Morphometric Features and Condition Factor Relationships with Reproductive Indices in *Tilapia guineensis*

UKA, A*[1] and SIKOKI, F.D[2]
[1]Department of Fisheries and Aquatic Resources Management,
Michael Okpara University of Agriculture,
Umudike, Nigeria.
*Corresponding author. Email: anyaeleuka@gmail.com
[2]Department of Animal and Environmental Biology,
University of Port Harcourt, Nigeria.
Email: sikokifrancis@yahoo.com

ABSTRACT
Relationships between indices of reproduction (Gonadosomatic index -GSI- and Hepatosomatic index -HSI-) , condition factor and morphometric features were examined in search of spawning signals in selection of Tilapia guineensis broodstock. One hundred and sixty fish comprising 70 females and 90 males were examined. Total length, standard length and body depth were measured to the nearest 1 cm while each fish was weighed to the nearest 0.1 g. The gonads and liver were removed and weighed separately to the nearest 0.001g. Gonadosomatic index, Hepatosomatic index and condition factor were calculated. Correlation analysis between the reproductive indices and the external features were carried out. Results revealed positive correlation between gonadosomatic index and body depth and between GSI and standard length in both sexes, indicating the dependence of gonadal development on body depth and standard length in both sexes. However, the relationship between the reproductive indices and total length was significant only in the female. The relationship between HSI and Standard length was also significant in female ($P<0.01$, $r = 0.707$) and male ($P<0.05$, $r = -0.216$) but in positive and negative direction respectively. The correlation between the reproductive indices and condition factor were not significant in both sexes. The correlation of GSI and HSI in male ($r = 0.062$) was not significant, while the positive correlation of GSI and HSI in female ($r = 0.300$) was significant ($P<0.05$). It was therefore concluded that body depth and standard length could be important factors in determining spawning success in both sexes, while total length may be an additional tool in determining spawning success only in female T. guineensis.

KEYWORDS: *Condition factor, Gonadosomatic index, Hepatosomatic index, Morphometric features and Tilapia guineensis*

INTRODUCTION

Gonadosomatic index and Hepatosomatic index are indices of reproduction (Delince *et al* 1987, Cek *et al* 2001). El-Sayed *et al* (2007) reported that hepatosomatic index and gonadosomatic index are the factors involved in the activation of the brain pituitary gonad (BPG) axis. They are crucial for better understanding of some biological processes related to the estimation of male and female reproductive success in fish. Gonadosomatic index was used as an indicator of reproductive activity in fish (Elorduy-Garay and Ramfrz-luna 1994, Merayo 1996 and Rajasitta *et al* 1997). The utility of gonadosomatic index to detect hydrated ovaries and therefore reproductive readiness from increase in weight was established by Hunter and Macewicz (1985). Thus the gonadosomatic index provides a useful estimation of spawning potential of fish (Coballos-Vazques and Elorduy-Garray 1998).

The condition factor (K) is used in order to compare the "Condition" robustness or well-being of fish (Bolger and Conolly 1989, Lizama *et al* (2002). It is based on premise that heavier fish of a particular length is in a better physiological condition than less robust fish (Bagenal 1978).

Condition factors of different tropical fish species were investigated and reported by Saliu (2001), Lizama *et al* (2002) and Anene (2005). The reports focused on the determination of changes in condition factor with season.

Uka and Edun (2011) reported that the correlation between gonadosomatic index and body depth, gonadosomatic index and condition factor in *Sarotherodon melanotheron* were significant only in male. The correlation of the total length and gonadosomatic index was significant in both sexes. They therefore concluded that total length may be an important factor in determining spawning success in both sexes. The report concluded that condition factor and body depth may be employed as additional tools in determining spawning success in male *S. melanotheron* only.

On the other hand, Arellano-Martinez and Ceballos-Vazquez (2001), reported a significant negative correlation between gonadosomatic index and condition index in both sexes of *Holocanthus passer*. They also reported a significant difference in gonadosomatic index but not in condition index values between the male and the female.

It is also known that close relationship exists between physiological status, condition factor and reproductive stage in fish (Arellano-Martinez and Ceballos-Vazquez 2001). For some fish, poor condition can mean that they will forgo spawning altogether or skip one or more spawning season (Rideout *et al* 2000). Callow (1985) stated that fish make tradeoffs in energy allocation between growth and reproduction. Those in better condition may have more surplus energy to devote to reproduction and be able to mature at a smaller size and younger age. Therefore depending on the relationship between the condition factor and the gonadosomatic index, the condition factor may be used to determine readiness to spawn without killing the fish (Arellano-Martinez and Ceballos-Vazquez 2001).

Morgan and Lilly (2006) reported that there was no significant effect of relative body condition on the probability of being adult for either male or female Cod. However, for female Cod, they reported a significant effect of liver condition on the probability of being an adult, after accounting for the effects of age and length.

In this study, the effects gonad condition (gonadosomatic index) and liver condition (hepatosomatic index) on body condition (condition factor) were investigated. The report also revealed how these reproductive indices influence certain morphometric features in *Tilapia guineensis*. The hypothesis was that the values of gonadosomatic index and hepatosomatic index reflect on physical appearance of *Tilapia guinneensis*. The results obtained are useful during physical examination to determine ripeness of *T. guineensis* brood for artificial and induced spawning exercise.

MATERIALS AND METHODS

Tilapia guineensis used in the study were collected from tidal recruitment ponds of a brackish water fish farm in Niger Delta, Nigeria. The species was identified using key provided by Campbell *et al* (1987). A total of 160 fish comprising 70 females and 90 males were studied. Each fish was measured for total length (TL), Standard length (SL) and body depth (BD) to the nearest 1cm (from the tip of the snout to the end of the caudal fin, from the tip of the snout to the base of the caudal fin and dorso-ventrally at mid-point respectively). The same fish was weighed to the nearest 0.1g and dissected to establish sex. The gonads and the liver were removed and weighed separately to the nearest 0.001g. Gonadosomatic index (GSI) for each fish was calculated as weight of the gonads relative to the body weight expressed as a percentage thus: GSI = $\frac{weight\ of\ gonad\ (g)}{weight\ of\ fish\ (g)}\ x\ 100$ (de Vlaming *et al* 1982). Hepatosomatic index (HSI) was calculated as weight of the liver relative to the total body weight expressed as a percentage thus: HSI = $\frac{weight\ of\ Liver\ (g)}{weight\ of\ fish\ (g)}\ x\ 100$ (Gomez-Marquez *et al* 2003). The ratio of body weight to total length in exponent 3 expressed as a percentage was used to calculate the condition factor thus: condition factor (K) = $\frac{100w}{L^3}$ (Maddock and Burton 1999). The percentage values obtained were transformed using square root transformation to attain normality of data prior to statistical analysis (Gomez and Gomez 1984). The reproductive indices were correlated with the condition index, total length, standard length and body depth. The calculated coefficient values were compared with the tabulated values to evaluate hypothesis.

STATISTICAL METHOD

The relationship between the condition factor (K), the total length of fish (cm), the standard length (cm) and body depth (cm) with gonadosomatic index (%) and Hepatosomatic index (%) as a measure of gonadal maturity and liver development or spawning readiness was evaluated using the correlation analysis. The model (Pauly, 1983) is as follows: r = $\sqrt{\frac{[\sum xy-(\sum x).(\sum y)^2}{[\sum x^2-\frac{(\sum x)2(\sum x)^2}{n}.(\sum y^2-\frac{(\sum y)^2}{n}]}}$ where r = correlation coefficient, x = length of fish (cm), weight of fish (g) or condition factor (K). y = Gonadosomatic index (%) or Hepatosomatic index (%). n = sample size of fish examined.

Test of significance of correlation x and y variables above was based on Njoku *et al* (1998) t =r/ $\frac{\sqrt{(1-r^2)}}{N-1}$ with N – 2 degree of freedom (df). Where r = computed correlation coefficient, r^2 = coefficient of determination (square of the correlation coefficient). N = Number of observation in the sample (test fish).

RESULTS

In male *T, guineensis*, there was no significant correlation (P>0.05) between gonadosomatic index and body condition (r= 0.053) and between hepatosomatic index and body condition (r= -0.077). Also no significant correlation (P>0.05) was detected between hepatosomatic index and total length(r= -0.189) as well as between hepatosomatic index and body depth (r= -0.198). The correlation between gonadosomatic index and body depth (r=0.239), gonadosomatic index and standard length (r= 0.238) were positively significant. See Table 1. The correlation between Hepatosomatic index and Standard length (r = -0.216) was significant (P<0.05) in male (table 1). The correlation between gonadosomatic index and hepatosomatic index (r = 0.062) was not significant (P> 0.05) in male (table 1)..

Table 1: Correlation of reproductive indices with body condition and ratios in male *Tilapia guineensis*.

Relationships	Degree of freedom (n – 2)	r-value calculated	r-value tabulated at 5% level	r-value tabulated at 1% level
GSI with K	88	0.053^{ns}	0.211	0.275
GSI with TL	88	-0.236*	0.211	0.275
GSI with BD	88	0.239*	0.211	0.275
GSI with SL	88	0.238*	0.211	0.275
HSI with K	88	-0.077^{ns}	0.211	0.275
HSI with TL	88	-0.189^{ns}	0.211	0.275
HSI with BD	88	-0.198^{ns}	0.211	0.275
HSI with SL	88	-0.216*	0.211	0.275
GSI with HIS	88	0.062^{ns}	0.211	0.275

r = Correlation,

In female, the correlation of gonadosomatic index with body condition (r=0.140), hepatosomatic index with body condition(r= 0.128) were not significant (P>0.05). On the other hand, the correlation of gonadosomatic index and total length (r=0.533), gonadosomatic index and body depth (r=0.496), gonadosomatic index and standard length (r=0.574) were highly significant (P<0.01) in female (See table 2. The correlation between Hepatosomatic index and Standard length (r = 0.707) was significant (P<0.01,) in female (Table 2). The correlation between gonadosomatic index and hepatosomatic index (r = 0.300) was significant (P< 0.05) also in female (table 2) .

Table 2: Correlation of reproductive indices with body condition and ratios in female *Tilapia guineensis*.

Correlation	df (n – 2)	r-value calculated	r-value tabulated at 5% level	r-value tabulated at 1% level
GSI with K	68	-0.140^{ns}	0.241	0.314
GSI with TL	68	0.533**	0.241	0.314
GSI with BD	68	0.496**	0.241	0.314
GSI with SL	68	0.574**	0.241	0.314
HSI with K	68	-0.128^{ns}	0.241	0.314
HSI with TL	68	0.686**	0.241	0.314
HSI with BD	68	0.575**	0.241	0.314
HSI with SL	68	0.707**	0.241	0.314
GSI with HSI	68	0.300*	0.241	0.314

df = degree of freedom, r = correlation

DISCUSSION

The effect of gonadosomatic index on body depth and standard length were significant in both sexes. Body depth or standard length may be important factors in determining spawning success in both sexes, since significant correlation exists between body depth and gonadosomatic as well as between standard length and gonadosomatic index in both sexes.

Uka and Edun (2011) reported total length as an important factor in determination of spawning success in both sexes of *Sarotherodon melanotheron* as a result of significant positive correlation of total length on gonadosomatic index in both sexes of the species.

Morales (1991) mentioned the importance of length in spawning of tilapia and stated that the tilapias attain their sexual maturity at a total length of 6 to 16cm. The assertion was based on the significant correlation between gonadosomatic index and body length in the studied species.

The finding in the present report corroborated the foregoing and shows that spawning success of *Tilapia guineensis* is a function of size in terms of the standard length and body depth.

There was significant correlation between hepatosomatic index and total length as well as between hepatosomatic and body depth in female but not in male. Equally the correlation between gonadosomatic index and hepatosomatic index in male was not significant, while the correlation between gonadosomatic index and hepatosomatic index in female was highly significant. The differences observed could be as a result of sex specific differences in energy allocation for gonadal formation to male and female *T. guineensis*. The male gonads were smaller than the female gonads, therefore the male fish requires less stored energy for gonadal development.

Encina and Granado-Lorencio (1997) reported higher energy requirement for the formation of heavier female gonads in *H. passer* than for the formation of lighter male gonads. Callow (1985) also stated that fish makes tradeoffs in energy allocation between growth (body building) and reproduction (gonadal development). Fessehaye (2006) reported significant effect of condition factor on reproductive success in male but not in female *Oreochromis niloticus*. He observed that with better condition, male are more productive. Arellano-Martinez and Ceballos-Vazquez (2001), reported a significant negative correlation between gonadosomatic index and condition index in both sexes of *Holocanthus passer*. Also recent feeding activity could influence hepatosomatic index value resulting in distorted correlation with gonadosomatic index. Osman *et al*. (2011) reported that the relationship between ovary and liver is not always as strong and positive as could be expected since hepatosomatic changes according to variation in recent feeding activity and reproductive behavior.

The factor of gonadosomatic index and hepatosomatic index were used to evaluate spawning potential of *Tilapia guineensis*. Arellano-Martinez and Ceballos-Vazquez (2001) considered increase in gonadosomatic values as a good indicator of ripening of gonads in *Halocanthus passer*. Kume and Joseph (1969) cited in Wang *et al* (2003) assumed that eastern pacific female Swordfish were about to spawn when the gonad index was equal or greater than 3.0 and the body length of eye folk length of about 170mm. de Martin *et al* (2000) report on the sexual maturity of most individuals of Swordfish (*Xiphias gladius*) was from a length based gonadosomatic index. Mejuto and Garcia (1997), recommended estimation of gonadosomatic index, histological analysis of developmental stages of oocytes and determination of oocyte diameter as veritable tools in estimation of spawning success in fish. Brown (1957) in Wang *et al* (2003) reported that storage of fat and protein takes place in the liver prior to spawning in many fishes. Roberts (1978) reported that HSI increase may be due to the increase in the hormone associated with sexual activities. He also mentioned that the feeding activity increases after spawning to increase lipids, proteins and water contents of the liver. This is to meet the requirements of yolk deposition in the developing oocytes for the next season. Osman *et al* (2011) declared that the enlargement of the liver resulted from the physiological changes that occurred during the pre-spawning period.

REFERENCES

Anene, A. (2005): Condition Factor of four Cichild Species of a Man Made Lake in Imo State, South Eastern Nigeria. *Turkish J. of Fisheries and Aquatic sciences 5*:43-47.

Arellano-Martinez, M. Ceballos-Vazquez, B.P. (2001): Reproductive Activity and Condition Index of *Holacanthus Passer (Teleostei Pomacanthidae)* in the Gulf of California, *Mexico, Rev. Boil. Trop. V. 49*(n3-4): 1-6pp.

Babiker, M.M. and Ibrahim, H. (1979): Studies on the Biology of Reproduction in the Cichlid *Tilapia nilotica* (L) Gonadal Maturation and Fecundity. *J. Fish Biol. 14*:437-447.

Bagenal, T. (1978): Aspects of Fish Fecundity. In: Shelby, D.G. (ed). *Ecology of Freshwater Fish Production.* Black well Scientific Publication. Oxford, London. 75-101pp.

Bolger, T and Connolly, P.L (1989): The selection of suitable indices for the measurement and analysis of fish condition. *J. of Fish Biol*. 34: 171 – 182.

Brown (1957). In: Wang, S., Sun, C.and Yeh, s. (2003): Sex Ratios and Sexual Maturity of Swordfish *(Xiphias gladius L.*) in the Waters of Taiwan. *Zoological Studies 42(4):* 529-539.

Callow, P. (1985): Adaptive aspects of energy allocation. In: Fish Energetics: New Perspectives. P. Tytler and P. Calow (eds). The Johns Hopkins University Press, Baltimore, P. 13-31.

Campbell, D; Mahatane, A. T and Aleem S. O (1987): Mass synchronized spawning of Tilapia guineensis. *African Regional Aquaculture Centre*, RAF/82/009. 4pp.

Cek, S; Bromage, N; Randall, C and Rana, K (2001): Oogenesis, Hepatosomatic and gonadosomatic indexes, and Sex ratio in Rosy Barb (*Rintius conchonius). Turkish journal of fisheries and Aquatic Sciences* (1) 33-41.

Coballos-Vazuez, B.P and Elorduygaray (1998): Gonadal development and spawning of the Golden eyed Tilapia *cauloatilus affinis* (Pisces: *Branchiostegidae*) in the Gulf of California Mexico. Bull Mar. Sci. 63: 469 – 479.

Delince, G.A; Campbell, D; Janssen, J. A. L and Kutty, M. N (1987): *Seed Production*. UNDP/FAO/NIOMR/RAF/82/009. ARAC/87/WP/13. 114pp

DeMartini, E.E., Uchiyama, J.H. Williams, H.A. (2000): Sexual Maturity, Sex Ratio, and Size Composition of Swordfish, *Xiphias Gladius*, Caught by the Hawai-Based Pelagic Longline Fishery, *Fish. Bull. 98*:489-506.

de Vlaming, V.O., Crossman, G. and Chapman, F. (1982): On the use of the Gonadosomatic Index. *Comp. Biochem. Physiol. 73*:31-39.

Elorduy — Garay, J and Ramirez-luna, S. (1994): Gonadal development and spawning of female ocean whitefish, *Caulolatilus princes* (Pisces: Branchiostegidal) in the Bay of La Paz, B.C.S; Mexico. *J. Fish Biol*. 44: 553—566.

El-Sayed, H; Akel, K. H and Moharram S. G (2007): Reproductive Biology of Tilapia zilli (GERV, 1848) from Abu Qir Bay, Egypt. *Egyptian Journal of Aquatic Research* 33 (1): 379 – 394. Abdel-Fattah M. (2006): *Tilapia culture*. CABI Publishing. 277pp.

Encia, L. and Granado-Lorencio, C. (1997): Seasonal Variations in the Physiological Status and Energy Content of Somatic and Reproductive Tissues of Club. *J. Fish Biol. 50*:511-522.

Fawole, O.O. and Arawomo, G.A.O. (2000): Fecundity of *Sarotheredon galilacus* (Pisces: Cichlidae) in Opa Reservoir, Ile-Ife, Nigeria. *Rev. Biol. Trop., 48*:201-204.

Fesshaye, Y. (2006): Natural Mating in Nile Tilapia (*Oreochnomis nilotrcus L.*): Implications for Reproductive Success, Inbreeding and Cannibalism. *Wageningen University Dissertation* 4088. (S.I.S.N). ISBN 908050 45401.159p.

Gomez, K.A. and Gomez, A.A. (1984): *Statistical Procedures for Agricultural Research* (2nd Eds). A Wiley-Interscience Publication. John Wiley & Sons. 680pp.

Gomez-Martinez, J.L., Catillo, R.M.A., Fbila, M.J.G. and Zamora, V.A.D. (1993): Reproduction de La Tilapia en la Laguna El Rodeo. Estado de Morelos. Mexico. *Topicos de Investigation Posgrado. III*:16-22.

Gomez-Marquez, J.L., Pen-Mendoza, B., Salgado-Ugarte, I.H. and Guzman-Arroyo, M. (2003): Reproductive Aspects of *Orcochnonuis niloticus* (Perciformes: Cichlidae) at Coatetelco Lake, Morelos, Mexico, *Rev. Biol. Trop. 51*(1): 1-9p.

Hunter, J.R and Macewic, B.J (1985): Measurement of spawning frequency in multiple spawning fishes. In: R. Laskert (ed). Anegg production method for estimating spawning biomass of pelagic fish: Application to the Northern Anchovy, *Engraulis mordax*. *NOAA Tech. rep. NMFS*. 36: 79 – 94.

Kume and Joseph (1969). In: Wang, S., Sun, C.and Yeh, s. (2003): Sex Ratios and Sexual Maturity of Swordfish *(Xiphias gladius L.*) in the Waters of Taiwan. *Zoological Studies 42(4):* 529-539.

Lizama, M., De Los, A.P. and Ambroso, A.M. (2002): Condition Factor in Nine Species of Fish of the Caheacidae Family in the Upper Parana River Floodplain, Brazil. *Braz. J. Biol. (6291)*: 113-124.

Maddock, D.M. and Burton, M.P (1999): Gross and Histological of Ovarian Development and Related Condition Changes in American *Plaice J. Fish Biol. 53*:928 – 944.

Mejuto, J. and Garcia, B. (1997): A Preliminary Analysis of Gonadal Indices of the Swordfish *Xiphia gladius_L.*) in the Atlantic Ocean. In *Comm. Conserve. Atl. Tunas Coll. Vol. Sci. Pap. 46*:336 - 344.

Merayo, C.R (1996): Seasonal change in the biochemical composition of the muscle and liver of bib (Trisopteries luscus L) (Pisces, Gadidae) from the Cantabrain sea (N. Spain). *Sc. Mar*. 60: 489 – 495.

Morgan, M.J. and Lily, G.R. (2006): The Impact of Condition on Reproduction in Flemish Cap. Cod. *J.Northw. Atl. Fish. Sci.; 37*:81 - 86.

Morales, D.A. (1991): *La Tilapia en Mexico*. Biologic. Cultivaoy Pesquerias. AG Editor. S.A. 190pp.

Njoku, D. C; M. O Onoh and N.C Ohazurike)1998): *Recent methods and field experimentation in Agriculture and biological Sciences.* Alphabet Nigeria publishers, Owerri, Nigeria. 111pp.

Osman, A. G. M, El-Sayed H. A, Farrang M. M, S and Moustafa M. A (2011): Reproductive Biology of Round Herring Etrumeus teres (Dekay, 1842) from the Egyptian Mediterranean water at Alexandria. *http://www.isrn.com/journals/zoology/2011/215950*.

Palacios, S.S.E. (1995): *Estudio Biological Pesquero de la Filapia Oreodnomis aureus_(Steindachner, 1964) en la Presa Adolfo Hopez Mateos (El Infiernillo), Michocacan Guerrero, Mexcio*. Tesis de Licenciatura, Facultad Decencies, UNAM. 81p.

Pauly, D (1983): Some simple methods for the measurement of tropical fish stocks. *FAO. FISH. TECH. PAP*. (*234);* 52pp.

Rajasitta, M; Paranko, J and Laine, T (1997): Reproductive characteristics of the male herring in the Northern Baltic Sea. *J. Fish Biol*. 51: 978 -988.

Ramos-Cruzi, S. (1995): Reproduction by Crecimiento de la Mojarra Tilapia *Oreochronuis aureus*) en la Presa Benito Juarez, Oaxaca, Mexico, en 1993, INP-SEMARNAP. Mexico, *Ciencia Pesquera No. 11*:54 - 61.

Rideout, R.M., Burton, M.P.O.M and Rose, G.A. (2000): Observations on Mass Atresia and Shipped Spawnig in Northern Atlantic Cod, from Smith Sound. New found land. *J. Fish Biol; 57*:1429-1440.

Roberts M. B. S (1978): *Biology: A functional Approach*. (2nd Edtn).The English language Book society and Nelson. 656pp.

Saliu,J.K. (2001): Observation on the Condition Factor of *Brycinus nurse* (Piscues: Cypriniformes, Characidae) from Asa Reservoir, Ilorin, Nigeria. *Tropical Freshwater Biology 10*:9-17.

UKa, A and Edun, M. O. (2011): Effect of Body condition on the Reproductive index of *Sarotherodon melanotheron* in Niger Delta, Nigeria. *J. of Aquatic Sci.* 26 (1): 65-71

Wang, S., Sun, C.and Yeh, s. (2003): Sex Ratios and Sexual Maturity of Swordfish *(Xiphias gladius L.*) in the Waters of Taiwan. *Zoological Studies 42(4):* 529-539.

ACKNOWLEDGEMENT

We are grateful to the Management of Nigerian Institute for Oceanography and Marine Research, for providing the facilities used for the study.