BioPublisher©

International Journal of Marine Science2016, Vol.6, No.31, 1-7
http://ijms.biopublisher.ca

Research Article Open Access

Comparison of Spawning Rate between Wild and Improved Strain of *Oreochromis shiranus* (Boulenger, 1897)

David Mbamba[1], Kumbukani Mzengereza[2,] ✉, Wales Singini [2], Fanuel Kapute [2], Hastings Zidana[1]

1. National Aquaculture Centre, P. O. Box 44, Domasi, Zomba, Malawi

2. Mzuzu University, Department of Fisheries Science, P/Bag 201, Luwinga, Mzuzu, Malawi

✉Corresponding author email: kumbumzenge@gmail.com

International Journal of Marine Science 2016, Vol.6, No.31doi:10.5376/ijms.2016.06.0031

Received: 01 Jun., 2016

Accepted: 20 Sep., 2016

Published: 21 Sep., 2016

Preferred citation for this article:

Mbamba D., Mzengereza K., Singini W., Kapute F. and Zidana H., 2016, Comparison of Spawning Rate Between Wild and Improved Strain of *Oreochromis shiranus* (Boulenger, 1897), International Journal of Marine Science, 6(31):1-7(doi: 10.5376/ijms.2016.06.0031)

AbstractThe study was conducted to determine the spawning rate of Malawian Tilapia, *Oreochromis shiranus* bred in hapas and placed in ponds at the Malawi's National Aquaculture Centre (NAC). Two strains compared were improved strain from fifth (F5) generation brooders which were procured from a selective breeding program and the wild strain. The brood stock fish were grouped into 3 size categories (24-59g which was designated as treatment 1), 60-99g brooders were denoted as treatment 2 and treatment 3 comprised of brooders that were >100g. Two reproductive parameters were measured every fortnight: number of eggs produced and condition factor (CF) of the fish. The results showed no significant differences in the number of eggs produced between improved and wild strain (P<0.05). The study has demonstrated the significance of using body weight and standard length in selecting both wild and improved strain as a selection criterion for brooders in Malawian Tilapia aquaculture industry.

Keywords (F5) Generation brooders; *Oreohromis shiranus*; Malawi; Aquaculture; Standard length

Introduction

Fish is the most important source of animal protein in Malawi comprising 60–70% protein (Balarin, 1987). However, due to the dwindling catches from natural water bodies, fish consumption has declined from 14.9 kg to around 4.6 kg per capita (GoM, 2013). Development of a resilient and sustainable fish farming industry in Malawi would be significant to the economy and food security of the country. The decline in wild fish supply has had serious and detrimental consequences to the health and nutritional standards of many Malawians. However, the flourishing of fish farming in Malawi as an alternative to dwindling wild stocks is dependent on many factors such as quality and adequate number of fingerlings as inputs. Good quality and adequate fingerling production remains a significant bottleneck to continued expansion of aquaculture development in Malawi. Despite that Tilapia aquaculture continues to expand and represents an important source of fish to domestic and export markets (Webster, 2006), the supply of adequate number of quality fingerlings poses a challenge in its advancement.

Most cultured Tilapias in Malawi are grouped into two genera (Trewavas, 1982) Tilapia which are macrophagous and substrate spawners and *Oreochromis* which are microphagous and mouth brooders. The term Tilapia in other cases was referred to *Oreochromis* species before the separation into its distinct genus. The present study focused on *Oreochromis shiranus* which is cultured by over 90% of the fish farmers in Malawi either in monoculture or poly culture with other species (NAC, 2004). Tilapia species (*Oreochromis* species included), have an excellent aquaculture potential because of their herbivorous and omnivorous feeding habits, high tolerance to wide range of water quality, ease of handling, resistance to diseases and parasites (ICLARM, 1991).

The need to develop effective criteria for brood stock selection is pre-requisite for mass fingerling production for *Oreochromis shiranus*. The knowledge of effect of body weight and length on spawning cannot be over emphasized because it is a positive step towards rapid expansion of aquaculture in Malawi.

The selection of brooders of *Oreochromis shiranus* with potential to give optimum number of eggs is necessary in fingerling production. Apparently, there is paucity of information on number of eggs that a specific size of either wild or improved strain of *Oreochromis shiranus* is able to produce. In Malawi, most hatchery operators use brooders with low spawning rate. This has been caused by inadequate data on the reproductive biology of *Oreochromis shiranus*. Previous studies on fish farming in Malawi placed much emphasis on nutritional, technological and sociological aspects (Noble, 1990). Limited studies if any have been conducted on the effect of biological and environmental factors on quantities of eggs spawned by *Oreochromis shiranus* species, which is paramount in choosing fish brooders that can give adequate number of eggs.

The present study was aimed at establishing guidelines for *Oreochromis shiranus* brooders selection which can give optimum number of eggs to meet the ever growing demand for fingerlings by both subsistence and commercial fish farmers in Malawi.

Methodology

The experiment was conducted at the National Aquaculture Centre (NAC), Zomba, and southern Malawi from the month of November to March. A total of 360 wild and improved brooders for *O. shiranus* were collected from the same centre and categorized into three ranges from 24 – 59 cm (9 -14cm) for treatment 1, 60 – 99g (14 – 16cm) for treatment 2 and 100 – 200g (16 – 20cm) for treatment 3. The brooders were stocked at a male: female ratio of 1: 3 in hapa nets placed in ponds (6×3×1m) in size at 5 fish per m^3. Fish were fed twice a day with Malawi Gold Standard (18% CP) feed at 3% daily body weight. Sampling was done every two weeks during which eggs were collected from the mouth of brooders. Water quality parameters: temperature, Dissolved Oxygen (DO) and pH were measured every day.

Data Analysis

Data was analyzed in SPSS (version 16.0) and One Way Analysis of Variance (ANOVA) was used to compare the treatment means. The significantly different treatment means were separated using Duncan's Multiple Range Test.

Results

Wild strain – *Oreochromis shiranus*

The proportion of female weight to number of eggs spawned is shown in table 1. The number of eggs increased as the body weight and length of fish increased. The mean minimum number of eggs spawned by 180 wild brooders in all treatments was 256 eggs and the mean maximum number was 523 eggs. The smallest number of eggs was 141, spawned by a brooder weighing 36g (SL: 11.6cm) and the largest number of eggs was 785, spawned by a brooder weighing 103g (SL: 16.3cm). There was a rapid increase in number of eggs for wild strain brooders weighing between 41-72g. However, the number of eggs started to increase at a decreasing rate after the brooders attained 72-134g.

Table 1 Mean number of eggs spawned by wild strain of *Oreochromis shiranus*

Treatment	Body weight	SL	TL	Eggs
1	41.45±1.35	11.73±15	14.292±19	256.38±6.4^a
2	71.95±1.08	14.413±09	17.557±11	418.60±8.0^b
3	134.20±3.99	17.480±18	21.062±19	523.2±12.50^c

Means with different superscripts within a column are significantly different (P<0.05)

Relationship of body weight (BW), standard length (SL) and eggs of wild strain brooders

Number of eggs, body weight, total and standard length was significantly correlated with BW (r = 0.70; P<0.01; n= 180, SL(r = 0.75; P<0.01; n = 180; and TL(r= 0.74; P<0.01; n = 180. The relationship between body weight and eggs, standard length and eggs was curvilinear while the relationship between standard length and body weight was linear.

Using the enter method to establish the correlation of the variables, the adjusted R square was 56% and other results are indicated in table 2.

Table 2 Mean number of eggs spawned by improved *Oreochromis shiranus*

Treatment	Body weight	SL	TL	Eggs
1	40.83±1.18	11.69±12	14.32±15	256±7.85[a]
2	79.30±1.63	14.93±13	18.18±15	436.68±10.25[b]
3	132.93±3.32	17.48±16	21.15±19	495.38±17.38[c]

Means with different superscripts within a column are significantly different (P<0.05)

All the variables (body weight, standard length and total length were not significantly different in this model; however, high value of relationship was obtained between standard length and eggs (Table3).

Table 3 Multiple regression of weight and length for wild strain of *Oreochromis shiranus*

Predictor variable	Beta	p- value
Body weight	-.150	.392
Standard length	.533	.077
Total length	.362	.223

Improved strain of *Oreochromis shiranus*

The number of eggs to body weight and length increased as the fish increased in weight and length (Table 2). The mean minimum number of eggs spawned by improved strain brooders of *Oreochromis shiranus* with mean body weight ranging from 41g – 133g (12 – 17cm) (all treatments) was 257 and the maximum mean number was 495 eggs. The smallest number of eggs spawned by a brooder weighing 33g (10.9cm) was 115, and the largest number of eggs was 1083 spawned by a brooder weighing 176g (19.3cm).

Relationship between body weight (BW), standard length (SL) and eggs of improved strain of *Oreochromis shiranus*

The number of eggs, body weight, total length and standard length was significantly correlated with BW (r = 0.74; P<0.01; n= 180, SL(r = 0.78; P<0.01; n = 180; and TL(r= 0.76; P<0.01; n = 180. The relationship between body weight and eggs, standard length and eggs was slightly curvilinear but the relationship between standard length and body weight was linear.

Using the enter method to establish the correlation of the variables, the adjusted R square was 60% and impact of other variables are indicated in table 4 below,

Table 4 Multiple regression of weight and length for improved strain of *Oreochromis shiranus*

Predictor variable	Beta	P -Value
Body weight	-0.052	.772
Standard length	1.112	.001
Total length	.288	.387

Standard length was a significant predictor in this model at P= .001 while the other variables were not significant predictors. The standardized Beta coefficient gives a measure of the contribution of each variable hence in this case; a unit change in standard length has a large effect on the dependent variable than the other variables (Table 4).

The number of eggs dropped as shown in figure 1 for wild strain brooders after attaining an average weight of 132g (18cm), while eggs for improved strain brooders continued to increase with the increase in body weight and length despite attaining the same weight at which the wild strain brooders showed a remarkable drop in the number of eggs (Table 5). There were no significant difference between the numbers of eggs produced by improved and wild strains of *Oreochromis shiranus* at P<0.89.

Table 5 Mean number of egg for wild and improved strain of *Oreochromis shiranus*

Treatment	Eggs	Std Error
1	399.39[a]	9.80
2	396.29[a]	10.44

Means with same superscripts are not significantly different at (P>0.05)

Water quality parameters

The average water temperature during the four months of the study was 26^0 C while dissolved oxygen was 8mg per liter (average). Data for pH was collected once per day and was fluctuated between the ranges of 6.5 – 8.6.

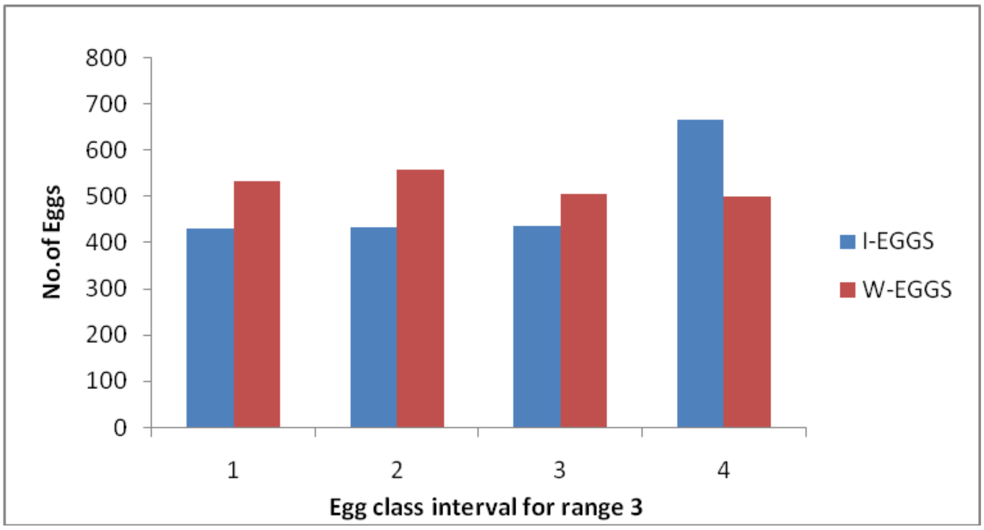

Figure 1 Egg spawning per class of wild and improved strain of *Oreochromis shiranus*

Discussion

Growth of wild and improved strains of *Oreochromis shiranus*

The observations show that all the three variables had influence on the number of eggs spawned. However, out of the three variables; standard length has greater impact on number of eggs spawned than weight and total length especially, for improved strain of *Oreochromis shiranus.* Standard length was significantly different at P= 0.001 (Table 4). Results of the present study corroborate those by Maluwa (1990) who reported that standard length had greater impact in determining the number of eggs spawned by wild strain of *Oreochromis shiranus*. Standard length has a greater influence on number of eggs spawned than the other variables because it represents the actual body length which also determines the size of the visceral space in which the eggs are contained. The larger the body size, the greater the space for egg development (El Sayed *et al*., 2003). On the other hand, body weight has positive correlation with body length but do not reflect the actual size of the visceral space because a fish may have heavy weight while its body length is shorter, thus providing a small visceral space for egg development. Similarly, total length, which has an inclusion of the caudal fin to the standard length and do not provide any extra fresh to contain the eggs. Findings of the present study agree with the reports by Sztramko and Teleki (1977); Tsai and Gibson (1971); Bagenal (1978) that larger fish with a greater visceral space for egg development have larger ovaries, and thus more eggs than smaller fish. The egg spawning trend between treatments changed with increase in body weight and length but decreased as the fish continued to advance in weight and length (Table 1 & 3). The results of the present study agree with the findings of Maluwa (1990) which show that number of ripe eggs in the gonad increased with body weight and length. Peters (1963), Siddiqui (1977); Babiker and Ibrahim (1978) had similar observations that there is an increase in egg number in the gonad with increasing body weight and length. The quantity of eggs in the gonad is a reflection of the eggs brooded in the mouth despite that some are reabsorbed. In addition, results of the current study have shown that there is a diminishing increase in number of eggs from brooders above a mean body weight of 72g (14cm).

The results show that *Oreochromis shiranus* compared with other *Oreochromis* species deposit more eggs per spawning interval, which ranges from 256 – 523 eggs from brooders weighing 41g to 133g (12cm -17cm) while *Oreochromis niloticus*, almost of the same length (12cm – 30cm) deposit 100 to 1,700 eggs (El-Sayed *et al*., 2003). In another related study, Chimits (1957) reported that *Oreochromis mossambicus* brooders of 75g – 500g spawned

50 eggs to 2000 eggs. However, the results of the present study are similar with El-Sayed *et al.* (2003)'s findings which stated that *Oreochromis niloticus* between 42 – 75g spawns eggs ranging from 305- 753 at a time.

Spawning drop-off point

The data for range 3 (treatment 3) was further categorized into classes to determine the spawning drop-off point since this range had the best egg numbers spawned. The number of eggs for wild strain of *Oreochromis shiranus* had a remarkable drop when the brooders attained an average weight of 132g (18cm) despite the increase in weight. These results agree with Maluwa (1990) which showed that the number of eggs in the mouth of the brooders decreased with length of fish above 18cm (170g). The slight difference in weight at which the brooders in the two studies had their number of eggs decreased might be due to differences in the age of the brooders since the brooders that were used by Maluwa (1990) were not of the same age with the brooders used in the current study. The other possible reason that could have caused this difference would be the type of feed given to the brooders. Watanabe (1985), Finn (1994) and Bhujel *et al*. (2001) reported that spawning performance and seed production of tilapia are directly related to brood stock nutrition. Despite the difference in weight of the brooders at the time the number of eggs showed a remarkable drop, the length was similar which shows that length indeed determines the carrying capacity of eggs by the brooder.

Observations made from the present study show that the number of eggs for both strains increases with the increase in body weight and length. The number of eggs for wild strain brooders had a remarkable drop at certain point in time while improved strain brooders continued to spawn at an increasing rate without a drop despite attaining the same weight at which the wild strain brooders had a remarkable drop. The difference in time of drop off in number of eggs might be due to differences in age suggesting that the improved strain brooders of *Oreochromis shiranus* attained the same weight as wild strain sooner than the latter, despite having younger age due to their relative advantage on growth performance as a result of attainment of desirable traits following selective breeding as reported by Maluwa (2008). The results suggest that the difference in spawning drop- off might be due to genetic vigor since the improved strain brooders are genetically improved.

Number of eggs between wild and improved strains of *Oreochromis shiranus*

The results on eggs spawned between improved and wild strain brooders show that there is no significant differences (P>0.05). The improved strain brooder with minimum mean body weight ranging from 24g – 200g (9.5 – 20cm) with minimum mean weight of 40g (12cm) spawned minimum mean number of 257 eggs while, wild strain brooder with minimum mean body weight 41g (12.cm) spawned 256 eggs. The improved strain brooders with maximum mean weight of 133g wild (17cm) spawned maximum mean number of 495 eggs and wild strain brooders with maximum mean weight of 134g (17cm) spawned maximum mean number of 523 eggs.

The number of eggs spawned by wild and improved strain though not significantly different but after the entire spawning period, improved strain would spawn a lot of eggs because of the delayed drop in number of eggs being spawned.

The results further show that all the independent variables for improved strain of *Oreochromis shiranus* had more influence on the number of eggs spawned than predictors for wild strain of *Oreochromis shiranus.*

Conclusion

The present study shows that body weight and length have an effect on number of eggs spawned by both wild and improved strains of *Oreochromis shiranus*. It has been observed that as the brooders increase in body weight and length, there is an increase in number of eggs spawned which starts to decrease with further increase in weight. There is a positive correlation among the three variables (standard length, body weight and number of eggs) within each strain but there is no significant difference in number of eggs spawned between wild and improved strain brooders of *Oreochromis shiranus*.

The study has also established that wild and improved strain brooders weighing >100g (17cm) is the best category for selection for breeding programs. Brooders ranging between 124 – 138g for wild strain *Oreochromis shiranus* produces the optimum number of eggs. Wild strain *Oreochromis shiranus* brooders that are above 138g show a rapid decrease in the number of eggs produced. On the other hand, improved strain brooders did not register a remarkable decrease in number of eggs spawned hence any brooder above 100g is suitable for selection.

Recommendations

The study recommends that 100g (17cm SL) and above brooders of wild and improved strains of *Oreochromis shiranus* are the best brooders to select for breeding purposes. Brooders from 60g (15cm SL) and above can be used for breeding when the hatchery operator has inadequate number of the first choice of brooders. Wild strain brooders below 60g (15cm) and above 132g (18cm SL) are not the ideal candidates to use for a breeding program because it is costly to manage them due to insufficient number of eggs that are spawned.

There is no cut-off point for improved strain brooders of *Oreochromis shiranus* above 100g. However, small brooders (below 100g) are not cost-effective to be used at the hatchery. Finally, it is advisable to use standard length as a selection criterion for brooders because of its accurate measure on number of eggs spawned.

Acknowledgement

Authors sincerely thank staff in the department of Fisheries Science at Mzuzu University for their valuable input and support towards this work as well as National Aquaculture Center for housing the experiment.

References

Aquaculture Project. 2004. Ministry of Natural Resources and Environmental Affairs, Lilongwe, Malawi.

Ayoade, R., B. 1988. The Nutritional Status and Role of Fish in Nutrition in Farm households in Zomba District.Research for the Development of Tropical Aquaculture Technology Appropriate for Implementation in Rural Africa. ICLARM/GTZ- Malawi Department of Fisheries/University of Malawi

Bagenal, T.,B. 1980. Aspects of fish fecundity.*In* S. D. Gerking, editor. Ecology of freshwater fish production. Halsted Press, New York.75-101

Bagenal , T.,B. and E. Braum. 1978. Eggs and early life history. InW.E.Ricker, editor.Methods for assessment of fish production in fresh waters.Blackwell Scientific Publications, Oxford and Edinburgh.Pages 166-198.

Bakier, M.,M. and H. Ibrahim 1978. Studies on the Biology of Reproduction in Cichlid Tilapia niloticus L: gonadal maturation and fecundity. Journal fish Biology, 473 – 448

Balarin. J.,D. 1983. A guide to Tilapia Breeding – The Baobab Hatchery Technique. Tilapia Culture Section Baobab Farm Limited, Mombasa, Kenya 211p

Banda, G.A. 1988. Farm- House hold Decision – Making with reference to fish farming in fish farming in Zomba District. Research for the Development of Tropical Aquaculture Technology Appropriate for Implementation in Rural Africa. ICLARM/GTZ- Malawi Department of Fisheries/University of Malawi

Bhujel, R.,C. 2001. Impacts of environmental manipulation on the reproductive performance of Nile tilapia (*Oreochromisniloticus*).Journal of Aquaculture in the Tropics (3)197 – 209.

Chimits, P, 1957.Tilapia and their culture: A second review and bibliography. FAO Fisheries Bulletin 10(1): 1-24.

El-Sayed, A.,F.,M., Mansour, C.R. and A.,A Ezzat 2003. Effects of dietary protein levels on spawning performance of Nile tilapia (*Oreochromisniloticus*) brood stock reared at different water salinities. Aquaculture (220) 619 – 632.

Fin, R.N. 1994.Physiological energetic of developing marine fish embryos and larvae.PhD thesis, University of Bergen, Norway.

Hislop,J.,R.,G. 1988. The influence of maternal length and age on the size and weight of the eggs and the relative fecundity of the haddock, *Melanogrammusaeglefinus*, in British water. Fish Biology *(*32):923-930.

ICLARM , 1991. A Case study of Malawi: The context of small scale integrated- Agriculture –aquaculture systems in Africa. Manila, Philippines, 189.

Lowe- Mc Connell, R.H. 1955. The Fecundity of Tilapia species. East Africa Agriculture Journal .(1) 45-52.

Macintosh, D., J. and D.C. Little 1995.Nile tilapia (*Oreochromis niloticus*).In N.R. Bromage and R.J. Roberts (Eds.), Brood stock management and egg and larva quality (277 – 320). Oxford, UK: Blackwell Science.

Maluwa,.A.O. 1990. Reproductive Biology and Fry Production of *Oreochromis shiranus* Boulenger, 1896 (Pisces: Cichlidae), A thesis submitted to the University of Malawi.

Mitton, J. B and W.M. Lewis. 1989. Relationships between genetic variability and Life-history features of bony fishes. Evolution (43)1712-1723. http://dx.doi.org/10.2307/2409387

National Aquaculture Centre . 2004. Annual Report. Department of Fisheries and JICA

Nikolskii, G.V 1969. Theory of fish population dynamics as a biological background for rational exploitation and management of fishery resources (translated from Russian by J.E.S. Badley). Oliver and Boyd. London

Noble,R.P and S. Chimatiro 1990.The Status of Fish Farming in Zomba District Research for the Development of Tropical Aquaculture Technology Appropriate for Implementation in Rural Africa.ICLARM/GTZ Malawi Department of Fisheries/University of Malawi.

Peters, H.M 1963. Fecundity, egg weight and Oocyte Development in Tilapia (Cichlidae, Teleostei).ICLARM transactions 2, ICLARM, Manila, The Philippines. 28

Rana,K. 1988 Reproductive biology and the hatchery rearing of tilapia eggs and fry. In J.F. Muir and R.J. Roberts (Eds.), Recent advances in aquaculture

(3)343- 406.London, England: Croom Helm.
http://dx.doi.org/10.1007/978-94-011-9743-4_5PMCid:PMC1052718

Shoesmith, E. 1990.A comparison of methods for estimating mean fecundity. *Journal of Fish Biology* 36:73-84.
http://dx.doi.org/10.1111/j.1095-8649.1990.tb03521.x

Siddiqui, A.Q 1977. Reproductive biology, length – weight relationship and relative condition factor of *Tilapia leucosticte* (Trewavas) in Lake Naivasha, Kenya. Fish Biology (10)251 – 260,

Sztramko, L. and G.C. Teleki, 1977.Annual Variations in the fecundity of yellow perch from Long Point Bay, Lake Erie. Transactions of American Fisheries Society (106): 578-582.
http://dx.doi.org/10.1577/1548-8659(1977)106%3C578:AVITFO%3E2.0.CO;2

Treasurer, J.W. 1981.Some aspects of the reproductive biology of perch percafluviatilis L. fecundity, maturation and spawning behavior.Fish Biology (18) 729-740.

Trewavas, E. 1982. Tilapias: Taxonomy and Speciation. In the Biology and Culture of Tilapias. Eds R.S.V. Pullin and R.H. Lowe-Mc Connel, 3-14 Manila, Philippines: ICLARM.

Tsai, C. and G.R Gibson. 1971. Fecundity of the yellow perch, *Percaflavescens* Mitchill, in the Patuxent River, Maryland. Chesapeake Science (12)270-284.
http://dx.doi.org/10.2307/1350914

Watanabe, T 1985. Importance of the study of brood stock nutrition for further development of aquaculture. In Cowey, C.B., Mackie, A.M and Bell, J.G. (eds.) Nutrition and Feeding in Fish. Academic Press, London, 395-414.

Webster, C.D. 2006. Tilapia Biology, Culture and Nutrition. Food Products Press, an imprint of the Haworth Press, Inc., 10 Alice Street, Binghamton, NY . 13904 – 1580

Welcomme R.L.,1967. The Relationship between Fecundity and Fertility in the Mouth brooding Cichlid Fish Tilapia leucosticte. Journal of Zoology, (151) 453 – 468.

Wright, R. M., and E.A. Shoesmith. 1988. The reproductive success of pike, *Esoxlucius*: aspects of fecundity, egg density and survival. Journal of Fish Biology (33):623-636.
http://dx.doi.org/10.1111/j.1095-8649.1988.tb05505.x

Zar, H.J. 1984. Biostatistical analysis. Second Edition Prent. Englewood Cliffs, New Jersey 07632. 718p.

Zivkov, M. and G. Petrova. 1993. on the pattern of correlation between the fecundity, Length, weight and age of pikeperch Stizostedionlucioperca. Journal of Fish Biology (43)173-182.
http://dx.doi.org/10.1111/j.1095-8649.1993.tb00421.x