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Interspecific Variations in the Fecundity of Some Dominant Fish Populations in Ikpoba River, Nigeria

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Abstract. Interspecific variability and trends in the fecundity of five dominant fish species, namely, *Auchanoglanis occidentalis* (Bagridae), *Brycinus longipinnis* (Characidae), *Tilipia mariae* (Cichlidae), *Malapterurus electricus* (Malapteruridae), and *Xenomystus nigri* (Notopteridae) from Ikpoba river were studied, vis-à-vis certain morphological attributes. Estimates of the "b" value (regression coefficient; exponent of length-fecundity relationship) ranged between 0.301 in *T. mariae* and 3.265 in *A. occidentalis* with a mean of 1.850. The maximum size of the fish populations examined did not significantly influence the relative magnitude of "b" (regression coefficient). The parameter β of the linear length-fecundity (LF) relationship of the form F= β are also presented. Estimates of β (slope of regression coefficient) ranged from min 2.18 in *X. nigri* to max 142 in *M. electricus*. LF data in this study suggested that absolute fecundity of the fish populations was dependent on the cube of their length, and hence body volume. There was a positive allometric functional relationship between the mean total body weight, mean body condition and mean absolute fecundity ($p < 0.05$). The mean absolute fecundity varied considerably among the families (coefficient of variation, cv = 74.04%). The decreasing order of variance of the mean for absolute fecundity was *M. electricus* > *T. mariae* > *B. longipinnis* > *A. occidentalis* > *X. nigri*. The hierarchy of mean absolute fecundity was *B. longipinnis* > *M. electricus* > *T. mariae* > *A. occidentalis* > *X. nigri.* There was no significant relationship between the mean absolute fecundity and mean total length ($p > 0.05$). Interspecific divergence in fecundity and morphometric attributes of these species (cv = 18.8-89.20%) appeared to enhance reproduction isolation or partitioning. This explains, in part, the reason for sustainable coexistence of these fish species within the same habitat in Ikpoba river.

Keywords: interspecific variation, fish fecundity, Ikpoba river, length-fecundity relationship, inland fishery

Introduction

Interpecific variations in the fecundity of fishes are important attributes of the inland water fisheries resources. Bagenal and Braum (1978) defined fecundity as the number of ripe ova in the female prior to the next spawning period, determined by counting all mature eggs in the ovary in relation to the length, body weight and ovary weight. Interspecific variations in the fecundity of fishes is also critical in the fisheries biology due to the relevance of these parameters in various applications, such as the assessment of population capacity and spatio-temporal regimes in the egg production capacity (Omoregie *et al.,* 1998; King, 1996). The knowledge of fecundity variance among different families of fishes is of significance in the investigations related to reproduction, life history, investment in fisheries, and various applied aspects of fisheries biology and pisciculture (King, 1997). Fecundity assessment of fishes has been further useful in race identification, progeny survival studies, stock evaluation, aquaculture-based induced spawning, and egg incubation (Coastes, 1988; Mareus, 1982; Bagenal, 1978). As a result, fecundity assessment of several fishes has been the subject of a number of biological and ecological studies (Pullin and Lowe-McConnell, 1982; Balarin, 1979; Fryer and Iles, 1972; Burchard, 1967).

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King (1998) reported, in a study on the weight-fecundity relationship of Nigerian fish populations, that as the maximum body weight of the fish increased, the number of eggs produced per gram increased. This trend may be linked to the biomechanism where a fish continues to grow after the fecundity has been stabilized, so that the fecundity for a given size appears to decline, albeit remaining constant (Bagenal, 1978). This phenomenon, best known in individual species, was also observed in multispecific populations. Little is known about interspecific fecundity variance of different families of fishes in numerous small rivers and streams in Nigeria (Komolafe and Arawomo, 1998; King, 1996). Besides the work of Roff (1986), there appears to be no previous investigation, with a holistic approach aimed at determining the fecundity variance with regards to different fish families in a given small body of water. Most of such studies in Nigeria have centered on families inhabiting large rivers, lakes, lagoons and reservoirs (Fawole and Adewoye, 1998; Mgbenekan and Eyo, 1992; Adebisi, 1987; Nwadiaro, 1987; Nwadiaro and Okorie, 1986; Fagade, 1979; 1978; Akintunde and Imevbore, 1979).

Earlier studies on the fishes of Ikpoba river have focused on heavy metal pollution (Eghaboh, 1998; Oguzie, 1996; Fufeyin, 1994), and length-weight relationship (LWR) of fish population (Ezemonye and Oshiokpekhai, 1999). No work has been done on the dynamics of fecundity variations of the fish populations of this river. The present work aims at contributing information on the fecundity dynamics of some dominant and economically important fishes found in Ikpoba river, Benin City, Southern Nigeria.

Materials and Methods

The fish samples were collected from four stations of Ikpoba river (Fig. 1) during November 2000 and October 2001. The fishing was carried out using traditional fishing gear and traps consisting of cast nets, gill nets, basket traps, and hook and line. Each specimen was identified by reference to the taxonomic works of Leveque *et al.* (1992), Teugels *et al.* (1992), Fischer and Bianchi (1984), and Reed *et al.* (1967). Routine body measurements of the total length (TL), the distance from the anterior part of the snout to the flexure line of the caudal penduncle; standard length (SL), the distance from the anterior part of the snout to the posterior end of the caudal fin; and the total weight (TW) were determined.

For the dominant and commercially important fish species the parameters, "a" (regression constant) and "b" (regression coefficient) of the allometric length-fecundity relationship (LFR) of the form, as described by Bagenal (1978), was estimated as below:

$$F = aL^b \quad (1)$$

this was transformed as:

$$\text{Log } F = \text{Log } a + b \text{ Log } L \quad (2)$$

Using LF data pairs and least squares linear regression, the linear LF functions of the form

$$F = a + \beta L \quad (3)$$

were determined

where:

L = length
F = fecundity
LF = length-fecundity
a = regression constant
b = regression coefficient (intercept on Y-axis)
β = slope of regression constant

Reproductive studies were carried out on the dominant gravid fish samples. They were sexed after dissection to reveal the gonads. Absolute fecundity, the total number of eggs found in a ripe female before spawning, as defined by Bagenal and Braum (1978), was determined by the direct count of all eggs after air-drying at 27-29 °C ambient temperature for 6 h (King, 1996). The determination of interspecific variation of egg production capacities was facilitated by the calculation of relative fecundity (weight-specific fecundity), i.e., the count of number of eggs per g total body weight (Bagenal, 1978). Standard fecundity (length-specific fecundity) was expressed as the number of eggs per cm total length (King, 1991; Nikolsky, 1963). The general well-being of the fish samples, defined as the condition factor (K), was computed as:

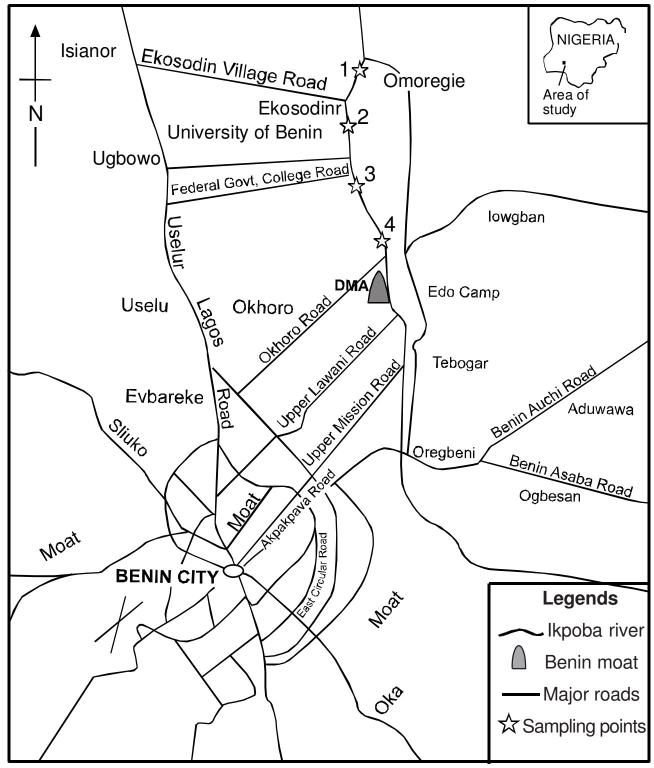

Fig. 1. Map of Benin City showing Ikpoba river and the sampling points (1, 2, 3, 4).

$$K = wt\, 100\, (TL)^{-3}$$

where:

wt = total body weight (g)
TL = total body length (cm)

Determination of the trend in interspecifc variations in fish morphometry (length, weight) and fecundity were statistically examined by coefficient of variations (cv) in accordance with Lowentin (1966), and the regression analysis using untransformed or double-log-transformed (common logarithm) data sets as described by King (1996).

Results and Discussion

A total of 247 fish specimens belonging to 13 families and 17 species were collected and studied. Out of these 64 fish specimens (25.9% of the total catch) were sexually active (ripe) females. The number of specimens of each of these species examined is given in Table 1. The dominant and gravid females examined belonged to five species, each a member of different family.

Morphometric measurements. A wide range of variations in the mean length and weight were observed within each species. These ranged from min total body length of 8.05 cm in *Brycinus longipinnis* (Characidae) to a max of 19.36 cm in *Malapterurus electricus* (Malapteruridae). The weight varied from 20.82 g in *Xenomystus nigri* (Notopteridae) to 106.27 g in *Malapterurus electricus* (Table 2).

The coefficient of variations for mean total length and weight were 18.82% and 82.42%, respectively (Table 3). Mean total body weight increased with mean total body length: degree of freedom (df) = 4; correlation coefficient (r) = 0.8537; $p < 0.05$.

The length-fecundity relationship (LFR) data of the fish populations studied, along with the available information on fish population specific results, ancillary statistics such as sample size or the number of individuals (n), length ranges, fecundity ranges, and their means are summarized in Table 2.

All the recorded length fecundity (LF) correlations were not significant at p = 0.05. Estimates of "b" ranged from 0.30 in *Tilipia mariae* to 3.265 in *Auchanoglanis occidentalis* (i.e., 10-fold variation), with the mean "b" value of 1.849 (standard deviation = 1.36). The exponential variability in values of "b" showed that the fish population in Ikpoba river had coefficient of variation (cv) = 73.62%, exhibiting high heterogeneous profile. A regression of the fish maximum length (L_{max}) versus length exponent in "b" was not significant (r = 0.424, df = 8, p = 0.05).

Across the five fish populations, for which L_{max} - β data pairs were calculated, a significant inverse relationship existed between L_{max} and "b" (r = 0.570, df = 4, p = 0.05). Values of β (Table 1) were heterogeneous (cv = 90.24%). These varied from β_{min} (minimum slope) of 2.18 (*X. nigri)* to β_{max} (maximum slope) of 142.88 (*M. electricus),* i.e., 65-fold variation, with a mean β of 29.0, which shows that the egg production capacity, in terms of increase in the egg number per cm, increased with body length.

Body condition. The body condition factor determined in this study was the morphological expression of the overall well-being of the fishes (King, 1991). It is an index of fitness of the fish populations and operates on the assumption that heavier the fish for a given length, the better condition (K) it has, and vice versa (Froese and Binohlan, 2002; Bolger and Connolly, 1989). Mean body condition varied remarkably between the species (cv = 59.06%). It ranked lowest in *X. nigri* and the highest in *T. mariae* (Table 2). It had no significant relationship between mean total body length, mean total body weight, and mean absolute fecundity at $p > 0.5$.

Fecundity. The fecundity values of the fish populations examined are shown in Table 2. The mean absolute fecundity varied remarkably among the species (cv = 74.04%). The decreasing order of mean absolute fecundity was *M. electricus* (Malapteruridae) > *T. mariae* (Cichlidae) > *B. longipinnis* (Bagridae) > *X. nigri* (Notopteridae). There was a significant positive relationship between mean absolute fecundity and mean total body weight (df = 4, r = 0.8345, p > 05). There was

Table 1. Length-fecundity relationships and related statistics for fish populations of Ikpoba river, Benin City, Edo State, Nigeria

Fish species/ Family	Number (n)	Length range (cm)	Fecundity min (cm)	Fecundity max (cm)	Fecundity mean (cm)	Length-fecundity parameters b	β	r
Auchanoglanis occidentalis (Family: Bagridae)	8	Tl: 12.2-15.7 Sl: 11.4-13.2	58.89	515.90	189.30	3.265	26.66	0.331
Brycinus longipinnis (Family: Characidae)	31	Tl: 7.9-9.8 Sl: 7.0-9.5	77.19	986.70	477.59	1.733	93.33	0.104
Tilipia mariae (Family: Cichlidae)	9	Tl: 12.2-16.7 Sl: 10.2-13.7	484.30	1191.30	758.72	0.301	9.375	0.080
Malapterurus electricus (Family: Malapteruridae)	11	Tl: 13.5-22.6 Sl: 11.0-19.8	177.60	2822.60	914.97	3.194	142.88	0.601
Xenomystus nigri (Family: Notopteridae)	5	Tl: 11.7-18.4 Sl: 11.2-17.7	49.00	139.00	77.88	0.756	2.18	0.303

b = regression coefficient (intercept on Y-axis); β = slope of regression coefficient; r = correlation coefficient; Tl = total body length; Sl = standard length

Table 2. The means and ranges (in parenthesis) of total length (TL) and total weight (TW), condition factor (K), and fecundity-related observations of fish populations of Ikpoba river, Nigeria

Parameters	*Auchanoglanis occidentalis* (Family: Bagridae)	*Brycinus longipinnis* (Family: Characidae)	*Tilipia mariae* (Family: Cichlidae)	*Malapterurus electricus* (Family: Malapteruridae)	*Xenomystus nigri* (Family: Notopteridae)
TL (cm)	14.11 (12.2-15.7)	8.05 (7.9-9.8)	14.94 (12.2-16.7)	19.36 (13.5-22.6)	15.14 (11.7-18.4)
TW(g)	33.43 (22.74-45.03)	9.72 (7.30-12.92)	77.82 (40.40-94.22)	106.27 (29.28-180.60)	20.82 (10.73-28.05)
Condition factor (K)	1.1900	0.6358	2.3337	1.4645	0.5999
Fecundity (range)	58.89-515.90	77.19-986.70	484.30-1191.30	138.10-2822.60	49.00-139.00
Absolute fecundity (mean)	189	477	758	914	77
Relative fecundity	5	49	9	8	3
Standard fecundity	13	41	50	47	5
Number of specimens examined	25	63	32	25	6
Number of specimens with ripe ovaries	8	31	9	11	5

no significant relationship between the mean absolute fecundity and mean total body length. However, with the exclusion of *X. nigri* and *A. occidentalis,* mean absolute fecundity increased with mean total length from 477 eggs in *B. longipinnis* (8.05 cm) to 914 eggs in *M. electricus* (19.36 cm). These were not statistically significant, which may be due to the small amount of data involved in the computations. For fish of the Ikpoba river, a summary of the degrees of interspecific variations in the species, as measured by coefficient of variation, regarding morphometric and fecundity parameter, is presented in Table 3. Only the body length had values less than 20%, the variation in all other parameters exceeded 60%.

The ability of a fish population to survive to sexual maturity and contribute to the gene pool is a measure of its fitness. Collectively, these surviving individuals show remarkable interspecific variations in total body length and weight of fecund females. This variation often determines the level of survival of the entire population. To protect a fish resource, with management regime in the face of unguided exploitations, it is important to relate fecundity variations to niche preference and survival. In this study, there were noticeable interspecific variations in the total body length, weight and fecundity of the sexually (ripe) active females examined. This may impose corresponding differences in resource exploitation pattern and reproductive habitat preference. Related studies have shown that body length and weight are correlates of reproductive investment, sexual maturity and egg production capacity (Fawole and Adewoye, 1998; King, 1991; Bagenal and Braum, 1978; Lagler *et al.,* 1977; Fryer and Iles, 1972). Dajoz (1977) and Wootton (1973) have reported that variations in body size in fish may result in differences in the choice of diet quality and quantity, which in turn may influence their reproductive attributes (maturity size, fecundity, egg size and variability of the eggs). It does imply that the observed interspecific divergence in the size of sexually matured females of the fish population in Ikpoba river could enhance reproductive isolation since reproductive investment and fecundity attributes have been noted to be size dependent.

The interpopulation variability of exponential LFR value of "b" in this study was lower than those reported by King (1997) for some Nigerian fish populations, which were moderately homogeneous. The "b" values of 0.301-3.265 fall below the

Table 3. Interspecific variability in the morphometric parameters and indices of fecundity observations of fish populations of Ikpoba river, Nigeria

Parameters	Coefficient of variation
Mean total length (cm)	18.82%
Mean total weight (g)	82.42%
Mean absolute fecundity	70.78%
Mean absolute fecundity	89.20%
Mean relative fecundity	74.04%
Mean standard fecundity	66.01%

range (1.56-5.77) reported by King (1997). These values also fall outside the values of "b" (2.3 - 5.3) reported by Bagenal (1978) for most fish. Similarly, Kock and Kellermann (1991) recorded "b" = 1.088-6.03 for Antarctic notothenioid fish. The mean of the length exponent "b" is not significantly different, showing that the "Cube Law" (Bagenal, 1978) can be applied to most of the fish studied. The observation is similar to that reported earlier for some selected Nigerian fish populations by King (1997). The implication, therefore, is that the body volume is an important morphometric determinant for fecundity dynamics in the fish studied.

The result of the regression of fish maximum size (L_{max}) examined versus length exponent in "b" showed that the maximum size of fish had no significant influence on the relative magnitude of the length exponent of the LFR. The inverse relationship exhibited between L_{max} and β suggested that as the maximum body length of the fish increased, the number of egg production also increased. This could be attributed to biomechanism, whereby fish continues to grow even after the fecundity has stabilized, so that the fecundity for a given size appears to decline albeit remaining constant (Bagenal, 1978).

There was a positive allometric functional relationship between the total body weight, condition factor and absolute fecundity. Earlier, Victor and Akpocha (1992) had reported an inverse relationship between the condition factor and length of *Parachanna obscura,* which was similar to the observations in the present study for the dominant fish populations in Ikpoba river, thus suggesting that habitat conditions were unfavorable for the larger length groups.

There was no significant relationship between the absolute fecundity and total body length in the present study. Fish species of the same length or weight had variable fecundities. Bagenal (1957) had earlier reported a wide variation in fecundity among individuals of the same fish species, with regard to size and age. The absence of any interspecific increase in absolute fecundity with total length of cichlids was similar to the observation of Nwadiaro (1987) for cichlids of the Sombrerio river. A comparison of the absolute fecundity values for some fish populations (*T. mari*ae and *M. electricus)* in this study with other related studies showed that the values reported by King (1998; 1996), Nwadiaro (1987), and Camara (1984), for *T. mariae* were higher than the values reported in the present study for the same species. However, the values reported in this study were higher than the reports of Adebisi (1987) for the five species. Fecundity values as reported by King (1998) for *M. electricus* were higher than those reported in this study, but the values from this study were higher than the observations of Okon (1994) for the same species in Ikpoba river. The relative fecundity data also followed the same pattern as the absolute fecundity. From the comparison and data available in this study, it would appear that a wide range of egg production occurred in different fish populations of the species stu-died. Several studies have reported that interpopulation disparity in egg production capacity is attributable to several fecundity related factors such as size of specimen, growth dynamics, and food resource conditions (King, 1998; 1996; Alvarez-Lajonchere, 1982; Bagenal and Braum, 1978; Bagenal, 1978; Dajoz, 1977; Wootton, 1973). Bagenal (1969; 1966) further suggested that variations in fecundity may be due to differential in the abundance of food.

The assumption of the domineering role of nutritional resources in regulating variations in fecundity (Leveque, 1997; Dajoz, 1977; Wootton, 1973), where fish in "good" body condition would be expected to have larger egg output than those in "poor" body condition (Baltz and Moyle, 1982), did not apply in this study, suggesting that other factors were more critical. Undeniably, fish ecological and fishery management experts have established a strong relationship between morphological and ecological similarities (Watson and Balon, 1984). It was assumed that the morphological similarity between species should lead to similar pattern of the same resource-exploitation and habitat preference. This suggests that resource use competition should be higher in morphologically similar species and linked to the behavioural pattern.

The significant level of divergence in morphological and reproduction character observed in this study appears to enhance minimization of intense resource competition and stable coexistence.

References

Adebisi, A.A. 1987. The relationships between the fecundities, gonadosomatic indices and egg sizes of some fishes of Ogun River, Nigeria. *Arch. Hydrobiol.* **111:** 151-156.

Akintunde, E.A., Imevbore, A.M.A. 1979. Aspects of the biology of Cichlid fishes of Lake Kainji, with special reference to *Sarotherodon galilaeus. Nig. J. Natural Sci.* **1:** 35-39.

Alvarez-Lajonchere, L. 1982. The fecundity of mullet (Pisces, Mugilidae) from Cuban waters. *J. Fish Biol.* **21:** 607-613.

Bagenal, T.B. 1978. Aspects of fish fecundity. In: *Ecology of Freshwater Fish Production*, S.D. Gerking (ed.), pp. 75-101, Blackwell Scientific Publications, Oxford, UK.

Bagenal, T.B. 1969. Relationship between egg size and the survival in brown trout (*Salmo trutta*). *J. Fish Biol.* **1:** 349-353.

Bagenal, T.B. 1966. The ecological and geographical aspects of the fecundity of the plaice. *J. Marine Biol. Assoc.* **46:** 161-168.

Bagenal, T.B. 1957. Annual variation in fish fecundity. *J. Marine Biol. Assoc.* **36:** 377-382.

Bagenal, T.B., Braum, H. 1978. Eggs and early life history. In: *Methods for Assessment of Fish Production in Freshwater*, T.B. Bagenal (ed.), pp. 165-101, IBP Handbook No. 3, Blackwell Scientific Publications, Oxford, UK.

Balarin, D. 1979. *Tilipia: A Guide to Their Biology and Culture in Africa,* pp. 1-175, Unit of Aquatic Pathobiology, University of Stirling, Stirling, Scotland.

Baltz, D.M., Moyle, P.B. 1982. Life history characteristics of tule parch (*Hysterocarpus traski*) populations in contrasting environments. *Environ. Biol. Fish* **7:** 227-242.

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

Burchard, J. 1967. The Family Cichlidae. In: *Fish and Fisheries of Northern Nigeria*, pp. 123-143, Ministry of Agriculture, Northern Nigeria.

Camara, O. 1984. Fecondite et Maturite du *T. mariaei* (Pelmatotilipia) et Essai d'Elevage Semi-Intensif du *O. niloticus* et *T. galiea* en Polyculture en Eau Douce a Okigwe. *M. Tech. Thesis*, African Regional Aquaculture Centre, Aluu, Port Harcourt, Nigeria.

Coastes, D. 1988. Length dependent changes in egg size and fecundities in females and brooded embryo size in males of fork tailed catfishes (Pisces: Ariidae) from the Spark River, Papua New Guinea, with some implications for stock assessment. *J. Fish Biol.* **33:** 455-464.

Dajoz, R. 1977. *Introduction to Ecology,* pp. 1-416, Hodder and Stoughton, London, UK.

Eghaboh, O.T. 1998. Studies on the Relationship Between Heavy Metals (Lead and Copper) and Cations (Monovalent and Divalent) in Three Fish Species in Ikpoba River. *B.Sc. Dissertation,* pp. 1-42, The University of Benin, Benin City, Nigeria.

Ezemonye, L.I.N. 1992. Heavy Metal Concentrations in Water, Sediments and Selected Fish Fauna, in Warri River and its Tributaries. *Ph.D Thesis,* pp. 1-199, The University of Benin, Benin City, Nigeria.

Ezemonye, L.I.N., Oshiokpekhai, A.J. 1999. Studies on the dynamics of fish population indices using the length-weight relationship (LWR) of *Tilipia zilli* in Ikpoba and Ovia Rivers, Edo State, Nigeria. *Tropical J. Environ. Sci. Health* **2:** 76-80.

Fagade, S.O. 1979. Observations on the biology of two species of *Tilipia* from the Lagos Lagoon, Nigeria. *Bull. Inst. Fond. Afr. Roiro (Ser. A.)* **41:** 627-658.

Fagade, S.O. 1978. On the biology of *Tilipia guinensis* from the Lekki Lagoon, Lagos State, Nigeria. *Nig. J. Sci.* **12:** 85-89.

Fawole, O.O., Adewoye, S.O. 1998. The length-weight relationship, condition factor and fecundity of the Cichlid, *Tilipia zillia* in Oba Reservior, Ogbomosho, Nigeria. *Nig. Biosci. Res. Commun.* **10:** 101-106.

Fischer, R., Bianchi, G. 1984. *FAO Species Identification Sheets for Fishery Purposes, Western Indian Ocean (Fishing Areas 51)*, pp. 1-6, Food and Agricultural Organization, United Nations, Rome, Italy.

Froese, R., Binohlan, C. 2002. Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. *J. Fish Biol.* **56:** 758-773.

Fryer, G., Iles, T.D. 1972. *The Cichlid Fishes of the Great Lakes of Africa*: *Their Biology and Evolution,* pp. 1-641, Oliver and Boyd, Edinburgh, UK.

Fufeyin, T.P. 1994. Heavy Metal Concentrations in the Water Sediments and Fish Species of the Ikpoba Reservoir in Benin, Benin City, Nigeria. *Ph.D Thesis*, University of Benin, Benin City, Nigeria.

King, R.P. 1998. Weight-fecundity relationship of Nigeria fish population. *Worldfish Centre Quarterly* **29:** 33-36.

King, R.P. 1997. Length-fecundity relationship of Nigerian fish population. *Worldfish Center Quarterly* **20:** 29-33.

King, R.P. 1996. Ecomorphological correlates of interspecific plasticity in reproduction investment and egg production of some Cichlid fishes (Cichlidae) of a Nigerian rainforest stream. *Arch. Hydrobiol.* **136:** 576-587.

King, R.P. 1991. Some aspects of the reproductive strategy of the *Ilisha africana* (Bloch, 1795) (*Teleostei clupeidae*) in Qua Iboe Estuary, Nigeria. *Cybium* **15:** 239-257.

Kock, K.H., Kellermann, A. 1991. Reproduction in aquatic notothenioid fish. *Antarctic Sci. Journal* **3:** 125-150.

Komolafe, O.O., Arawomo, G.A.O. 1998. Reproduction of *Oreochromis niloticus* (Linnaeus) in Opa Reservior, Ile-Ife, Nigeria. *Biosci. Res. Commun.* **10:** 167-174.

Lagler, K.F., Bardach, J.E., Miller, R.R., Passino, D.R.M. 1977. *Ichthyology,* pp. 1-506, 2nd edition, John Wiley and Sons, New York, USA.

Leveque, C.L. 1997. *Biodiversity Dynamics and Conservation: The Freshwater Fish of Tropical Africa*, pp. 1-438, Cambridge University Press, UK.

Leveque, C.L., Pauley, D., Teugels, G.G. 1992. *Faune Des Poisons d'eaux et Saumatres de l' Afrique de l'Quest (Tome 2)*, pp. 1-902, Orstom et Mrac, Paris, France.

Lowentin, R.C. 1966. On the measurement of relative variability. *Systematic Zoology* **15:** 141-142.

Mareus, C.Y. 1982. The Biology of *Ilisha africana* (Blach) of the Nigerian Coast. *Ph.D. Thesis*, University of Lagos, Lagos, Nigeria.

Mgbenekan, B.O., Eyo, J.E. 1992. Aspects of the biology of *Clarias gariepinus,* Anambra River Basin. 2. Maturation and condition factor. *J. Sci. Agric. Technol*. **2:** 52-55.

Nikolsky, G.V. 1963. The Ecology of Fishes, pp. 1-352, Academic Press Inc., Ltd., London, UK.

Nwadiaro, C.S. 1987. Fecundity of Cichlid fishes of the Sombreiro River in the lower Niger Delta, Nigeria. *Rev. Zool. Afr*. **101:** 433-437.

Nwadiaro, C.S., Okorie, P.U. 1986. Some aspects for the reproductive biology of *Chrysichthys filamentosus* Boulenger, 1912 (Siluroidi, Bagridae) in Oguta Lake, Imo State, Nigeria. *Rev. Zool. Afr*. **99:** 233-241.

Oguzie, F.A. 1996. Heavy Metals in Fish Water and Effluent of the Lower Ikpoba River in Benin. *Ph.D. Thesis,* The University of Benin, Benin City, Nigeria.

Okon, E.E. 1994. Some Aspects of the Feeding Habits and Reproductive Biology of *Malapterurus electricus* and *Auchanoglanis occidentalis* in Akpa Atak Eka Streams in Uyo. *B.Sc. Thesis*, University of Uyo, Nigeria.

Omoregie, E., Ufodike, E.B.C., Jauro, I.A. 1998. Variations in fecundity and fertility of the common carp primed with pituitary extracts of carps, *Tilipia* and *Clarias*. *J. Aqua. Sci.* **13:** 15-18.

Pullin, R.S.V., Lowe-McConnell, R.H. (eds.). 1982. The biology and culture of tilipias. In: *ICLARM Conference Proceedings 7,* International Center for Living Aquatic Resources Management, Manila, Philippines.

Reed, W., Burchard, J., Hopson, A.J., Jennes, J., Yaro, I. 1967. *Fish and Fisheries of Northern Nigeria*, Ministry of Agriculture, Northern Nigeria.

Roff, D.A. 1986. Predicting body size with life history models. *Bioscience* **36:** 316-323.

Teugels, G.G., Reid, G., King, R.P. 1992. Fishes of the Cross River Basin (Cameroon - Nigeria): taxanomy, zoogeography, ecology and conservation. *Musee Royal De L'Afrique Centrale, Tervuren, Belgique, Annales Sci. Zoologiques* **266:** 132.

Victor, R., Akpocha, B. 1992. The biology of Snakehead, *Channa obscura* (Gunther), in a Nigerian pond under monoculture. *Aquaculture* **101:** 17-24.

Watson, D.J., Balon, E.K. 1984. Ecomorphological analysis of fish taxocenes in rainforest streams of Northern Borneo. *J. Fish Biol.* **25:** 371-384.

Wootton, R.J. 1973. The effect of size of food ration on egg production in the female three-spined stickleback, *Gasterosteus aculeatus* L. *J. Fish Biol.* **5:** 89-96.