# Determination of a method for calculation of Allometric Condition Factor of fish

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**ABSTRACT.** There is no agreement among authors that study fish condition by the allometric method ($K=W/L^b$) with regard to the best procedure for *b* coefficient calculation. Some authors use a constant coefficient for all sub-samples (seasons of the year, for instance), whilst others calculate *b* value for each sub-sample. To demonstrate which of these methods fits better, this study verified that the use of one *b* value for each sub-sample leads to distortion of Condition Factor values. Comparing the two tested methods, it may be concluded that the method which calculates *b* coefficient from groupings of all individuals and uses *b* as a constant value for all sub-samples is the most convenient method to study fish condition.

**Key words:** methods, condition factor, condition index, length-weight relationship, *Hypostomus strigaticeps*.

**RESUMO. Determinação de um método para cálculo do Fator de Condição Alométrico de peixes.** Dentre os trabalhos que objetivam o estudo da condição de peixes com o uso do método alométrico ($K=W/L^b$), não há um consenso sobre o procedimento mais adequado para o cálculo do coeficiente *b*, pois alguns autores utilizam um coeficiente constante para todas as sub-amostras (estações do ano, por exemplo), enquanto outros calculam um valor de *b* para cada sub-amostra. Com a intenção de demonstrar qual desses procedimentos é mais adequado, este trabalho verificou-se que a utilização de um valor de *b* para cada sub-amostra provoca distorções nos valores do Fator de Condição. Conclui-se, então, que o método que calcula o coeficiente *b* a partir do agrupamento de todos os indivíduos e o utiliza com um valor constante para todas as sub-amostras é, dentre os dois procedimentos testados, o mais adequado para estudo da condição de peixes.

**Palavras-chave:** métodos, fator de condição, índice de condição, relação peso-comprimento, *Hypostomus strigaticeps*.

## Introduction

The Condition Factor is a frequently used index for fish biology study, as it furnishes important information related to fish physiological state, based on the principle that individuals of a given length, exhibiting higher weight, are in a better condition. Based on this concept, this index variation during the year has been used as an additional datum to study reproduction and seasonal cycles of feeding processes. Besides, the comparative study of distinct populations permits to evaluate the quality of the environments in which these animals live (Braga, 1986; Bolger and Connolly, 1989).

The method used to calculate the Condition Factor (*K*) was initially described by the expression $K=W/L^3$, in which *W* represents the weight and *L* the individual length. Several authors (Le Cren, 1951; Ricker, 1975; Braga, 1986; Bolger and Connolly, 1989) discuss, however the method's employment, and conclude that it does not permit the comparison of results obtained from individuals with distinct sizes, because the use of the exponent 3, which is not a real representation of the length and weight relationship for the great majority of fish species, results that the fish condition shows a variation in function of their length.

As an alternative, the greater part of the cited authors propose the use of the Allometric Condition Factor by means of the expression $K=W/L^b$, in which *b* is estimated by the length-weight relationship equation ($W=aL^b$), which is adjusted from data of the sampled individuals. However, there is no agreement referring to the ways by which data are gathered for *b* calculation. Some of the authors estimate this coefficient from only one equation, which links all the analysed individuals (Antoniutti *et al.*, 1985; Barbieri and Verani, 1987;

Stergiou, 1993). Others calculate a *b* value to each sub-sample, separating, for instance, individuals from distinct gender (Andrian and Barbieri, 1992), or collected in distinct seasons (Camara *et al.*, 1993).

Current study investigates the possible distortions caused when distinct proceedings are used to calculate *b* coefficient and suggest which is better to study fish condition.

## Material and methods

To fulfill a theoretical discussion, actual data were employed. These came from fish of the species *Hypostomus strigaticeps* (Siluriformes, Loricariidae), caught from the Corumbataí River (22°12'47"S, 47°37'40"W), in the state of São Paulo, Brazil, between June and December 2000. The Standard Length (to the nearest 0.1cm) and Total Weight (to the nearest 0.01g) were obtained from each collected specimen.

In order to get a uniformity of the data related to individual Standard Lengths in all seasonal sub-samples, and thus, a fixed referential to compare the seasonal weight variations to the fish condition (a basic premise to permit an impartial judgment of the distinct methods used to calculate the Condition Factor), the option was to use only data from individuals smaller than 11 cm. Length and weight ranges of the analyzed individuals of each sub-sample are shown in Table 1. Statistical comparison of four sub-samples, referring to these variables - indicating Standard Length homogeneity and Total Weight seasonal variation - is shown in Table 2.

**Table 1.** Number (*n*) and length and weight range of analyzed individuals of each seasonal sub-sample

| Season | *n* | Standard length (cm) range | Total weight (g) range |
|---|---|---|---|
| autumn | 17 | 8.4 - 10.9 | 19.37 - 44.26 |
| winter | 20 | 8.2 - 10.9 | 19.59 - 44.34 |
| spring | 20 | 8.3 - 10.9 | 21.30 - 42.50 |
| summer | 18 | 8.1 - 10.5 | 16.45 - 34.51 |

These data were transformed to natural logarithms and, using the minimum squares method, the *b* value was obtained (from the expression $W=aL^b$) in two distinct ways: (1) grouping all 75 analysed individuals, and (2) separating them for each season. Their Allometric Condition Factor ($K=W/L^b$) was then calculated by using *b* obtained in both ways. Results in each season for these indexes (such as the variables Standard Length and Total Weight) were confronted, using the Kruskal-Wallis test and, when necessary, the multiple comparisons *a posteriori* method (Campos, 1983), adopting $\alpha=0.05$.

## Results

Figure 1 and Table 2 indicate that the seasonal sub-samples did not show significant fish Standard Length differences. Rather their Total Weight showed statistically smaller values during summer, when compared to those of other seasons.

Adjusted equation of length-weight relationship for all grouped individuals is the following:
$W = 0.0481\ L^{2.833}$

The equations of the length-weight relationship adjusted to individuals separated for each season are the following:
autumn: $W = 0.0302\ L^{3.040}$
winter: $W = 0.0750\ L^{2.653}$
spring: $W = 0.0848\ L^{2.596}$
summer: $W = 0.0904\ L^{2.515}$

Data in Figure 2 and Table 2 show that the Condition Factor obtained from the use of *b* with a constant value for all the seasons varies as fish weights. On the other hand, the use of distinct *b* values for the seasons implied different directions for variations of condition factor and body weight of fish.

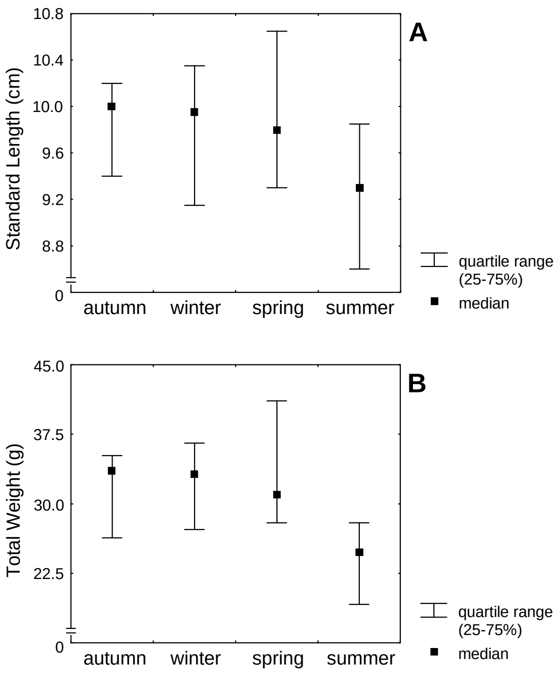


**Figure 1.** Medians and quartile ranges of Standard Length (A) and Total Weight (B), verified at each seasonal sub-sample

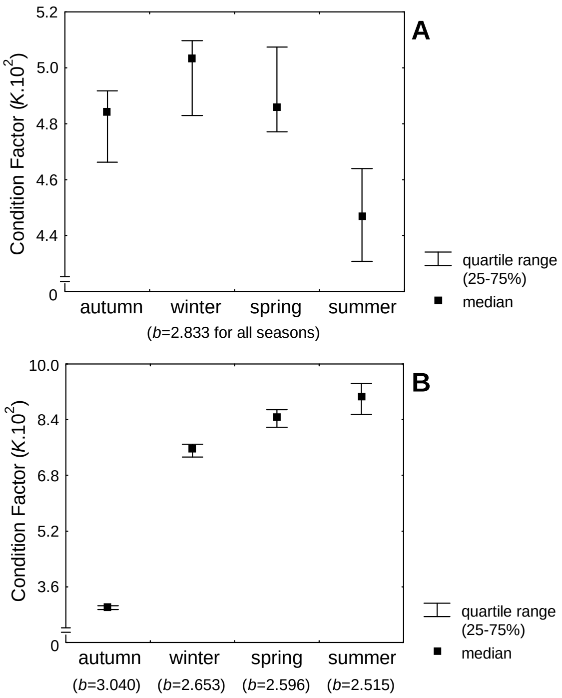


**Figure 2.** Median and quartile ranges verified at each seasonal sub-sample for the Condition Factor. In A, this index was calculated using a unique value of *b* for the four seasonal sub-samples. In B, the value of *b* varied in each sub-sample

**Table 2.** Statistical comparison (Kruskal-Wallis test) of the Standard Length, Total Weight and Condition Factor (with constant and seasonal *b*) among the sub-samples ($\alpha$=0.05)

| | Standard Length | Total Weight | Condition Factor (constant *b*) | Condition Factor (seasonal *b*) |
|---|---|---|---|---|
| Autumn *versus* winter | $P>0.05$ (ns) | $P>0.05$ (ns) | $P>0.05$ (ns) | $P<0.05$ (*) |
| Autumn *versus* spring | $P>0.05$ (ns) | $P>0.05$ (ns) | $P>0.05$ (ns) | $P<0.05$ (*) |
| Autumn *versus* summer | $P>0.05$ (ns) | $P<0.05$ (*) | $P<0.05$ (*) | $P<0.05$ (*) |
| Winter *versus* spring | $P>0.05$ (ns) | $P>0.05$ (ns) | $P>0.05$ (ns) | $P<0.05$ (*) |
| Winter *versus* summer | $P>0.05$ (ns) | $P<0.05$ (*) | $P<0.05$ (*) | $P<0.05$ (*) |
| Spring *versus* summer | $P>0.05$ (ns) | $P<0.05$ (*) | $P<0.05$ (*) | $P>0.05$ (ns) |

ns: no significant differente; * significant differente

## Discussion

The analysis of the expression used to calculate the Allometric Condition Factor ($K=W/L^b$) indicates that the condition (*K*) and weight (*W*) should be directly proportional. Consequently, the higher the weight of individuals with the same length, the higher their Condition Factor (Bolger and Connoly, 1989). From such concept, one may conclude that, since individuals in a sample show no statistically distinct lengths, the Condition Factor variation should follow the weight variation of these individuals.

Results shown here indicate that, from both methods, only the one in which the *b* coefficient was used as a constant value for four seasons is adequate, since it reproduced the expected results using length and weight data. The second method, in which *b* for each season was used, resulted in incoherence with the reasoning presented in the above paragraph.

This fact may be mathematically explained if one compares, for instance, the spring and summer data. One observes that in the latter the animals showed lower weight, while their lengths were not significantly distinct to those during spring. Consequently, the construction of the length-weight curve ($W=aL^b$), using data of the individuals collected during summer, has given a numerically lower *b* value. When this coefficient (*b*) was applied in the denominator of the Condition Factor expression, it caused a distortion of results. As a consequence, condition of these individuals showed much higher values than those expected by the length and weight data analysis.

Considering that this discussion is based only on the mathematic relation among the variables in the expression $K=W/L^b$, and that it does not depend on the criteria used for sub-samples separation, one may infer that the use of a *b* coefficient value for each sub-sample related to sex, sexual maturity or place of collections, for instance, also produces distorted results, and the distortion grade will be directly proportional to the difference of *b* values.

Another way to calculate the condition of animals from distinct sub-samples consists in assuming that the constant *a* of the length-weight relationship ($W=aL^b$) is numerically equal to the Condition Factor, once $a=W/L^b$ (Braga, 1986, 1993). Such a method is, however, based on the length-weight relationship curve adjustment for each sub-sample, and indirectly admits the use of a variable value of *b*. As a corroboration of such reasoning, it was observed that the equations of the length-weight relationship, when adjusted separately by season, presented numerically equal regression coefficients (*a*) to the Condition Factor medians shown in Figure 2B.

In the case in which distinct sub-samples present very near *b* values, the results obtained by any of the tested methods application would be basically similar, once the distortion condition values grade is directly proportional to the difference of *b* values. In the same way, however, as the expression $K=W/L^3$ has been criticized due to the fact that its premise is not always correct for most fish species ($b=3$), one may suggest that the method based on direct or indirect calculation of the *b* value for each sub-sample should be replaced by the other method tested in this study. However, it should be emphasized that, since the purpose of a study may be distinct to that in which the individuals condition is to be analysed, the *b* coefficient may be calculated independently for each sub-sample, as a way to determine the length-weight relationship parameters for individuals in each one of them.

## Conclusion

The most convenient procedure for studying fish Condition Factor, among those investigated in this study, consists in using the *b* coefficient, calculated from a unique assemblage that links all the individuals, with a constant value for all sub-samples (individuals collected in distinct seasons, or belonging to distinct gender, for example).

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