

SALINITY TOLERANCE OF GREY MULLET, *Mugil cephalus* (Linnaeus) FRY IN THE LABORATORY

Soyinka Olufemi Olukolajo*, Lawal-Are Aderonke Omolara

¹Department of Marine Sciences, University of Lagos, Nigeria

Abstract: The salinity tolerance of grey mullet, *Mugil cephalus* (L) fry was investigated in replicate tanks of different salinity regimes of fresh water (0‰), 5‰, 10‰, 15‰, 20‰, 25‰ and sea water (30‰) in the laboratory for eight weeks. The salinity tolerance experiments showed that the fish tolerated a salinity range of 5‰ to 25‰. The highest survival of 40% was recorded at salinities 10‰ and 15‰. Statistical analysis of the mortality in all the salinity regimes with ANOVA showed no significant ($p>0.05$) variation. The highest % gain in length and weight were 22.02 and 22.09 respectively in the 15‰ and 20‰ salinity regimes. The least FCR value of 2.11 and the best FCE value of 47.39 were recorded in the 25‰ regime. The best SGR value of 0.019 was recorded in both the 15‰ and 20‰ regimes. The fish has a good potential for brackish water aquaculture; its fishery and culture in the brackish environment can be sustained.

Keywords: Survival, Mortality, Specimens, Fry, Tank, Regime

Özet: **Laboratuvar Koşullarındaki Has Kefal *Mugil cephalus* (Linnaeus) Yavrularının Tuzluluk Toleransı**

Has kefal *Mugil cephalus* (L.) yavrularının tuzluluk toleransı sekiz haftalık bir süre boyunca laboratuvar koşullarında tatlı su (‰ 0), ‰ 5, ‰ 10, ‰ 15, ‰ 20, ‰ 25 ve ‰ 30 tuzluluklarında tekrarlanmak suretiyle tanklarda araştırıldı. Tuzluluk tolerans deneyleri balıkların ‰ 5 ile ‰ 25 arasındaki tuzluluk değerlerine dayandıklarını gösterdi. Yüzde kırk gibi en yüksek yaşama oranı ‰ 10 ve ‰ 15 tuzluluk değerlerinde kaydedildi. Tüm tuzluluk değerlerindeki ölüm oranlarının ANOVA ile yapılan istatistiksel analizleri kesin bir varyasyon göstermedi ($p>0.05$). Uzunluk ve ağırlık bakımından en yüksek % artış ‰ 15 tuzlulukta 22.02 ve ‰ 20 tuzlulukta ise 22.09 olarak belirlendi. En düşük FCR değeri olan 2.11 ile en iyi FCE değeri 47.39 ‰ 25 tuzluluk değerinde kaydedildi. En iyi SGR değeri olan 0.019 ise ‰ 15 ve ‰ 20 değerlerinde kaydedildi. Kefal balıkları acısu yetiştiricilik ortamları için iyi bir potansiyele sahip olup acısu ortamında balıklandırma ve yetiştiriciliği kabul edilebilir.

Anahtar Kelimeler: Yaşama, Ölüm, Örnekler, Yavru, Tank, Sistem

* Correspondence to:

Soyinka Olufemi OLUKOJO, Department of Marine Sciences, University of Lagos, Nigeria

Tel: +2348033808071

E-mail: soyinka.olufemi@gmail.com

Introduction

Mulletts (Mugilidae) are common fishes in the coastal waters of tropical and subtropical countries of the world. Sixteen species have so far been identified in West Africa (Fowler, 1936; Cadenat, 1954 and Blay, 1995), and these constitute an important proportion of the catches of commercial and subsistence fishermen in some countries in this area (Brulhet, 1975; Payne, 1976). The striped mullet, *Mugil cephalus*, is perhaps the most widespread and abundant inshore teleost (Collins, 1985). Size is generally more biologically relevant than age in fishes, due to several ecological and physiological factors that are more size-dependent than age dependent. Variability in size has important implications for diverse aspects of fisheries science and population dynamics (Erzini, 1994).

Adult *M. cephalus* are highly euryhaline, and survive in a range of salinities from 0‰ in fresh water to hypersaline waters. Adult *M. cephalus* can be found along the open coasts, but juveniles are most likely found in estuaries (Collins, 1985). Silva and De Silva (1981) reported that the percentage of grey mullet catches increased with increasing salinity. Larger fishes were found in the deeper areas. Stability of the water column and suitable food in coastal lagoons, river deltas, and estuarine mangrove areas have been identified as important factors influencing the recruitment of juvenile Mugilidae (Blaber and Blaber, 1980; Blaber, 1987; Vieira, 1991)

In spite of the abundant biological data on this species from other countries, comparative data from brackish water lagoons in Africa, with Nigeria in particular is highly insufficient. Yet the fish constitutes a mainstay of the fisheries resources in the coastal communities; if the potentials are well exploited, a viable mullet fishery and culture can be maximally sustained. In this report, the salinity tolerance of grey mullet, *Mugil cephalus* fry in Lagos Lagoon (high brackish water), Nigeria, are investigated in the laboratory to give information for culture of the species in brackish and fresh waters.

Materials and Methods

Collection of specimens

Collection of live fry from the Lagos Lagoon was made using hand nets at shallow portions of the lagoon near the shore for the salinity tolerance experiments.

Experimental set-up

The experiment was carried out in translucent rectangular white plastic tanks each of 35 litres capacity and filled with 25 litres of water. Replicate tanks for each salinity regime of fresh water (0‰), 5‰, 10‰, 15‰, 20‰, 25‰ and sea water (30‰) were used. The salinity in each tank was determined using a refractometer. The freshwater was obtained from tap-water that has been dechlorinated for over 24 hours, while the sea water was obtained from the Lagos bar-beach. The experimental tanks were placed in a compartment where there was a reduced effect of direct sunlight. The fries of *M. cephalus* used were acclimatized in lagoon water of 15‰ salinity for five days. Ten live specimens each were then placed in the experimental tanks of varied salinities after the acclimatization period. They were fed with formulated coppers feed at a daily ration of 5% of their total body weight. Adjustments in weight of feed fed were done fortnightly after measuring the weight of fish remaining in tanks. Growth, survival and mortality of the specimens were monitored over eight weeks. Change of water in the tanks and measurements were done fortnightly. Aerating air-pumps were used during the experimental period to aerate the tanks.

Physical – chemical parameter measurement

The physico-chemical parameters were determined twice a week. Water temperature was measured using a simple mercury-in-glass thermometer. The salinity of the water was determined using a Refractometer (BIOMARINE, Aqua Fauna Model. Dissolved oxygen (DO) of the water samples was determined using a Jenway DO Meter (Model 4310). The pH values were determined using a Jenway Hanna pH meter (HI 991301 Model).

Length – weight measurement

The total length (TL) of the specimens was measured on a measuring board to the nearest 0.1 centimeter. The total weight of the fish was taken on a 'Sartorius' top loading balance (Model 1106 2608053) or a triple beam balance to the nearest tenth of a gram.

Statistical analyses

The data obtained were subjected to statistical analyses using different formulae:

$$\text{The Food Conversion Ratio (FCR)} = \frac{\text{dry food fed (g)}}{\text{live weight gained (g)}}$$

$$\text{The Food Conversion Efficiency} = \frac{\text{weight gained} * 100\%}{\text{feed intake}}$$

$$\text{The Specific Growth Rate} = \frac{\log(\text{final body weight}) - \log(\text{initial body weight}) * 100\%}{\text{time (in days)}}$$

To test if the differences in mortality observed in the different salinity levels were significant, ANOVA was employed.

Results and Discussion

Survival / Mortality of *M. cephalus* fry in varied salinities

Salinity tolerance experiment carried out showed that the fries of *M. cephalus* could survive in varying salinity range of 5‰ to 25‰. The summary of the weekly survival / mortality record for *M. cephalus* fry in the tanks is given in Table 1 while Figure 1 showed the percentage survival curve for *M. cephalus* in varied salinity regimes. The ANOVA test indicated that there was no significant variation ($p > 0.05$) in the differences observed in mortality in the various salinity regimes.

Physico-chemical parameters in culture tanks

The weekly illustration of the physico-chemical parameters during the salinity tolerance experiment is presented in Fig. 2. The pH ranged from 7.60 – 10.15 (mean 7.89 ± 0.13); DO ranged from 2.47 – 10.16 (mean 7.08 ± 0.46) and temperature ranged from 28.6 – 30.0°C (mean 29.02 ± 0.13).

Effects of salinity on the growth of *M. cephalus*

Summary of the percentage gain or loss in total length and body weight of *M. cephalus* in varied salinity levels is presented in Table 2. The specimens in 0‰ and 30‰ salinity regimes all died within the 1st week of the experiment. The initial mean total length of the fries ranged from 1.9-2.2 cm (2.04 ± 0.10); while the initial mean body weight was 0.10g (0.1 ± 0.00). The final mean total length was 3.0 ± 2.06 , while the final mean body weight was 0.69 ± 0.50 . The highest % gain in mean length of 22.02 was recorded in the 15‰ and 20‰ salinity regimes, while the lowest value of 17.43 was in the 5‰ salinity regime. The highest

% gain in mean weight of 22.99 was recorded in the 15‰ and 20‰ salinity regimes, while the lowest value of 11.49 was in the 5‰ salinity regime.

The FCR values of the fish in all the regimes ranged from 2.11-3.91, with the highest value recorded in the 5‰ regime and the lowest in the 25‰ regime. The FCE (%) values ranged from 25.58-47.39, with the highest value recorded in the 25‰ regime and the lowest in the 5‰ regime. The SGR values of the fish in all the salinity regimes ranged from 0.014-0.019, with the highest value recorded in the 15‰ and 20‰ regimes, while the lowest was recorded in the 5‰ regime

The differences in growth between different salinity regimes examined in the present study were not found to be significant and this agreed with the report by McDonough and Wenner (2003). Cardona (2000) revealed that the metabolic rate of young specimens was negatively affected by high salinity levels and that an improved growth performance was achieved in freshwater and oligohaline water (0.1-5 ‰). A stratified study on microhabitat use carried out on the Island of Minorca (Balearic archipelago), western Mediterranean sea, demonstrated that juvenile specimens, shorter than 200mm (TL), concentrated all year round in freshwater or oligohaline sites. Mesohaline areas were usually avoided, except in summer. Immature fish, with a total length between 201 and 300mm showed a similar pattern although in some seasons avoided freshwater sites. The habitat selection pattern of adults, i.e. fish longer than 301mm, changed seasonally due to their offshore migration during the spawning season (from late summer to early winter). They usually showed a greater preference for polyhaline areas and strongly avoided freshwater sites, which might also be due to their shallowness (Cardona, 2000).

Table 1. Weekly survival / mortality of *M. cephalus* fry in varied salinity regimes.

Salinity regime (%)	Initial number per tank	Mortality per week								Survival at the end of the 8th week	% Survival
		1	2	3	4	5	6	7	8		
0	10	10	-	-	-	-	-	-	-	0	0
5	10	2	1	3	0	0	0	0	0	3	30
10	10	2	3	1	0	0	0	0	0	4	40
15	10	3	1	2	0	0	0	0	0	4	40
20	10	5	3	0	0	0	0	0	0	2	20
25	10	4	2	2	0	0	0	0	0	2	20
30	10	10	-	-	-	-	-	-	-	0	0

Table 2. Summary of the growth performance of *M. cephalus* in varied salinity levels.

Salinity (%)	Initial mean total length (cm)	Final mean total length (cm)	Gain or loss in mean total length	% gain or loss in mean total length	Initial mean body weight (g)	Final mean body weight (g)	Gain or loss in mean body weight	% gain or loss in mean body weight	Food Conversion Ratio	Food Conversion Efficiency (%)	Specific Growth Rate (% per day)
0	2.0	0.0	0.0	0.0	0.1	0.00	0.00	0.0	-	-	-
5	1.9	3.8	1.9	17.43	0.1	0.60	0.50	11.49	3.91	25.58	0.014
10	2.0	4.1	2.1	19.27	0.1	1.00	0.90	20.69	2.29	43.67	0.018
15	2.1	4.5	2.4	22.02	0.1	1.10	1.00	22.99	2.30	43.48	0.019
20	2.1	4.5	2.4	22.02	0.1	1.10	1.00	22.99	2.31	43.29	0.019
25	2.0	4.1	2.1	19.27	0.1	1.05	0.95	21.84	2.11	47.39	0.018
30	2.2	0.0	0.0	0.0	0.1	0.00	0.00	0.0	-	-	-

The differences in growth or gain in length and weight between different salinity regimes examined in this study were not found to be significant. The high survival rate of *M. cephalus* fry (1.5-2.0 cm TL) in water of different salinities (5-25‰) demonstrated in this present investigation revealed the ability of grey mullets to adapt to wide salinity fluctuations. The mortality experienced within the 1st week in the 0‰ and 30‰ salinities was probably connected with the abrupt transfers. Ciccoti *et al* (1994) noticed a high survival rate and tissue osmolality regulation of *M. cephalus* juveniles (SL = mean 28.05, SD = 3.54mm) acclimated to freshwater gradually in 48 hours. The morphological and biochemical aspects of esophagus and gills in juveniles are similar to those of the adult, suggesting that osmotic regulatory mechanisms are precociously developed to allow the colonization of eutrophic inland waters. From their investigation, Hotos and Vlahos (1998) highlighted that *M. cephalus* fry acclimated in aquaria with 20‰ sea water acclimated gradually over 35-40 days with no signs of stress. By direct transfer from 20‰ to salinities of

35, 40, 45, 50, 55, 60, 65, 70, 75 and 80‰, mortality occurred at salinities greater than 45‰.

The physical and chemical parameters obtained in the present study showed a similar pattern in all the varied salinity regimes. There were no wide fluctuations in those parameters and is clear that *M. cephalus* can thrive well under a trophic climatic condition.

Bulli and Kulikova (2006) reported the response of early juveniles of the harder, *Liza haematocheila* (= *Mugil soiuy*) to changes in water salinity, and the growth and survival of larvae in water of different salinity levels. They discovered that at decreasing salinity, the growth rate, the content of defatted dry matter, and the content of lipids increased. In freshwater, the stock lipids (triacylglycerols) accumulate more intensively.

From the FCR and FCE values, it could be seen that the fry in the 25‰ salinity regime had the lowest FCR, hence the best FCE, which meant that there was more effective utilization of less unit weight of feed to produce a unit weight of flesh than in the other regimes. However, the best SGR

was in the 15‰ and 20‰ salinity regimes, which were slightly higher than those in 10‰ and 25‰ regimes.

Conclusions

The ability of grey mullet fry to tolerate a wide range of salinity regime demonstrated in this study further agreed to the euryhalinity of the species and its potential candidature for brackish water fish culture.

Acknowledgments

The authors express their profound gratitude to Professor (Emeritus) Kola Kusemiju for his invaluable contributions to the conception and design of the experiment; and the revising of the draft of the manuscript for intellectual content. We thank Mr. Anipole Biodun for the editorial assistance.

References

- Blaber, S.J.M., (1987). Factor influencing recruitment and survival of mugilids in estuaries and coastal waters of Southeastern Africa, *American Fisheries Society Symposium*, **1**: 507-518.
- Blaber, S.J.M., Blaber, T.G., (1980). Factors affecting the distribution of juvenile estuarine and inshore fish, *Journal of Fish Biology*, **17**: 143-162.
doi: [10.1111/j.1095-8649.1980.tb02749.x](https://doi.org/10.1111/j.1095-8649.1980.tb02749.x)
- Blay, J., (1995). Food and feeding habits of four species of juvenile mullet (Mugilidae) in a tidal lagoon in Ghana, *Journal of Fish Biology*, **46**: 134-141.
doi: [10.1111/j.1095-8649.1995.tb05952.x](https://doi.org/10.1111/j.1095-8649.1995.tb05952.x)
- Brulhet, J., (1975). Observations on the biology of *Mugil cephalus ashanteensis* and the possibility of its aquaculture in the Mauritanian coast, *Aquaculture*, **5**: 271-281.
doi: [10.1016/0044-8486\(75\)90004-6](https://doi.org/10.1016/0044-8486(75)90004-6)
- Bulli, L.I., Kulikova, N.I., (2006). 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.
- Cadenat, J., (1954). Note d'ichthyologie oust-africain 8. Regime alimentaire sur les mullets de la cote occidentale d'Afrique, *Bulletin de l'Institute francais d'Afrique noire (ser. A)* **16**: 584-591.
- Cardona, L., (2000). 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**(5): 727-737.
doi: [10.1006/ecss.1999.0594](https://doi.org/10.1006/ecss.1999.0594)
- Ciccotti, E., Marino, G., Pucci, P., Cataldi, E., Cataudella, S., (1994). Acclimation trial of *Mugil cephalus* juveniles to freshwater: morphological and biochemical aspects, *Environmental Biology of Fishes*, **43**(2): 163-170.
doi: [10.1007/BF00002487](https://doi.org/10.1007/BF00002487)
- 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.
- Erzini, K., (1994). An empirical study of variability in length and age of marine fishes, *Journal of Applied Ichthyology*, **10**: 17-41.
doi: [10.1111/j.1439-0426.1994.tb00140.x](https://doi.org/10.1111/j.1439-0426.1994.tb00140.x)
- Fowler, H.W., (1936). The marine fishes of West Africa. *Bulletin of the American Museum of Natural History*, **70**: 1-605.
- Hotos, G.N., Vlahos, N., (1998). Salinity tolerance of *Mugil cephalus* and *Chelon labrosus* (Pisces: Mugilidae) fry in experimental conditions, *Aquaculture*, **167**(3-4): 329-338.
doi: [10.1016/S0044-8486\(98\)00314-7](https://doi.org/10.1016/S0044-8486(98)00314-7)
- McDonough, C.J., Wenner, C.A., (2003). Growth, recruitment and abundance of juvenile *Mugil cephalus* in South Carolina estuaries, *Fisheries Bulletin*, **101**: 343-357.
- Payne, A.L., (1976). The relative abundance and feeding habits of the grey mullet species occurring in an estuary in Sierra Leone, West Africa, *Marine Biology*, **35**: 277-286.
doi: [10.1007/BF00396875](https://doi.org/10.1007/BF00396875)
- Silva, E.I., De Silva, S.S., (1981). Aspects of the biology of grey mullet, *Mugil cephalus* L., adult populations of a coastal lagoon in Sri Lanka, *Journal of Fish Biology*, **19**(1): 1-10.
doi: [10.1111/j.1095-8649.1981.tb05806.x](https://doi.org/10.1111/j.1095-8649.1981.tb05806.x)
- Vieira, J.P., (1991). Juvenile mullets (Pisces: Mugilidae) in the estuary Lagoa dos Patos, RS, Brazil, *Copeia*, 409-418.
doi: [10.2307/1446590](https://doi.org/10.2307/1446590)