Ilorin Journal of Science
Volume 10, Number 2, 2023, pp. 103 – 111 (Printed in Nigeria)
ISSN: 2408 – 4840 © 2023 Faculty of Physical Sciences, University of Ilorin
https://doi.org/10.54908/iljs.2023.10.02.003

ILORIN
JOURNAL OF SCEINCE

ILJS-23-009

# Growth performance and survival of African catfish (*Clarias gariepinus*, Burchell 1822) fingerlings raised at different stocking densities

**Mustapha,[1*] A. K., Oladejobi,[2] G. K. and Kolawole,[3]. A. A.**

[1,2] Department of Zoology Osun State University, Osun State, Nigeria.
[3]Deparment of Biological Sciences, Federal University of Kashere, Gombe State, Nigeria.

## Abstract

Stocking density is among the leading factors that affect the growth, survival, and other metabolic activities of fish, and the water quality and farming profitability in fish culture. The major intention of the work is to find out the optimum stocking density for Clarias gariepinus fingerlings in culture media that would maximize production. Five hundred and twenty-five fingerlings (mean weight 5.88±0.14g, mean length of 9.46±0.12cm) were stocked randomly into 45 litre (0.5 × 0.3 × 0.3) m3 rectangular plastic tanks at six different stocking densities of 25, 50, 75, 100, 125 and 150 fingerlings/tank in triple and were fed for six months with fish feed with 35% crude protein at 3% of their body weight two times daily. The mean weight gain, specific growth rate, feed conversion ratio, and survival rate were all dependent on stocking density. The water parametric quality data obtained throughout the study were within the range for healthy fish culture, but dissolved oxygen concentration decreases with increasing stocking density. In general, as stocking density increases the growth and survival percentage of the experimental fish decreases and the total fish yield increased significantly with increasing stocking density and reached the peak at stocking density 75 fingerlings/ tank

**Keywords:** Clarias gariepinus, stocking density, Diet, Fingerlings, Protein efficiency ratio.

## 1. Introduction

Today fish production in Nigeria is still facing the challenges of meeting the rising demand. The capture of fish from the wild has reduced drastically in recent time and many fish in the wild are over-exploited and their future is threatened. The cost of fishing equipment also contributes to the high cost of fish production. And yet the demand for fish has continued to rise in Nigeria. The fish culture which is believed to have come to relieve pressure on overburdened wild fisheries and provide affordable fish to the teaming population is still faced with several challenges which seem to continue to increase until appropriate technologies and sustainable efforts in fish production are made.

Several factors affect the effort being made to develop fish culture. Such factors include stocking density, an important parameter and a major factor that directly affects the fish growth and yield. The consequences of overstocking on the growth rate and survival of some African catfishes such as *Clarias gariepinus* **(**Oke and Goosen, 2019) and *Heterbrancus longifilis* (Ewa-Oboho and Enyenihi,1999) and Tilappines (Mamunur *et al.*, 2016; Shamsuddin *et al.*, 2022) and *Micropterus salmoides* (Jia, *et al*., 2022) have been studied.

Corresponding Author: Mustapha, A. K.
Email: abdur-rahman.mustapha@uniosun.edu.ng

Nelly *et al.*, (2009) noted that overstocking causes fish stress and disease which cause low feed utilization, low growth rate, low yield, and eventual bulk death and financial shortage, especially if the culture system exceeds its carrying capacity.

Leatherland and Cho (1985) had earlier noted that overstocking enhances stress, which requires higher energy and the result is retarded feed utilization and growth rate. Stocking density also influences profit and loss from the production system, as it directly affects the fish's growth, survival, behavior, general well-being, water quality, feeding requirement, and the general production of fish (Gibtan et al., 2008; Oke and Goosen,2019).

However, Suleiman and Solomon, (2017) opined that where there is low stocking density, the fish may not form shoals or group together and may feel uncomfortable. Consequently, they stated that determining the optimum stocking density and a critical factor for a species is not only for designing an efficient culture system. but for optimum husbandry practices.
Overstocking is a common aquaculture practice used to enhance stock production density though it has been proven to hurt the growth of cultured fishes. The African catfish, Clarias gariepinus is very popular and it is a preferred species of many fish farmers in Nigeria for fish farming as the fish displays a lot of qualities that make it desirable for culture. The fish is recognized for its prosperous feed conversion, diseases resistance, high fecundity, faster growth rate, low technology farming system, ability to withstand stress, possession of low bone content and fine flavor, excellent food meat quality, and tolerance to low dissolved oxygen content and wide ranges of other inauspicious environmental situation where many other culturable species cannot survive as well as being highly palatable (Ojutiku, 2008; Mustapha and Adeniyi, 2022).

Most fish farmers lack sufficient knowledge of the optimum stocking density that would maximize production for fish fingerlings in ponds and a lot could not justify the basis of the stocking density. It is on the basis of this knowledge gap that the current study was based to reveal and determine the optimum stocking density for Clarias gariepinus fingerlings culture.

## 2. Materials and Methods

The work was carried out at the Zoology Department, Osun State University. The study was conducted in 45 litre (0.5x 0.3 x 0.3) $m^3$ rectangular plastic tanks, each filled with 35 litre of water for eight weeks. Five hundred and twenty-five (525) *Clarias gariepinus* fingerlings (*initial* mean weight 5.88±0.14g) raised in the garden were stocked randomly at six different stocking density of 25, 50, 75, 100, 125 and 150 fingerlings/tank designated as $P_1$(D25), $P_2$(D50), $P_3$(D75), $P_4$(D100), $P_5$(D120) and $P_6$(D150) respectively. The fish were fed with standard feed (Blue crown) twice daily. The experimental tanks were monitored for growth, mortality was recorded and water quality was manipulated by constant replacement of lost water through evaporation, daily cleaning, and siphoning the leftover feed and wastes regularly changing the water weekly. All the fish in the tanks were sampled and weighed using a sensitive scale (Electronic kitchen scale EK5055) calibrated in grams. Water temperature and pH were monitored with digital ExStik-II, EXTECH parameter water quality instrument (Taiwan), and dissolved oxygen was monitored using a portable oxygen meter -Agilent Oxi 3206.

The following growth parameters were used to evaluate the growth and feed utilization from the data collected following the method of Olaniyi and Salau (2013) and Aliu and Ademiluyi (2020).

$$Mean\ weight\ gain(MWG) = \frac{Final\ weight\ (g) - Initial\ weight\ (g)}{Culture\ period\ (day)}$$

$$Specific\ Growth\ Rate\ (SGR) = \frac{Log\ of\ Final\ weight - Log\ of\ Initial\ weight}{Culture\ perod\ (days)} X\ 100$$

$$PER = \frac{Weight\ gain}{Protein\ fed} (\ where\ protein\ fed = \frac{\%\ protein\ in\ diet\ \ x\ total\ diet\ consumed)}{100}$$

$$FCR = \frac{Fish\ feed\ intake}{Weight\ of\ fish}$$

$$Survival\ rate\ (\%) = \frac{Initiial\ stocked\ \ - mortality}{Initial\ stocked}\ x\ 100$$

The biomass(g/tank) was calculated as Number of fish harvested X Mean body weight. The net yield (**g**/tank) evaluated as: Biomass harvested – Biomass stocked.

Biomass $(g/tank) =$ No of fish harvested X Mean body weight.

Net yeild (g/tank) $=$ Biomass harvested $-$ Biomas stocked

### Statistical Analysis

One-way analysis of variance at 5% and Duncan's new multiple range tests using the SPSS Statistical Package (Version 25) were used to determine the significant differences among the mean of the above data.

## 3. Results and Discussion

### 3.1 Results

The composition the experimental diets is shown in Table 1. Table 2 shows the growth performance and feed utilization of the fish, *C. gariepinus* recorded at varying stocking densities and Figure 1, illustrates the growth performance of the fish at different stocking density during the study time. Table 3 shows the records of the mean values of water quality parameters in the experimental tanks.

**Tabe 1: Composition of Experimental diets (Blue Crown)**

| Compositions | Quantity (kg) |
|---|---|
| Maize (8.8%) | 19kg |
| Wheat offal (15%) | 15.3kg |
| Soya bean meal (48.5%) | 34.5kg |
| Fish meal (72%) | 29.0kg |
| Bone meal | 0.5kg |
| Methionine | 0.2kg |
| Lysine | 0.5kg |
| Salt | 0.5kg |
| Vitamin C | 0.5kg |
| **Total** | **100kg** |

**Table 2:** Growth performance and feed utilization of Clarias gariepinus at different stocking densities.

| Week | P1(D25) | P2(D50) | P3(D75) | P4(D100) | P5(D120) | P6(D150) |
|---|---|---|---|---|---|---|
| Initial weights(g) | 5.88±0.14[a] | 5.88±0.14[a] | 5.88±0.14[a] | 5.88±0.1[a] | 5.88±0.14[a] | 5.88±0.14[a] |
| Final weights(g) | 28.50±0.21[b] | 24.50 ± 0.02[b] | 22.10 ± 0.20[b] | 12.66 ±0.12[a] | 10.42±0.11[a] | 8.30 ± 0.01[a] |
| Weight gain (g) | 23.68 ±0.11[b] | 19.58 ± 0.31[b] | 17.71 ± 0.11[b] | 7.71 ± 0.32[a] | 5.52±1.01[a] | 3.50 ± 1.06[a] |
| *SGR % day-1 | 0.38±0.11[b] | 0.34± 0.21[b] | 0.32 ± 0.03[b] | 0.18 ± 0.11[a] | 0.14± 0.42[a] | 0.08 ± 0.42[a] |
| *FCR | 1.28±0.40[a] | 1.53± 1.37 [a] | 1.59± 0.06[a] | 2.19± 0.12[b] | 2.34± 0.33[b] | 2.48± 0.33[b] |
| *PER | 2.35±0.04[c] | 1.94± 0.07[c] | 1.92± 0.02c | 1.32± 0.08[b] | 1.08± 0.9[b] | 0.78± 0.06[a] |
| Survival (%) | 97.0±0.97[b] | 96.0± 0.23[b] | 95.0± 0.55[b] | 89.0± 0.96[a] | 85.0± 0.76[a] | 84.0± 0.89[a] |
| Net yield (g/tank) | 566±1.06[b] | 931± 0.45[d] | 1217±1.78[e] | 678±1.54[c] | 545± 0.96[b] | 363± 1.09[a] |

Figures in the same row having similar superscript are not significantly different from one another ($p>0.05$).

*SGR= Specific Growth Rate
*FCR= Feed Conversion Ratio
*PER=Protein Efficiency Ratio

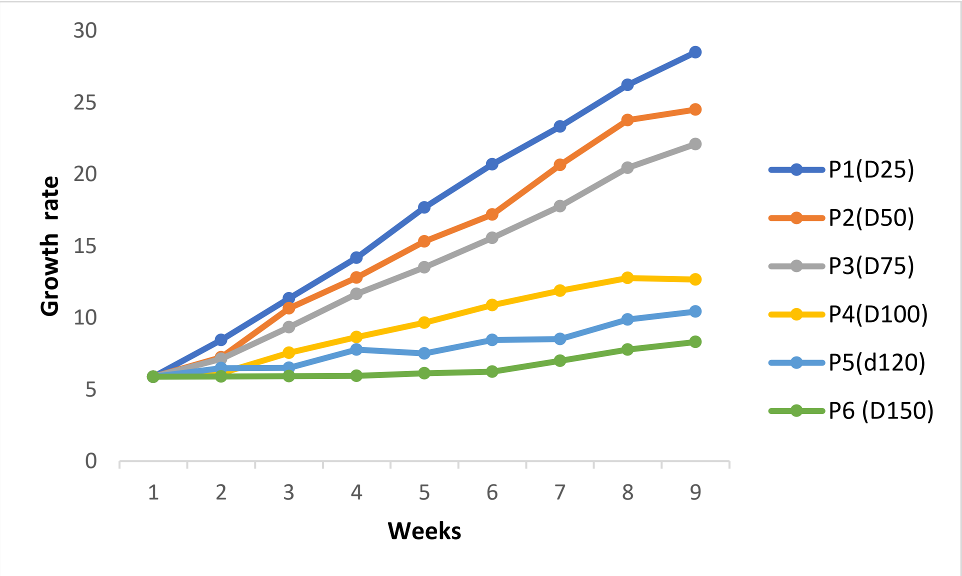


**Figure 1:** Growth performance of the fish fed the experimental diets

**Table 3:** Mean values of water quality parameters during the experiments.

| Water parameter | Stocking density | | | | | |
|---|---|---|---|---|---|---|
| | P1 | P2 | P3 | P4 | P5 | P6 |
| Temperature ($^0$C) | 25.1±0.17 | 25.9 ± 0.21 | 26.1± 0.06 | 26.5± 0.24 | 26.7 ± 0.11 | 26.8 ± 0.09 |
| pH | 6.1 ± 0.31 | 6.3 ± 1.12 | 6.4± 1.11 | 6.5± 0.91 | 6.7 ± 0.73 | 6.7 ± 1.17 |
| Dissolved Oxygen (mg/l | 6.5 ± 1.32 | 6.4 ± 1.14 | 6.4 ± 0.92 | 6.2± 1.32 | 6.0 ± 0.29 | 5.8 ± 1.77 |

P1-P6 = Stocking density

Stocking density significantly affected, (P<0.05), the final weight, weight gain, specific growth rate, feed conversion ratio, protein efficiency ratio, percentage survival and final biomass of the fish fingerlings (Table 2). Final weight, weight, and specific growth rate (SGR) values were highest in $P_1$ (D25) media, followed by $P_2$(D50) and then $P_3$(D75) and they were not significantly different from one another but the values were significantly lower for $P_4$(D100), then $P_5$(D120) and lowest for $P_6$(D150), the highest stocking density. Specific Growth Rate (SGR) increases as the stocking density increases. It was observed in this study that the Feed Conversion Ratio (FCR) which ranged from 1.28±0.40 to 2.48± 0.33 increases as the stocking density increases. Protein Efficiency Ratio (range 0.78± 0.06 to 2.35±0.04) decreases with increased stocking density. The highest PER in this study was recorded from $P_1$(D25) media and the lowest from $P_6$(D150) tanks (Table 2). There is no significant difference (P>.0.05) between $P_1$(D25), $P_2$(D50), and $P_3$(D75), but a significantly higher Feed Conversion Ratio and lower Protein Efficiency Ratio were noticed with the higher stocking densities. Fish survival (%) (range 84.0± 0.89 to 97.0±0.97) were not significantly different (P>0.05) between $P_1$ (25), $P_2$ (D50) and $P_3$(D75), but were significantly different (P<0.05) with $P_4$(D100), $P_5$(120) an $P_6$(D150).

The net yield which is the difference between biomass harvested and biomass stocked ranged from 363± 1.09 to 1217±1.78 g/tank. The net yield increase from $P_1$(D25) up to $P_3$(D75) after it decreases from $P_3$(D75) to $P_6$(D150). No significant differences observed at both lower and higher stocking density. The highest net yield was observed in $P_3$(D75). Table 3 shows records of mean values of water quality parameter in the experimental media. The ranges of the water quality parameters measured during the experimenter period were temperature**;** 25.1–26.8$^0$C, dissolved oxygen; 5.8 -6.5 mg/l and pH; 6**.**1–6.7. The water colour tends to change from light green to grey with increasing stocking density. Water temperature and dissolved oxygen decrease with increasing stocking density.

## 3.2 Discussion

The general decrease observed in the body weight, specific growth rate and protein efficiency ratio of C. gariepinus as the stocking density increases could be attributed to stress as observed by M'balaka *et al.*, (2013) and Mamunur et al., (2016) that high stocking densities lead to aggressive interaction and loss of appetite which eventually result in growth retardation.

Ellis *et al.,* (2002) has earlier observed an opposite relationship between stocking density and fish growth where an increase in stocking density resulted in to decrease in final body weight, weight gain, and Specific Growth Rate (SGG). He further observed that increasing stocking density reduces the space available to individuals**,** causing stress to fish and thus affecting the social interaction, feed intake, and conversion efficiencies in fish, and eventually causing reduced growth as observed in this study. The slow growth observed in the culture media may be attributed to the reduction in fish response to feed as a result of overcrowding and inconducive water environmental condition for healthy growth of the fish as population increase in the tanks. The survival rate was also affected by the stocking density as it decreases with increasing stocking density. They could be attributed to the changes in the normal physiochemical parameters of the culture media as the stocking density increases and the stress enchanter by the fish as a result of competition for space interaction and belligerent feeding habit (where energy meant for growth is used up in feeding activities) which eventually leads to death of the weaker fish as similarly noted and cited M'balaka *et al.*, (2013) and Mamunur *et al.,* (2016)**.** No cannibalism was observed within the culture media as there seem to be no

differential growth of the fish in the culture media. However, Abou *et al.,* (2007) and Gokcek and Akyurt (2007) reported that high stocking densities may on certain occasions have no effect on mortality rates, but may promote total fish yield though it may encourage competition for food and negative influence on the reproductive status of the fish. Mortality occurs regularly when important parameters like dissolved oxygen in the culture media are used up due to overcrowding especially when the culture media reaches its maximum carriage capacity,
The physicochemical parameters of the culture media were found desirable for the fish. The pH range falls within the tolerable ranges for ideal tropical fishes. The water temperature values were also at their tolerable ranges for fish culture. The water temperature increases significantly as the stocking density increases. This may be attributed to the fact that the heat generated through the activities of fish becomes intense as the biomass of fish increases due to growth.

Yengkokpam *et al.,* **(**2020**)** reported that an increase in water temperature may not kill the fish, but stop its feeding and the fish will only merely live to survive the harsh conditions.
Throughout the experimental period, the dissolved oxygen concentration was at tolerable ranges of 5.8mg/l to 6.5mg/l. The progressive decrease in the dissolved oxygen values as the stocking density increases is attributed to the fact overcrowding results high dissolved oxygen demand. Overcrowding could cost energy lost as the fish struggles to breath atmospheric oxygen due to dissolved oxygen depletion and this could eventually slow down their growth.
The observed water colour change from light green to greyish – as the stocking density increase in the culture media could be due to increasing the rate of pollution increases as a result of the increase in activities of fish.

Yengkokpam *et al*., (2020 stated that the carriage capacity of a pond is a factor of water management. The observed increase in Feed Conversion Ratio as the stocking increases in this study and the decrease of Protein Efficiency Ratio with increase stocking density with no significant difference (P>0.05) between $P_1$(D25), $P_2$(D50) and $P_3$(D75) but significant between $P_4$(D100), $P_5$(D 120) and $P_6$(D 150) is attributed to overcrowding which is a sign that the media capacity can no longer support their normal growth further.

The maximum biomass or the critical standing crop that the media can support for normal fish growth, sufficient and efficient space, and reduced changes in the daily feed input to the system are important factors considering the size aquacultural system.
Better FCR and PER values with no significant difference from one another (p>0.05, were found in the lower stocking density groups $P_1$(D25), $P_2$(D50), and $P_3$(75. but with increase in stocking density beyond $P_3$(D75), the values changed to higher FCR and lower PER**.** This may be associated with the increased energy expenditure as a result of stress and the consequence decrease growth in crowded situations as observed by Ellis et al., (2002**).** However, Rahman *et al.,* (2006) and Jiwyam, (2011) observed that some air-breathing catfishes such as *Clarias gariepinus* can withstand high stocking density condition. Also, Saraiva *et al.,* (2022) believed that though it is difficult to set minimum and maximum stocking density levels that will protect the welfare, but the production density could be estimated quite accurately if the farmer knows the water volume and has good biomass control. They consequently opined, that application of fish welfare assessments based on operational welfare indicator, ensuring that good management practice is in place is a preferable approach to monitoring the effects of density on captive fish. They further reiterated that a more practical option is that the acceptable level of different welfare indicators such as water quality, health, nutritional and behavioral conditions coupled with good economic balance of the fish farmer will give room to estimate the density, life stage and the production system. They further said that studying the effect of

stocking density on the welfare in fish culture should focus on welfare aspect and management practices that will improve the quality of life and welfare of captive fish as well as bringing ethical and economic benefit to aquaculture companies instead of being on a fixed option.

The result of the study is similar to Biswas *et al,* (2015) and Mane *et al.,* (2019) as it shows that high stocking densities contributed significantly to poor feed efficiency and growth of fish fingerlings. In the study, it was observed that the lowest survival rate was found in the treatment with highest stocking density and retarding growth was observed in the fish in the media with high stocking density and this is in consistent with Biswas *et al*., (2015) and Debnath *et al*., (2015). $P_1$(D25) had the highest growth rate and weight gain in term of SGR, PER, followed by $P_2$(D50) and then $P_3$(D75). However, the media with higher stocking densities, $P_5$(D120) and $P_6$(D150) of fish fingerlings had the lowest growth rate. In this study the most economic stocking density is $P_3$(75) (Table 2) as it is the one that which yielded the highest biomass per unit area the culture media.

## Conclusion

There are different growth rates in the culture media and the fish growth rates decrease with the increase of stocking density. The present findings indicated that the stocking density in $P_3$(D75) was considered the most economical, yielding the highest fish production than that of the lower stocking density in $P_1$(D25) and $P_2$ (D50), although the individual growth rate at $P_3$(D75) is not statistically (not significantly different from one another ($p>0.05$)) better than. the one achieves at the lowest stocking density. Based on the result of the study, it is suggested that *C. gariepinus* fingerlings be stocked at 75 fingerlings/35 litre for optimum production especially higher growth, and survival.

## Acknowledgment

The authors would like to thank Department of Zoology, Osun State University, Osogbo for providing the enabling environment for the work with the facilities in the fisheries section of the Zoological garden.

## References

Abou, Y., Fiogbe, E.D., Micha, J.C. (2007): Effects of stocking density on growth, yield and profitability of farming Nile tilapia, *Oreochromis niloticus* L., fed Azolla diet, in earthen ponds. *Aquaculture Research,* **38**, 595–604.

Aliu B. S. and Ademiluyi A. G. (2020): Substitution of fishmeal with blood meal in the diets of Clariid Catfish *Heterobranchus bidorsalis* fingerlings. *African Journal of Agriculture and food Science* **3(3)**, 21-28

Biswas, P., Kohli, M.P.S., Chadha, N.K., Bhattacharjya, B. K., Debnath, D., Yengkokpam, S., Sarma, K.K., Gogoi, P., Kakati, A., Sharma, A.P., (2015): Optimizing stocking density of *Labeo rohita* fry in cage aquaculture system as a tool for floodplain wetland fisheries management. *Proc. Acad. Sci. India Sect*. B **85**, 181–190.

Debnath, D., Yadav, A. K., Bhattacharjya, B. K., (2015): Time-series analysis of fish yield rates from beels of Assam under AFDC Ltd. *CIFRI NEWS* **20 (1),** 5 (13.07.20). www. cifri.res.in/newsletter1.html.

Ellis, T., North, B., Scaott, A.P., Bromage, N.R., Porter, M., Gadd, D., (2002); The relationship between stocking density and welfare in farmed rainbow trout. *J. Fish Biol*. **61,** 493–531.

Ewa-Oboho, I., and Enyenihi, U. K. (1999): Aquaculture implications of growth and variation in the African catfish: *Heterobranchus longifilis* (Val.) reared under controlled conditions. *Journal of Applied Ichthyology,* **15,** 111-115.

Gibtan, A., Getahun, A., Mengistou, S. (2008): Effect of stocking density on the growth performance and yield of Nile tilapia [*Oreochromis niloticus* (L., 1758)] in a cage culture system in Lake Kuriftu, Ethiopia. *Aquaculture Research*, **39(13),** 1450–1460.

Gokcek, C. K., Akyurt, I., (2007): The effect of stocking density on yield, growth, and feed efficiency of himri barbel (Barbus luteus) nursed in cages. Isr. *J. Aquacult.* -Bacmid. **59,** 99–103.

Jia, R.; Wang, L.; Hou, Y.; Feng, W.; Li, B.; Zhu, J. (2022): Effects of Stocking Density on the Growth Performance, Physiological Parameters, Redox Status and Lipid Metabolism of Micropterus salmoides in Integrated Rice–Fish Farming Systems Antioxidants, 11, 1215. https://doi.org/10.3390/ antiox11071215.

Jiwyam, W., (2011): The effect of stocking density on yield, growth and survival of Asian river catfish (Pangasius bocourti Sauvage, 1880) cultured in cages. *Aquac. Int*. **19,** 987–997.

Leatherland, J. F., and Cho, C. Y. (1985): Effect of rearing density on thyroid and internal gland activity and plasma and hepatic metabolite levels in rainbow trout, Salmo gairdneri Richardson. *Journal of Fish Biology,* **27,** 5838.

Mane, A.M., Dube, K., Varghese, T., Chavan, B. R., Kamble, M. T., (2019): Effects of stocking density on growth performance, survival and production of *Catla catla* and *Labeo rohita* during nursery rearing in cages. *Proc. Acad. Sci. India Sect.* B **89**, 275–281.

M'balaka M., Kassam D. and Rusuwa B. (2013): The effect of stocking density on the growth and survival of improved and unimproved strains of *Oreochromis shiranus*. *Egyptian Journal of Aquatic Research* 38, 205–211

Mamunur Rahman, Debashis Kumar Mondal, Rurul Amin and Mohammad Golam Muktadir (2016): Impact of stocking density on growth and production performance of monosex tilapia (*Oreochromis niloticus*) in ponds. *Asian Journal of Medical and Biological Research,* **2 (3),** 471-476. ISSN 2411-4472 (Print) 2412-5571

Mustapha A. K. and Adeniyi W. O. (2022): Replacement of Fish Meal with Feather Meal in the Diet of Clarias gariepinus, *Pan African Journal of Life Sciences* **6(3):** 524-530. www.pajols.org Online ISSN:2672-5924.

Nelly Isyagi A, Karen Veverica L, Rashid Asiimwe, William Daniels H. (2009): Manual for the Commercial Pond Production of the African Catfish in Uganda Department of Fisheries and Allied Aquacultures; Auburn University, Alabama, USA.

Ojutiku, R. O. (2008): Comparative survival and growth rate of *Clarias gariepinus* and Heteroclarias hatchlings fed live and frozen Daphnia. *Pakistan Journal of Nutrition*, **7(4):** 527-529.

Oke Vincent and Goosen Neill Gurgens (2019): The effect of stocking density on profitability of African Catfish (Clarias gariepinus) culture in extensive pond systems. *Aquaculture* **507**:385-392

Olaniyi CO and Salau, BA (2013): The Effect of Pawpaw (Carica papaya) Leave meal on the Growth Performance and Blood Profile of African Catfish. Transnational *Journal of Science and Technology*.**3(7),** 3-9

Rahman, M.N., Islam, M.N., Halder, G.C., Tanaka, M., (2006): Cage culture of sutchi catfish, Pangasius sutchi (Fowler 1937): effects of stocking density on growth, survival, yield and farm profitability. *Aquaculture Research***. 37,** 33–39.

Saraiva J.L, Rachinas-Lopes P. and Arechavala-Lopez P (2022): Finding the "golden stocking density": A balance between fish welfare and farmers' perspectives. Front. *Vet. Sci.* **9:**930221. doi: 10.3389/fvets.2022.930221

Shamsuddin, M.; Hossain, M.B.; Rahman, M.; Kawla, M.S.; Tazim, M.F.; Albeshr, M.F.; Arai, T. (2022): Effects of stocking larger-sized fish on water quality, growth performance, and the economic yield of Nile Tilapia (Oreochromis niloticus L.) in Floating Cages. *Agriculture,* **12,** 942. https://doi.org/ 10.3390/agriculture12070942

Suleiman M.A. and Solomon R.J. (2017): Effect of stocking on the growth and survival of *Clarias gariepinus* grown in plastic tanks. *Direct Research Journal of Veterinary Medicine and Animal Science*; **2(3):** 82-92111

Yengkokpam Sona, Basanta Kumar Das, Dipesh Debnath, Pronob Das, Anil Kumar Yadav, Niti Sharma, Simanku Borah, Ningthoujam Samarendra Singh a, Kishore Kumar Sarma (2020): Effect of stocking density on growth and yield of Labeo bata fingerlings reared in cages. *Aquaculture Reports* **18** -10050 www.elsevier.com/locate/aqrep