated grasshopper, *Zonocerus variegatus* (L) (*Acridoidea*:
335 *Pygomorphidae*). *Bioscience Research Communications*. 11(2):121-126.
- 336 Adeparusi E. O. and Agbede J. O. (2004). Evaluation of *leucaena* and *gliricidia* leaf protein
337 concentrate as supplements to Bambara groundnut (*Vigna subterranea* L. *Verdc*) in the diets of
338 *Oreochromis niloticus* in 6th *International Symposium of Tilapia in Aquaculture (ISTA)*. 335-346.
- 339 Ahmad H. M. and Diab S. A. (2008). Replacement of fish meal protein by okara meal in
340 practical diets for all male monosex Nile tilapia (*Oreochromis niloticus*). *8th International*
341 *Symposium on Tilapia Aquaculture*. 729-737.
- 342 Allan J. D. (2004). Land Scapes and Riverscapes: The influence of Land Use on Streams and
343 Ecosystems. *Annual Review of Ecology, Evolution, and Systematics*. 35: 257- 284.
- 344 American Public Health Association (APHA, 2006). Standard methods for the examination of
345 water and waste water. *APHA Washington DC. 14th edition*. 107.
- 346 Andrews, J.W. 1979. Some effects of feeding rate on growth, feed conversion and nutrient
347 absorption of channel catfish. *Aquaculture* 16(3): 243–246.
- 348 Chebbaki K., Akharbach H., Talbaoui E., Abrehouch A., Ait ali A., Sedki S., Ben Bani A., and
349 Idaomar M.(2010). Effect of fish meal replacement by protein sources on the extruded and
350

355 pressed diet of European sea bass juvenile (*Dicentrarchus labrax*). *Agriculture and Biology*
356 *Journal of North America*. 1(4): 704-71.
357

358 Davies S. J. and Gouveia A. (2010). Response of common carp fry diets containing a pea seed
359 meal (*Pisum sativum*) subjected to different thermal processing methods. *Elsevier*. 305(1-4):
360 117- 123.
361

362 Ekpo K. E. and Onigbinde A. O. (2007). Characterization of Lipids in Winged Reproductives of
363 the Termite *Macrotermis bellicosus*. *Pakistan Journal of Nutrition*. 6 (3): 247-251.
364

365 Gabriel U. U., Akinrotimi O. A., Bekibele D. O., Onunkwo D. N. and Anyanwu P. E. (2007).
366 Locally produced fish feed: potentials for aquaculture development in sub-Saharan Africa.
367 *African Journal of Agricultural Research*. 2(7): 287-295.
368

369 Gatlin D. M. III., Barrows F.T., Brown P., Dabrowski k., Gaylord T. G., Hardy R.W., Herman
370 E., Hu G., Krogdahl A., Nelson R., Overturf K., Rust M., Sealey W., Skonberg D., Souza E. J.,
371 Stone D., Wilson R., and Wurtele E. (2007). Expanding the utilization of sustainable plant
372 products in aqua feeds: a review. *Aquaculture Research*. 38 (6): 551-579.
373

374 Goytortu'a B.E, Civera C. R., Rocha M. S. and Green Y. A. (2006). Partial replacement of red
375 crab (*Pleuroncodes planipes*) meal for fish meal in practical diets for the white shrimp,
376 *Litopenaeus vannamei*. Effects on growth and in vivo digestibility. *Aquaculture*. 256: 414-422.
377

378 Hardy R.W. (2006). Worldwide fish meal production outlook and the use of alternative protein
379 meals for aquaculture. En: Editores: Sau'rez L. E. C., Marie D. R., Salazar M. T., Lo'pez M. G.
380 N., Cavazos D. A. V., Ortega PCAGy. Avances en Nuticio' n Acui' cola VIII. *VIII Symposium*
381 *International de Nuticio' n Acui' cola*. Universidad Auto'noma de Nuevo Leo'n, Me'xico. 410-
382 419.
383

384 Kasper C. S., Watkins B. A. and Brown P. B. (2007). Evaluation of two soybean meals fed to
385 yellow perch (*Perca flavescens*). *Aquaculture Nutrition*. 13(6): 431- 438.

386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415

Lee K., Oilce Y. and Kanazawa T, eds. (1993). The third international on nutrition in cardiovascular diseases. Annals NY Academic Science. 676.

Nwanna L. C. (2003). Nutritional Value and Digestibility of Fermented Shrimp Head Waste Meal by African Catfish *Clarias gariepinus*. *Pakistan Journal of Nutrition* 2(6): 339-345

Orilogbon J. O. and Adewole A. M. (2011). Ethnoichthyological knowledge and perception in traditional medicine in Ondo and Lagos States, southwest Nigeria. *Egyptian Journal of Biology*. 13: (57-64).

Oso J. A., Edward J. B., Ogunleye O. A. and Majolagbe F.A. (2013). Growth Response and Feed Utilization of *Clarias gariepinus* Fingerlings Fed with Bambara Groundnut as protein source. *Journal of Natural Sciences Research*. 3(5): 84- 90.

Oyekoge O. O., Akintola A. J. and Fasoranti J. O. (2006). Dietary potentials of the edible larvae of *Cirina forda* (westwood) as a poultry feed. *African Journal of Biotechnology*. 5(19): 1799-1802.

Yang Y., Xie S., Cui Y., Lei W., Zhu X., Yang Y. and Yu Y. (2004). Effect of replacement of dietary fish meal by meat and bone meal and poultry by- product meal on growth and feed utilization of gibel carp, *Carassius auratus gibelio*. *Aquaculture Nutrition*. 10: 289- 294.

Wang Y., Guo J. L., Cui Z. H. and Bureau D. P. (2006). Replacement of fish meal by rendered animal protein ingredients in feeds for cuneate drum (*Nibea miichthioides*). *Aquaculture*. 252: 476- 483.