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LENGTH-WEIGHT RELATIONSHIP OF EIGHT FISH SPECIES FROM THE CROSS RIVER, NIGERIA

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ABSTRACT

Pair-wise length-weight data for eight species of fish from the Cross River estuary were analysed using linear regression procedure. The estimated coefficients are within the expected range for teleost. The potential application of these results are also elucidated.

INTRODUCTION

Out of about 25,000 known species of fish in the world, Fishbase- 99 (an electronic encyclopedia on fish, published by the International Centre for Living Aquatic Resource Management (ICLARM) contains information on about 23,000 species. Exactly 758 of these species covered in Fishbase are from the Nigerian waters. For the Cross River System, Fishbase has information on 25 species only.

In the Cross River estuary, the artisanal gill-net fisheries exploit more than 28 fish species (Uweh-Bassey 1988) and the idustrial trawlers exploit about 23 species (Lowenbeng and Kunzel 1991). Considering that most of the entries in Fishbase on species from the Cross River are not on the quantitative aspect of fish biology; this paper seeks to fill this gap in knowledge by providing quantitative information on the length-weight relationship (LWR) of eight fish species caught from the Cross River System.

MATERIALS AND METHODS

The LWR in fishes usually takes the form

$$W = aL^b \qquad \ldots(1)$$

Where W = the body weight of the fish, a = multiplicative factor, L = linear measure (e.g. total length or fork length of fish body), and b = an exponent usually close to 3 (Bertalanffy 1951) but which may range from 2.5 to 3.5 (Carlendar 1969, 1979) or in exceptional cases from 2 to 4 (Pauly and Gayanilo 1997).

Estimating the parameters of Equation 1 was done in 3 different ways.

(1) **Non-linear fitting technique**: In this method the length-weight (LW) data pairs were fitted to Equation 1 directly through a non-linear iterative procedure (Press *et. al 1986*) which employed the quasi-Newton algorithm.

(2) **Log transformed data, ln with correction:** In this procedure, the LW data pairs are transformed into their logarithm values before being fitted to Equation 2 using least square method.

$$\text{Log}W = \log a + b\log L \qquad \ldots(2)$$

Log transformation of the data introduces systemic bias into the procedure. Such errors were corrected by the method of Sprugel (1983) by multiplying the coefficient with a correction factor (CF):

$$CF = \exp(SEE^2/_2) \qquad \ldots(3)$$

Where

$$SEE = \sqrt{(\{\sum \log Y_i - \log y^2/(N{-}{-}2)\}} \qquad \ldots(4)$$

Here SEE = the standard error of estimate, $\log Y_i$ = the log-transformed values of the dependent variable, logY = the corresponding predicted values from

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Equation 2. The SEE must be converted to base e (by multiplying by 2.303) before being used in Equation 3.

(3). **Log transformation with no correction.** This is the same as method (2) above, but with no correction.

Tucked away, often, in the appendix sections of many (undergraduate) research theses are usually an array of unanalysed (or poorly analysed) data e.g. on the length and weight of the fish studied. All the data used for this analysis came from such sources (see DATA SOURCES below). These analyses were done using Abee Software (Pauly and Gayanilo 1997).

Table 1: Coefficients of the length-weight equations $W = aL^b$ for eight species of fish from the Cross River estuary. (As SE = Asymptotic Standard error, cv = coefficient of variation, Cl = Confidence Interval, A- r^2 = adjusted r^2)

Species, Sample Size, Source	Non-linear fit	Log transformed, Ln with correction	Log transformed $\log_{10}$ no correction
Arius heudeloti n = 193 Ekpenyong 1980	a = 0.0007 ASSE = 0.0002 Cv = 0.24 b = 3.646 ASSE = 0.0002 Cv = 0.0596 r^2 = 0.97162 A-r^2 =0.97133	a = 0.0286 ASSE = 0.2386 Cl = 0.0179-0.0455 b 2.671 SE = 0.0721 Cl = 2.5927-2.8118 r^2 = 0.8767 Cl = 0.9148-0.9504	a = 0.02479 SE = 0.1036 Cl = 0.0155 – 0.0396 b = 2.671 SE = 0.07208 Cl = 2.529-2.812 r^2 = 0.8767
Chrisichthys nigrodigitatus n=200 Ekpenyong 1980	a = 0.0006 ASSE = 0.0002 Cv = 0.2584 b = 3.7085 ASSE = 0.0598 cv = 0.0161 r^2 = 0.93916 A-r^2 =0.93854	a = 0.00215 SE = 0.1586 Cl = 0.0016 – 0.0029 b = 3.369 SE = 0.04343 Cl = 3.283-3.4538 r^2 = 0.9681 Cl = 0.9788-0.9878	a = 0.00209 SE = 0.0689 Cl = 0.0015-0.0029 b = 3.369 SE = 0.0434 Cl = 3.2836-3.4538 r^2 = 0.968 Cl = 0.9788-0.9878
Chrisichthys nigrodigitatus n=63 Etim 1980	a = 0.0219 ASSE = 0.0057 Cv = 0.2614 b = 2.9513 ASSE = 0.0750 cv = 0.0254 r^2 = 0.97575 A-r^2 =0.97494	a = 0.02009 SE = 0.25567 Cl = 0.0120-0.0335 b = 2.984 SE = 0.08423 Cl = 2.81585-3.15227 r^2 = 0.9536 Cl = 0.9614-0.98586	a = 0.01921 SE = 0.11104 Cl = 0.0115-0.032 b = 2.984 SE = 0.08423 Cl = 2.81585-3.15227 r^2 = 0.9126 Cl = 0.9421-0.9671
Ethmalosa fimbriata n = 113 Uwe – Bassey 1982	a = 0.0203 ASSE = 0.0085 Cv = 0.4220 b = 3.0299 ASSE = 0.1387 cv = 0.0458 r^2 = 0.85255 A-r^2 =0.84987	a = 0.02006 SE = 0.32758 Cl = 0.0106-0.0381 b = 3.041 SE = 0.11127 Cl = 2.82288-3.25904 r^2 = 0.87062 Cl = 0.9049-0.95346	a = 0.01941 SE = 0.14226 Cl = 0.0102-0.0369 b = 3.041 SE = 0.11127 Cl = 2.829-3.259 r^2 = 0.88 Cl = 0.9012-0.9541
Ethmalosa fimbriata n = 94 Etim 1982	a = 0.0242 ASE = 0.011 Cv = 0.4525 b = 2.975 ASE = 0.150 cv = 0.05 r^2 = 0.86575 A-r^2 =0.8628	a = 0.01123 SE = 0.34021 Cl = 0.0057-0.0221 b = 3.247 SE = 0.11798 Cl = 3.0119-3.4815 r^2 = 0.8917 Cl = 0.9171-0.9627	a = 0.01073 SE = 0.1478 Cl = 0.0055-0.0211 b = 3.247 SE = 0.11798 Cl = 3.0119-3.482 r^2 = 0.892 Cl = 0.91714-0.9627
Hepsetus odoe N = 48 Ologunmeta 1981	a = 0.0049 ASSE = 0.0001 Cv = 0.195 b = 3.3358 ASSE = 0.065 cv = 0.0196 r^2 = 0.9851 A-r^2 =0.98448	a = 0.0063 ASSE = 0.2018 Cl = 0.0042-0.0095 b = 3.249 ASSE = 0.07253 Cl = 3.103-3.3964 r^2 = 0.9776 Cl = 0.97988-0.993770	a = 0.00628 SE = 0.08765 Cl = 0.0042-0.0094 b = 3.25 SE = 0.07253 Cl = 3.103-3.3963 r^2 = 0.9776 Cl = 0.9798-0.9937
Polydactylus quadrifilis N=50 Isong 1980	a = 0..0265 ASSE = 0.0120 Cv = 0.4526 b = 2.8357 ASSE = 0.1326 cv = 0.0468 r^2 = 0.9193 A-r^2 =0.91587	a = 0.01287 SE = 0.4299 Cl = 0.0054-0.0307 b = 3.059 SE = 0.13404 Cl = 2.7878-3.29 r^2 = 0.9156 Cl = 0.9248-0.9754	a = 0.0124 SE = 0.1867 Cl = 0.0052-0.0296 b = 3.059 SE = 0.134 Cl = 2.7877-3.329 r^2 = 0.9156 Cl = 0.9248-0.9754
Polydactylus quadrifilis N=199 Ojong 1994	a = 0.0147 ASSE = 0.0065 Cv = 0.4396 b = 2.9115 ASSE = 0.1024 cv = 0.0352 r^2 = 0.8899 A-r^2 =0.8887	a = 0.01304 SE = 0.21406 Cl = 0.0086-0.0198 b = 2.865 Cl = 2.738-2.992 r^2 = 0.953 Cl = 0.954-0.9868	a = 0.001175 SE = 0.09296 Cl = 0.0077-0.0179 b = 2.865 SE = 0.0647 Cl = 2.738-2.992 r^2 = 0.953 Cl = 0.954-0.9868

TABLE 1 CONTD.

Pomadasys jubelini N=50 Isong 1980	a = 0.0435 ASSE = 0.0126 Cv = 0.2898 b = 2.8652 ASSE = 0.1028 cv = 0.0359 r^2 = 0.9455 A-r^2 =0.94319	a = 0.0332 SE = 0.2495 C1 = 0.0201-0.0549 b = 2.966 SE = 2.966 C1 = 2.776-3.1558 r^2 = 0.954 C1 = 0.959-0.9868	a = 0.0328 SE = 0 10836 C1 = 0.0198-0.543 b = 2.966 SE = 0.094 C1 = 2.776-3.1558 r^2 = 0.954 C1 = 0.9595-0.9868
Pseudotolithus elongatus N = 62 Achima 1992	a = 0.0022 ASSE = 0.0007 Cv = 0.3246 b = 3.3732 ASSE = 0.0905 cv = 0.0268 r^2 = 0.95383 A-r^2 =0.95226	a = 0.00853 SE = 0.35349 C1 = 0.0042-0.0173 b = 2.991 SE = 0.10223 C1 = 2.78696-3.19586 r^2 = 0.93452 C1 = 0.94514-0.97988	a = 0.00844 SE = 0.15352 C1 = 0.0042-0.0171 b = 2.991 SE = 0.10223 C1 = 2.78696-3.19586 r^2 = 0.91419 C1 = 0.9424-0.96664
Pseudotolithus typus N=171 Ogozi 1980	a = 0.0968 ASSE = 0.0255 Cv = 0.2637 b = 2.2387 ASE = 0.0744 cv = 0.0332 r^2 = 0.84619 A-r^2 =0.84436	a = 0.15928 SE = 0.24145 C1 = 0.0992-0.2557 b = 2.099 SE = 0.07035 C1 = 1.96081-2.23659 r^2 = 0.08404 C1 = 0.8889-0.93779	a = 0.15613 SE = 0.10486 C1 = 0.0973-0.2506 b = 2.099 SE = 0.07035 C1 = 1.9608-2.23659 r^2 = 0.91419 C1 = 0.9424-0.96664

RESULTS AND DISCUSSION

Table 1 contains the calculated values of the regression coefficients (a and b) together with r the correlation coefficients. Other associated statistics, notably coefficient of variation, asymptotic standard error, adjusted r, and confidence intervals, are also given. The allometric parameters, a and b, could vary according to the time of sample collection. Significant test would not be very useful since it would be difficult to separate the components of variation due to time. So no significant test were conducted since the samples were collected at different seasons and often many years apart. Whatever, the results in Table 1 are new because the original data were never subjected to this kind of anlaysis. Although 3 different methods were used, invariably the results from the non-linear fit were the most bias-free.

There are compilations of the LWR coefficients for 40 fish species from freshwater ecosystems (King 1996a) and for 22 fish species inhabiting coastal/brackish waters (King 1996b) of Nigeria. All the analyses in those compilations were done using method 3 in this study (see this Materials and Methods). I assume that other authors whose results were inco-operated in that compilation also used the same method.

King's (1996b) compilation shows that *C. nigrodigitatus* from the Cross River has b = 3.042 and a = 0.0079. In this study, b = 3.369 and a = 0.00209. For *Ethmalosa fimbriata,* King (1996 b) presents 12 cases (8 for the Cross River and 4 for coastal waters off Akwa Ibom State) and mean b = 3.0143 (range 3.38 to 2.7). For the 8 cases in the Cross River, mean a = 0.024987 and mean b= 2.905. The mean b = 3.144 and mean a = 0.01507 obtained in this study is within the range presented by King (1996b). For *Hepsetus Odoe* in Ikpa river b = 3.376 and a = 0.0022 (King 1996 a). These values are similar to the ones obtained in this study (Table 1).

LWR studies leads to the concept of allometry. The difference in growth rate between one part and the whole organism or between one part and another part considered as a standard is termed allometry of growth (Wilbur and Owen 1964). If b = 3, growth in weight is termed isometric and weight growth is proceeding in the same dimension as the cube of the length. This is what happens in fishes whose body form and specific gravity do not change as it grows (Ricker 1975). If b ≠ 3, then growth in weight is termed allometric as growth proceeds in a different dimension from L^3.

Allometric studies are useful for a variety of purposes. The well known formular for condition index is derived by making *a* the subject of Equation 1 and multiplying it by 100. LWR is used in converting a given weight to length and vice-versa in a fish sample.

LWR finds application in the derivation of the von Bertalanffy model for growth in weight of fishes. The exponent 3 in that model is the *b* coefficient of the LW regression when growth is isometric. The *b* coefficient in LWR is used as an input in the computation of secondary (somatic) production using the method of Crisp (1984).

LWR is useful in the study of sexual dimorphism. For sexually dimorphic species, the b value should be significantly different between males and females. Better still, ANCOVA (Analysis of Covariance) should reveal a significant difference between LW regression lines when there is dimorphism.

LWR helps reveal the ontogenic onset of sexual characters (e.g. in crustaceans). This is usually marked by the position of a kink on the LW regression line. LWR will help in differentiating local forms or races (e.g. the distinction between subtidal and intertidal populations of bivalve) in that the *b* coefficient should be significantly different between such races.

LWR studies is important and should not be seen as a "thing to have your teenage children do as a way of learning about ideas of correlation and regression, and you might find the results mildly useful in estimating average weight of fish caught from samples of length of fish caught" (Hilbron and Walters 1992).

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