



SUBSTITUTION OF WATER HYACINTH IN THE DIET OF GREY MULLET *Mugil cephalus* (L) FRY REARED IN THE LABORATORY

*SOYINKA, O. O. & K. KUSEMIJU

Department of Marine Sciences, University of Lagos, Nigeria

*Corresponding author: soyinka.olufemi@gmail.com +2348033808071

ABSTRACT

The effect of substituting fish feeds on the growth of *Mugil cephalus* fry, at various levels (20%, 30% and 40%) of dried water hyacinth, *Eichhornia crassipes* to reduce cost of fish production, was determined over a period of six weeks (42 days) in lagoon water condition in the laboratory. Eighty fry were used and there were four feeding regimes with a replicate for each regime, at 10 specimens per tank. The higher gain in weight of 0.39 g (125.81%) was recorded in the fry fed with 40% water hyacinth substitution diet. The higher gain in length of 1.0 cm (40.0%) was recorded in the control (100% Coppens feed). The higher condition factor was 2.59 in the 40% water hyacinth substitution diet. The better food conversion ratio, the higher food conversion efficiency and the higher specific growth rate were 2.51, 39.78% and 0.86 g/day respectively in the 40% water hyacinth diet. The economic analyses further reflected the benefit of the cost of production using 40% water hyacinth meal in *M. cephalus* feed for good yield and reduction in the cost of fish production.

Keywords: feeding trial, benefit cost ratio, profit index

INTRODUCTION

Nlewadim and Deekae (1997) reported that the popularity of the grey mullet in aquaculture is due to high quality of its flesh, its extreme tolerance for a wide range of temperature and salinity, which is important for culture in intertidal ponds. Additionally they readily accept supplemental feeds such as rice bran, peanut meal and cake. Full-scale commercial production of *Mugil cephalus* is not yet common. Jana *et al.* (2004) reported that a periphyton supported aquaculture system can be used successfully for the culture of herbivorous brackish water fish species like *Mugil cephalus* in inland saline groundwater and thus could contribute to the development of sound and sustainable aquaculture technology. According to Wassef *et al.* (2001), using a diet containing 40% protein, 20% ulva meal or a diet containing 40% dietary yeast enriched with vitamin E enhanced the growth and muscle structure of the grey mullet, *M. cephalus*.

According to Kusemiju and Akingboju (1988), the shortage and high cost of conventional pelleted feed has severely constrained the development of low-cost aquaculture systems suitable for small-scale farmers in the developing world, hence the need to assess the potential of non-conventional fish feeds such as water hyacinth, *Eichhornia crassipes* (Mart).

Since water hyacinth occur in many tropical and subtropical countries and produces dense mono-specific strands which often cover hundreds of hectares, its utilization could provide an important resource for man. Boyd (1969) also noted that the weed contained a large amount of crude protein, satisfactory level of amino acids, and relatively high levels of mineral nutrient, ether and carbohydrate.

The objectives of this study were to investigate the nutritive value of water hyacinth plant, its acceptability by *M. cephalus* and the possibility of reducing the cost of fish production by substituting the plant in the fish feed.

MATERIALS AND METHODS

Experimental set-up

A total of fourteen experimental plastic tanks of 35 litres capacity were used for the feeding trials. There were seven feeding regimes, each with a replicate tank. The tanks were well aerated using air pumps and the water in each tank was renewed completely every fortnight. The experiment was carried out at the Marine Research Laboratory of the Department of Marine Sciences, University of Lagos.

Fish used for the experiment

Collection of live fry from the Lagos Lagoon, using hand net with small mesh size was made for the feeding trial. Live specimens of *M. cephalus* fry (total length: 2.1 – 3.0 cm; total weight: 0.10 – 0.29 g) were collected from the Lagos Lagoon and acclimatized in rectangular glass tanks (300 litres capacity) at the Marine Research Laboratory of the Department of Marine Sciences, University of Lagos, for days. The fishes were fed with the control diet to satiation from second day of acclimatization.

After acclimatization, Ten (10) specimens each were placed per tank, fourteen tanks in all. Prior to stocking in experimental tanks, the fry were randomly sorted and weighed. The total length (TL) was taken from the tip of the snout to the end of the caudal fin (Tesch, 1968; Bannister, 1976). The length was measured to the nearest 0.1 cm on a measuring board. The total weight of the fish was taken on a 'Sartorius' top loading balance (Model 1106 2608053) to the nearest tenth of a gram. The specimens of *M. cephalus* fry used ranged in size: total length, 2.1 – 3.0 cm; total weight, 0.10 – 0.29 g. The fry were fed twice daily at 5% of body weight for 42 days. Fortnightly, the water in the experimental set-up was changed totally and the fishes were re-weighed. The quantity of feed fed was adjusted based on the new fortnight weight of the fish in tanks. Fish mortality was also monitored and record was taken.

Diets used in experiment

The dried water hyacinth was used to substitute fish feed at various levels: 20%, 30% and 40% (Note: This was to make comparison with the works of Kusemiju and Akingboju (1988) in which the similar percentage substitution was used in feeding a herbivorous cichlid as *Sarotherodon melanotheron*). Table 1 showed the composition of the experimental diets used during the feeding trials, while Table 2 presented the proximate composition of formulated Coppens feed. Proximate composition of the dried water hyacinth was carried out according to AOAC (2000), in the Department of Chemistry, University of Lagos.

Table 1: Composition of the experimental feeds

Cage/ Tank	Feed type
1	Formulated Coppens feed only (control)
2	20% dried water hyacinth; 80% Coppens
3	30% dried water hyacinth; 70% Coppens
4	40% dried water hyacinth; 60% Coppens

Table 2: Proximate composition of Coppens Starter fish feed (Coppens CatCo Crumble Top® 0.3 – 0.5mm feed)

Components	Composition (%)
Protein	45 – 56
Fat	10.4 – 15.5
Crude fibre	0.4 – 1.3
Ash	7.3 – 9.0
Total Phosphorus	1.3 – 1.5
Vitamin A	22, 500 IU/kg
Vitamin D3	2, 500 IU/kg
Vitamin E	200 mg/kg
Vitamin C (stable)	300 mg/kg
Gross energy	20.5 MJ – 4.9 Mcal
Digestible energy	19.1 MJ – 4.6 Mcal
Metabolisable energy	15.9 MJ – 3.8 Mcal
Calcium	0.7 – 18

Source: Patrick, *et al.* (2006); Fashina-Bombata and Somotun (2008).

Measurement of water quality parameters in experimental tanks

Physico-chemical parameters were determined weekly during the feeding trial. The water temperature was measured using a simple mercury-in-glass thermometer. The salinity was determined using a Refractometer (BIOMARINE, Aqua Fauna Model). The pH values were determined using a Jenway Hanna pH meter (HI 991301 Model).

Estimation of the growth and nutrient utilization

The fortnight weights and feed fed to fish were used to compute the growth and nutrient utilization parameters following the method of Oliva-Teles and Goncalves (2001).

Mean weight gain = $W_f - W_i/n$; where f = final, i = initial, n = number

Relative growth rate = $\text{Weight gain} \times 100/\text{Initial body weight}$

Specific growth rate = $\text{Log } w_f - \text{Log } w_i \times 100/t$,
 where t = time (in days)

Feed conversion ratio = $\text{Feed intake (g)} / \text{Fish weight gain (g)}$

Feed conversion efficiency (%) = $1/\text{Feed conversion rate} \times 100$

Protein Efficiency ratio = $\text{Mean weight gain (g)} / \text{Mean protein intake}$

Analysis of the cost / profit

Estimated investment cost analysis = $\text{Cost of feeding (₦)} + \text{Cost of fry stocked (₦)}$

Profit index = $\text{Value of fish (₦)} / \text{Cost of feed (₦)}$

Incident of cost = $\text{Cost of feed (₦)} / \text{Mean weight gain of fish produced (g)}$

Net profit = $\text{Total cost of fish cropped (₦)} - \text{Total expenditure (₦)}$

Benefit cost ratio = $\text{Total cost of fish cropped (₦)} / \text{Total expenditure (₦)}$ (Mazid *et al.*, 1997)

RESULTS

Effects of different feeds on the growth of *M. cephalus* fry

(i) Proximate composition of feed ingredients used in the feeding trial.

The proximate composition of water hyacinth is presented in Table 3. Water hyacinth had a lower crude protein value (11.34%) than coppens (45 - 56%), but the crude fibre in water hyacinth was higher than that in coppens. There was a significant

difference ($p < 0.05$) in the crude protein and fibre content of coppens and dried water hyacinth.

Table 3: Proximate composition of water hyacinth, *Eichhornia crassipes* used in the feeding experiment of *Mugil cephalus* fry

Components	Composition (%)
Crude Protein	11.34
Crude Fat	0.59
Crude Fibre	18.16
Ash	2.87
Moisture	12.03

(ii) Moisture content of fresh water hyacinth
 The moisture content of fresh water hyacinth, *Eichhornia crassipes* was also determined (Table 4). The moisture content in the leaves and stems (the parts actually used for the feeding experiment) was 96.0%.

(iii) Mortality / Survival of *M. cephalus* fry during the feeding trial experiment

The weekly mortality record is presented in Table 5. At end of the experiment, only tanks 1A, 1B, and 4A had some specimens remaining in them. The percentage survival was as follows: 20% (Tank 1A); 40% (Tank 1B) and 10% (Tank 4A). Thus on the average, Tank 1 had 30% survival, while Tank 4 had 5% survival. The differences observed in mortality in the tanks were subjected to statistical analysis to see if there was any significant variation. The result of the ANOVA showed that there was no significant variation ($p > 0.05$) in mortality in the different tanks.

Table 4: The moisture content in fresh water hyacinth

	Mean weight of fresh plant (g)	Mean weight of dried plant (g)	Mean weight of moisture (g)	Percentage weight of moisture (%)
Complete plant	58.98	2.35	56.63	96.01
Plant without root	47.86	1.92	45.94	95.99

Table 5: Mortality record for *M. cephalus* fry during the feeding trial experiment

Feeding regime	Initial number per tank	Mortality per week						Survival at the end of the 6 th week	% Survival
		1 th	2 nd	3 rd	4 th	5 th	6 th		
1A	10	7	1	0	0	0	0	2	20
1B	10	3	0	1	0	1	1	4	40
2A	10	8	2	-	-	-	-	0	0
2B	10	4	0	2	4	-	-	0	0
3A	10	4	1	3	2	-	-	0	0
3B	10	6	1	0	3	-	-	0	0
4A	10	6	2	0	0	1	0	1	10
4B	10	9	1	-	-	-	-	0	0

(iv) Growth in weight

The initial mean weight of specimens in tank 1 was 0.34g while the final mean weight was 0.72 g giving an increase mean weight of 0.38 g representing a percentage weight gain of 111.76%. Tank 4 specimens had an initial mean weight of 0.31 g and a final mean weight of 0.71 g, thus with a mean weight increase of 0.39 g. This represented a percentage

mean weight gain of 125.81%. Summary of the growth in weight is shown in Fig 1. From the cumulative gain in weight of *M. cephalus* fry, it could be seen that specimens fed with Coppens feed only, had higher mean growth rate every fortnight; specimens on 40% substitution with dried water hyacinth had an initial increase, followed by a decrease and then an increase again in weight.

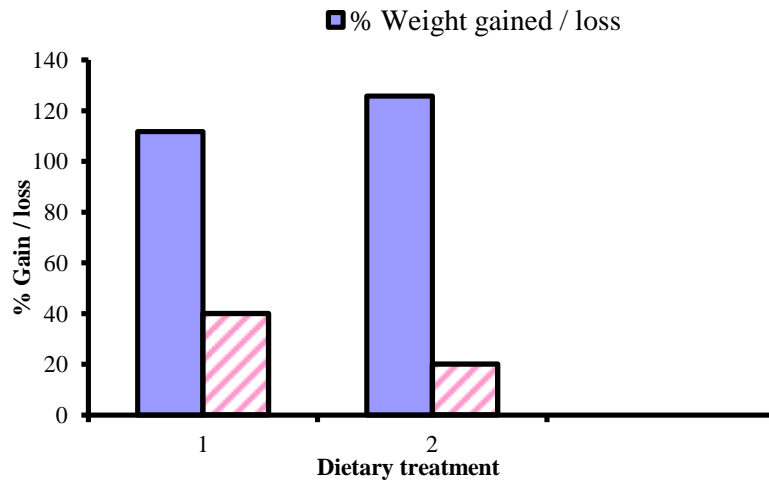


Fig 1: Percentage gain in weight / length of *M. cephalus* fry fed with experimental diets

Key: 1 = 100% Coppens feed (control), 2 = 40% water hyacinth (WH) + 60% Coppens feed (CF)

(v) Growth in length

The initial mean length of specimens in tank 1 was 2.5 cm while the final mean length was 3.5 cm giving an increase mean length of 1.0 cm representing a

percentage length gain of 40.00%. Tank 4 specimens had an initial mean length of 2.5 cm and a final mean length of 3.0 cm, thus with a mean length increase of 0.5 cm. This represented a percentage mean length

gain of 20.00%. A summary of the growth in length is shown in Fig 1. The length measurements of all the specimens showed that a general increase in growth with time occurred but more significant gain in length was achieved by specimens on the Coppens feed.

(vi) Condition factor of *M. cephalus* fry
The initial and final condition factors for the specimens in the remaining feeding regimes are shown in Fig 2. The final condition factor for *M. cephalus* fry was 1.68 (tank 1) and 2.59 (tank 4). This showed that the fry fed with 40% water hyacinth substitution had the better condition factor.

(vii). Food conversion ratio (FCR) of *M. cephalus* fry
The food conversion ratio (FCR) of fish fed with Coppens feed was 4.50 and fry fed with 40% water hyacinth substitution was 2.51. The lower FCR value recorded was in the 40% water hyacinth substitution dietary treatment and therefore is probably the better feeding regime for *M. cephalus* as demonstrated in this experiment. This meant that the specimens on this diet were able to convert 2.51 unit weight of feed to a unit weight of muscle. Illustration of the food conversion ratio is shown in Fig 3.

(viii) Food conversion efficiency (FCE) of *M. cephalus* fry
The food conversion efficiency (FCE) of fish fed with coppens feed was 22.22% and fry fed with 40% water hyacinth substitution was 39.78%. The higher FCE value recorded was in the 40% water hyacinth substitution dietary treatment and therefore is probably the better feeding regime for *M. cephalus* as demonstrated in this experiment. This meant that the specimens converted 39.78% of the food ingested into flesh. Illustration of the food conversion efficiency is shown in Fig 4.

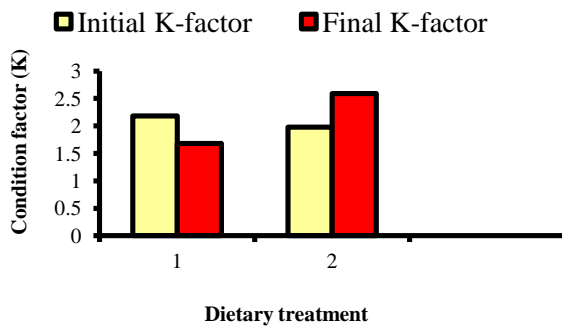


Fig 2: Initial and final condition factor (K) of *M. cephalus* fry in the feeding trial

Key: 1 = 100% coppens feed (control), 2 = 40% water hyacinth (WH) + 60% coppens feed (CF)

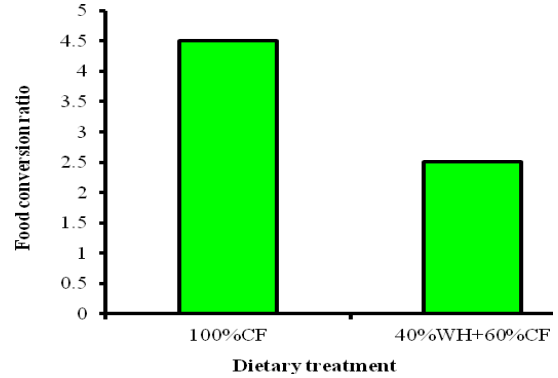


Fig 3: Food conversion ratio (FCR) of *M. cephalus* fry in the feeding trial

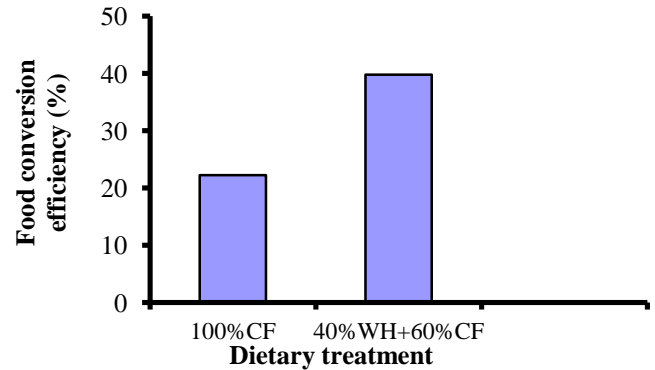


Fig 4: Food conversion efficiency of *M. cephalus* fry in the feeding trial

(ix) Specific growth rate (SGR) of *M. cephalus* fry

The SGR (g/day) of the specimens is illustrated in Fig 5. The value recorded were 0.79 g/day (coppens feed only) and 0.86 g/day (40% water hyacinth substitution). The higher rate of growth in weight per day was therefore in the dietary treatment of 40% water hyacinth substitution.

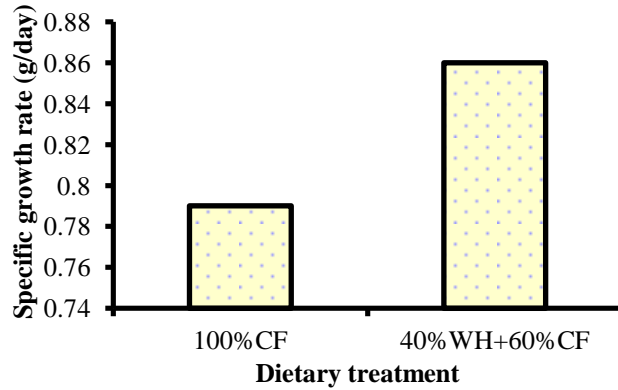


Fig 5: The specific growth rate of *M. cephalus* fry in feeding trial experiment

(x) Water quality parameters

The results of the physico-chemical parameters obtained are presented in Table 6

(xi) Economic analysis

The profitability or economic viability of the diets was calculated and the results are presented in Table 7.

Table 6: Water quality parameters in the feeding regimes

Parameters	Control diet (100% coppers)	40% Water hyacinth substitution diet
Water temperature (°C)	28.0 – 29.0 (28.67 ± 0.52)	28.0 – 29.0 (28.75 ± 0.46)
Salinity (‰)	14.0 – 16.0 (14.83 ± 0.98)	14.0 – 16.0 (15.13 ± 0.74)
pH	7.50 – 7.89 (7.68 ± 0.16)	7.50 – 7.77 (7.61 ± 0.13)

Table 7: Economic indices of *M. cephalus* fed with coppers and water hyacinth diets for 42 days under laboratory conditions

Parameters	Control diet (100% coppers)	40% Water hyacinth substitution diet
Cost of stocked fingerlings (₦)	100	100
Cost of feeding (₦)	5.18	2.69
Total expenditure (₦)	102.92	101.51
Value of fish cropped (@ ₦50 each)	150	50
Net profit	47.08	-51.51
Profit / individual fish (₦/fish)	15.69	51.51
Incidence of cost (₦/g)	13.63	6.90
Profit index	9.65	18.59
Benefit cost ratio (BCR)	1.46	0.49

DISCUSSION

The proximate composition of data showed that coppers feed had the higher crude protein, while water hyacinth had the higher crude fibre. Water hyacinth inclusion in the diet significantly increased the crude fibre content of the feed fed to fish in the 40% substitution diet. This probably affected the food conversion ratio and feed utilization by the fry. Fagbenro and Arowosege (1991) highlighted that

high fibre aid digestion of feed more easily. This is probably why the fry in the 40% water hyacinth substitution diet had a higher gain in weight than those fed with the control diet only.

The mean moisture content of complete water hyacinth plant in this study was found to be 96.01%, while the rest of the plant without the root was 95.99%. This meant that the dry matter content of 3.94% for the entire plant and 4.01% for plants with

the roots removed was obtained. Generally, aquatic plants are reported to contain a lot of moisture (Klymchuk *et al.*, 2008), Boyd (1969) and Kusemiju and Akingboju (1988) recorded a dry matter content of 5.9% and 6.9% respectively for freshly harvested water hyacinth. The result obtained in this study is similar to those of these authors. Edwards (1980) reported that fresh water hyacinth had crude protein content below 2.0% (as compared to the dried plant which had 14.2% crude protein content). He therefore suggested that water hyacinth should be dehydrated prior to use as a feed. In this study, roots of water hyacinth were not used due to its nature of absorbing impurities from the water in which it grows.

From the mortality record under the feeding trial in this study, it was observed that *M. cephalus* fry experienced high mortalities during acclimatization and the feeding experiment. The highest percentage survival obtained was 40%. Several authors have given similar reports (Hotos and Vlahos, 1998; Bulli and Kulikova, 2004).

M. cephalus fry had percentage gain in weight of 125.81% and 111.76% on 40% water hyacinth substitution and 100% coppens feeds respectively. It was clear that the fry utilized both artificial feeds beneficially. However, 40% substitution level by water hyacinth yielded a better growth. A slight drop in mean weight of about 0.10 g was observed in the 40% water hyacinth diet, after the second week, but the fry gradually increased in weight with time. This may not be unconnected with the fry trying to adapt to the dried water hyacinth. Appreciable weight gain was obtained for mullet fry fed on coppens feed only. Kusemiju and Akingboju (1988) recorded an initial loss in weight up to 0.70 g in tilapia specimens fed on dried water hyacinth only. One possible reason in this study why the fry did better on the 40% water hyacinth substitution feed could be the effective utilization of algae and plant materials common to fry of *M. cephalus* in the wild (Collins, 1985) and from the examination of the stomach content of *M. cephalus* for the food and feeding habit. The increase observed in the length of the specimens was not as prominent as that of the weight. However, specimens on coppens feed only had a 40% increase while 40% water hyacinth substitution had 20% increase.

The condition factor was higher in the 40% water hyacinth substitution (2.59). Kusemiju and Akingboju (1988) obtained K-value of 4.77 for

tilapia fed with dried water hyacinth. Onadeko and Kusemiju (1987) reported a good condition of growth for tilapia fed on 60% feed + 40% poultry waste.

The food conversion ratio of fry fed on 40% water hyacinth (2.51) was better than that for coppens feed only (4.50). This meant that less weight of water hyacinth than coppens feed would be required to produce one gramme of fish flesh. The efficiency with which fry on the 40% water hyacinth feed converted the food consumed into fish flesh was better.

The specific growth rate of *M. cephalus* fry was highest in the 40% water hyacinth feed and this meant that the fry under this feeding regime adequately took advantage of the diet at a better rate than on the other diet.

The water quality parameters obtained during the experiment did not vary considerably. The ranges obtained were within tolerable limits for *M. cephalus* (Huet, 1971; Sylvester *et al.*, 1974; Kulikova *et al.*, 1986).

Although in the 40% water hyacinth substitution feed where mortality reduced the amount of fish remaining to the end of the experiment, the benefit cost ratio could be said to favour the diet used since the value was > 1.0, which is an indication of increase in the fish value above the amount invested. Consequently, a fish farmer tends to make more profit when 40% water hyacinth meal is used to replace fish meal in the diets of *M. cephalus*.

CONCLUSION

The present investigation indicated vividly that water hyacinth can be used as artificial feed for *M. cephalus* at appropriate partial substitution of fish feed, thus saving considerable cost. The weed has invaded Nigerian waters. It is suggested that it could be collected and processed on a large scale as both a fish feed and in substitution of some quantities of formulated fish feed. This would help to reduce the expenditure on formulated feeds, thereby cutting down the cost of fish production.

However, it is recommended that a study on the growth increment of *M. cephalus* and the cost-effectiveness using higher percentage substitution (60%, 80% and 100%) of an expensive feed as coppens with the dried water hyacinth, be carried out in future.

REFERENCES

- AOAC (2000). Official methods of analysis. 17th edition, Association of Official Analytical Chemists, AOAC International, Gaithersburg MD, USA. 51pp.
- Bannister, J.V. (1976). The length-weight relationship, condition factor and gut contents of the Dolphin fish, *Coryphaena hippurus* (L) in the Mediterranean. *Journal of Fish Biology*, 9: 335 – 338.
- Boyd, C. E. (1969). The nutritive value of three species of water weeds. *Economic Botany*, 23:123 – 127.
- Bulli, L. I. and Kulikova, N. I. (2004). Adaptive capacity of the larvae of the haarder *Liza haematocheila* (Mugilidae, Mugiliformes) under decreasing salinity of the environment. *Journal of Ichthyology*, 46(4): 525 – 535.
- Collins, M. R. (1985). *Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (South Florida) – striped mullet*. U.S. Army Corps of Engineers, TR EL – 82.4 11pp.
- Edwards, P. (1980). Food potentials of aquatic macrophytes. ICLARM Studies and Reviews, 5, ICLARM Manila, 51pp.
- Fagbenro, O.A. and Arowosegbe, I.A. (1991). Utilization of agricultural wastes and by-products in fish feeds production in Nigeria. Proceedings of the 6th Annual Conference of Fisheries Society of Nigeria, Lagos, pp. 121-130.
- Fashina-Bombata, H.A. and A.O. Somotun, A.O. (2008). The Effect of Lyophilized Goat Testes Meal as First Feed on the Growth of ‘Wesafu’: An Ecotype Cichlid of Epe-Lagoon, in Lagos State, Nigeria, *Pakistan Journal of Nutrition*, 7 (5): 686-688.
- Hotos, G. N. and Vlahos, N. (1998). Salinity tolerance of *Mugil cephalus* and *Chelon labrosus* (Pisces: Mugilidae) fry in experimental conditions. *Aquaculture*, 167(3-4): 329 – 338.
- Huet, M. (1971). *Textbook of fish culture: breeding and cultivation of fish*. Fishing News Books Ltd., Farnherm Survey, England. 437pp.
- Jana, S. N., Garg, S, K. and Patra, B. C. (2004). Effect of periphyton on growth performance of grey mullet, *Mugil cephalus* (Linn.), in inland saline groundwater ponds. *Journal of Applied Ichthyology* 20 (2): 110 – 117.
- Klymchuk, D., Vorobyova, T., Sivash, O. and Jadko, S. (2008). Effects of water deficit on water relations of *Alisma plantago-aquatica* L. under natural environment. *General Applied Plant Physiology*, 34 (3-4): 227 – 238.
- Kulikova, L.G., Cardona, L.C. and Diouf, P.S. (1986). Effects of salinity on the habitat selection and growth performance of Mediterranean flathead grey mullet, *Mugil cephalus* (Osteichthyes, Mugilidae), *Estuarine, Coastal and Shelf Science*, 50: 727 – 737.
- Kusemiju, K. and Akingboju, O.S. (1988). Comparative growth of *Sarotherodon melanotheron* (Ruppell) on formulated fish feed and water hyacinth diets. In: Oke, O.L., Imevbore, A.M.A. and Farri, T.A. editors. Proceedings of the International workshop / seminar on water hyacinth held in Lagos, 7th – 12th August, 1988. 196 – 203.
- Nlewadim, A.A. and Deekae, S.N. (1997). Collection of juvenile mullet species from brackishwater tidal farm in Nigeria. *NAGA, The ICLARM Quarterly*. 20: 19 – 20.
- Mazid, M.A., Zaher, M., Begum, N.N., Aliu, M.Z. and Nahar, F. (1997). Formulation of cost-effective feeds from locally available ingredients for carp polyculture system for increased production. *Aquaculture* 151: 71 – 78.
- Oliva-Teles, A. and Goncalves, P. (2001). Partial replacement of fish meal by brewers yeast (*Saccaromyces cerevisiae*) in the diets for sea bass (*Dicentrarchus labrax*) juveniles, *Aquaculture*, 202: 269 – 278.
- Onadeko, G.A. and Kusemiju, K. (1987). Substitution of fish feed with poultry waste in the diet of *Sarotherodon melanotheron* (Ruppell). *Nigerian Journal of Basic and Applied Sciences* 2, 165 – 172.
- Patrick, K., Xu, X., Neila, H., Jean, M. and Ibrahim, I.T. (2006). Effect of weaning age and diet on

pikeperch larviculture. *Aquaculture* 264 (1-4): 197 – 204.

Sylvester, J.R., Nash, C.E. and Emberson, C.E. (1974). Preliminary study of temperature tolerance in juvenile Hawaiian mullet (*Mugil cephalus*), *Prog. Fish Cult.*, 36: 99 – 100.

Tesch, F.W. (1968). Age and growth. In: *Methods for Assessment of fish production in freshwater* (Ricker,

W.E. ed.) Blackwell Scientific Publication, Oxford. 93 – 123.

Wassef, E. A., El-Masry, M. H. and Mikhail, F. R. (2001). Growth enhancement and muscle structure of striped mullet, *Mugil cephalus* L. fingerlings by feeding algal meal-based diets. *Aquaculture Research* 32 (1): 315 – 322.