

## Length-weight relationship and condition factor of *Curimata inornata* Vari, 1989 in four different water bodies in the State of Amapá, Brazil

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**ABSTRACT:** The condition factor is an index that indicates the fish welfare status in relation to the environment where it lives and reflects recent nutritional conditions and/or usage of reserves in cyclic activities. It is also possible to relate the condition factor to environmental conditions and to behavioral aspects of the species. The Curimatidae is a family of detritivorous fishes distributed in the Amazon Basin, with species alternating between the upper, middle, and lower Amazon and its tributaries. With the aim of investigating whether different environmental conditions may interfere in any way in the populations of *Curimata inornata* present in the state of Amapá we used 658 individuals from two quarterly sampling programs. The Vila Nova, Matapi Rivers and the Igarapé da Fortaleza were sampled quarterly between March and December 2001 and the Araguari River between November 2011 and March 2013. The length-weight relationship and the condition factor were calculated for each sampling point and for the different seasons of the hydrological cycle of the water bodies. The allometry coefficient values followed an increasing trend in terms of the conservation degree of the rivers under analysis. The condition factor of the individuals showed no correlation with the hydrological regime of the water bodies. Thus, the population structure of *C. inornata* in the rivers under study was highly impacted by the environmental conservation degree, but the hydrological regime of the water bodies did not influence the population structure.

**Keywords:** Length-weight relationship, condition factor, Curimatidae, Amapá.

### Relação peso comprimento e fator de condição de *Curimata inornata* Vari, 1989 em quatro diferentes corpos d'água no Estado do Amapá, Brasil

**RESUMO:** O fator de condição é um índice que indica o grau de bem estar do peixe frente ao ambiente em que vive e reflete aspectos nutricionais recentes e/ou gastos de reservas em atividades cíclicas, sendo possível, relacioná-lo às condições ambientais e aos aspectos comportamentais das espécies. Os curimatídeos são peixes detritívoros distribuídos na bacia amazônica, com espécies se alternando entre o alto, médio e baixo Amazonas e seus tributários. Foram utilizados dados de captura de quatro corpos d'água do Estado do Amapá. Foram utilizados 658 exemplares de *Curimata inornata*, provenientes de dois programas de amostragens trimestrais. Os rios Vila Nova, Matapi e o Igarapé da Fortaleza foram amostrados trimestralmente entre março e dezembro de 2001 e o rio Araguari entre novembro de 2011 e março de 2013. A relação peso-comprimento e o fator de condição (K) foram calculados para cada ponto amostral e para as diferentes estações do ciclo hidrológico dos corpos d'água, inverno e verão. Os valores do coeficiente de alometria encontrados nos diferentes corpos d'água segue uma tendência crescente quanto ao grau de preservação dos rios analisados. O fator de condição dos indivíduos não apresentou relação com o regime hidrológico dos corpos d'água. A estrutura populacional de *Curimata inornata* nos rios estudados sofre então uma grande interferência quanto ao grau de preservação do ambiente, sendo o regime hidrológico dos corpos d'água não determinantes para sua composição populacional.

**Palavras-chave:** Relação peso-comprimento, fator de condição, Curimatidae, Amapá.

### 1. Introduction

Information regarding the population structure of economically important fish is an essential tool in the management of natural resources. Population conditions such as population structure and density are relevant data and serve as bases for the monitoring of population behavior in subsequent moments (AGUIAR, 2005), especially for the evaluation of possible impacts caused by increased human activity and development in areas close to water bodies.

The length-weight relationship is an easy and quick way of describing fish growth, without taking into account its age. It has been used to convert length into weight, using the length or vice versa (NOMURA, 1962) as one of the steps to study the condition factor (BRAGA, 1986, 1993, 1997). This parameter is an important and efficient tool to highlight changes in fish conditions over time and can be used to monitor reproduction, feeding, and accumulation of fat

(GOMIERO and BRAGA 2003, 2005, 2006), as well as seasonal changes in the environmental conditions (BRAGA et al., 1985).

Therefore, the length-weight relationship is crucial for studies on the life cycle of organisms and is frequently used in morphometric comparison between populations (BOLGER and CONOLLY, 1989).

The condition factor is a very common index in fisheries biology studies because it indicates the fish welfare status in relation to the environment where it lives (BRAGA, 1986). The condition factor reflects recent nutritional conditions and/or use of reserves in cyclic activities. It is also possible to relate it to environmental conditions and behavioral aspects of the species (VAZZOLER, 1982).

Interspecific and interpopulation morphometric comparisons of fish species can be derived from the allometry coefficient, which indicates any changes in the

ontogenetic development. In addition, this relation may serve as a basis to compare the stress levels or different environment conditions between fish that are characterized by a broad geographic distribution (BOLGER and CONNOLLY, 1989). The species of the family Curimatidae are distributed over the Amazon Basin, with species alternating between the upper, middle, and lower Amazon and its tributaries. These fish are generally detritivorous, consuming most of the organic matter at the bottom of the rivers and on the banks of the water bodies. These fish move around in shoals and undertake migrations with reproductive goals.

Despite its frequent capture through artisanal fishing in inland waters, these fish have no significant economic impact during landing because its market value is relatively low. However, this fish is a common food resource for coastal communities.

The objective of this work was take advantage of data collected in two research projects already carried out for to check if different environmental conditions could interfere in any way in the populations of *Curimata inornata* present in the state of Amapá.

## 2. Materials and Methods

Fish catch data from four water bodies in the state of Amapá was used (Figure 1). The igarapé da Fortaleza is an important water body of the Macapá and Santana municipalities, because it is mainly responsible for the formation of “ressacas” (backwaters) that exist in these municipalities.

The term “ressaca” is a local term used for the various lake valleys that exist in the region. These lakes are formed during the rainy season, which occurs from December to June, and are sustained by rainfall and mainly by the rise in the river level. The “ressacas” contain rich vegetation, and therefore, are less likely to be inhabited by large predators. This environment offers food, shelter, and refuge, forming a protected and favorable environment for the development of young fish.

The Matapi is a large-sized river with white waters in the collecting area; it is strongly influenced by the tidal regime, similar to the other water bodies of the region. The Santana industrial district is located along the margins of this river, with frequent crossing of container ferries and ships occurring long its lower part.

The Vila Nova River has characteristics similar to the Matapi River; however, there are fewer ferries and ships in this region. Both rivers have slurry bottoms and dense vegetation.

In the igarapé da Fortaleza, two areas between the coordinates 00°02,10'S 051° 06,48'W and 00°00,04'S 051° 07,71'W, and 00°02,28'S 051°08,55'W and 00°02,01'S 051°08,72'W were sampled. In the Matapi and Vila Nova Rivers, one point in each river per collection was sampled. In the Matapi River, sampling was performed downstream using the ferry that crosses the river, between the coordinates 00°01,30'S 051°12,43'S and 00°01,70'S 051°12,53'W, as reference. The Vila Nova River was

sampled upstream of the ferry that crosses the river, between the coordinates 00°04,8'S 051°18,32'W and 00°04,49'S 051°17,67'W.



Figure 1. Location of sampling points used. / Figura 1. Localização dos pontos de amostragem utilizados.

The basin of the Araguari River is the largest in the State of Amapá, with an area of approximately 42,710 km<sup>2</sup>. The basin occupies nearly one-third of the total area of the State of Amapá, with an extension of approximately 300 km from its source in the Serra do Tumucumaque to its mouth, which is situated in the Atlantic Ocean (delimited by the coordinates 0° 30' N 51° 00'W and 1° 30'N 52° 30'W). The river has a recognized economic and social relevance because of the construction of the Coaracy Nunes Hydroelectric Power Plant (UHECN), and it is used for fishing. The fish were sampled for this study during the construction of the Ferreira Gomes Hydroelectric Power Plant (UHEFG); which is located downstream of the UHECN.

We assessed 658 *Curimata inornata* individuals from two quarterly sampling programs, both conducted using standardized batteries of gill nets, with a mesh size varying from 15 to 60mm from the distance between the adjacent nodes.]The total length (in millimeters) and weight (in grams) of the fish were recorded, and were fixed in 10% formalin, without sex determination. For the length-weight relationship, the following formula was applied:  $Wt = \alpha Lp^b$  (LE CREN, 1951) where  $Wt$  corresponds to the weight,  $Lp$  is the standard length,  $\alpha$  is the factor related to the degree of fattening of the individuals, and  $b$  is the allometry coefficient, which is associated with the growth pattern of individuals. The  $\alpha$  and  $b$  values were estimated from the method of least squares (prediction model), after Napierian logarithmic transformation of the following equation:  $= \ln \alpha + b \ln Lp$ .

The condition factor (K) was calculated using the expression  $K = Wt/Lp^b$  (SANTOS, 1978) for each sample point and for the different seasons of the hydrological cycle of the water bodies: winter and summer (=flood and drought).

To test whether the samples were from the same population due to the proximity between the water bodies, the non-parametric Kruskal-Wallis test was used, and the Bartlett's variance test was used to verify whether the samples differed among themselves.

The Pearson's correlation coefficient was used to verify the samples with similar characteristics and those distinct from the remaining ones.

### 3. Results

Descriptive statistics from the four analyzed populations are presented in Table 1.

**Table 1.** Descriptive statistics of the sampling locations for *Curimata inornata*. / **Tabela 1.** As estatísticas descritivas dos locais de amostragem de *Curimata inornata*.

Statistics	Fortaleza	Araguari	Matapi	Vila Nova
Observations	219	18	106	301
Minimum	6.687	6.800	6.788	6.515
Maximum	15.610	15.600	13.941	15.140
Range	8.923	8.800	7.153	8.625
Median	11.210	13.000	9.206	10.766
Average	11.220	12.044	9.541	10.733
Variance (n-1)	1.908	7.025	2.946	3.243
Standard deviation (n-1)	1.381	2.650	1.716	1.801
Standard deviation Lp	13.813	2.789	17.714	18.008
Standard deviation Wt	16.249	27.398	15.531	20.060
Coefficient of variation	0.123	0.214	0.179	0.168

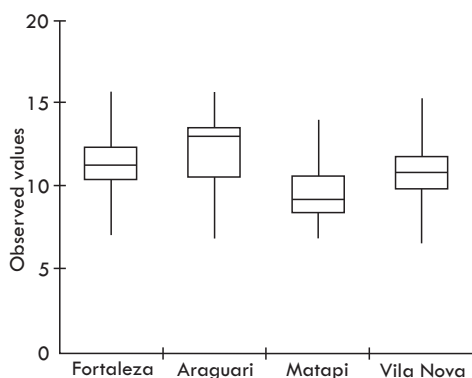
Using the Kruskal-Wallis test ( $K=73.848$ ,  $p<0,0001$ ) and the variance analysis performed by using the Bartlett's test ( $B=7,815$ ,  $p<0,0001$ ), we determined that the samples were from populations with different characteristics in length, which indicates that at least between the closest water bodies, there was no exchange among individuals.

Using the proximity matrices generated by the Pearson's correlation coefficient (Table 2), we determined that the observed difference was attributable to the populations from the Matapi River and the igarapé da Fortaleza.

**Table 2.** Pearson's similarity matrix among the analyzed populations of *Curimata inornata*. / **Tabela 2.** Matriz de similaridade de Pearson entre as populações analisadas de *Curimata inornata*.

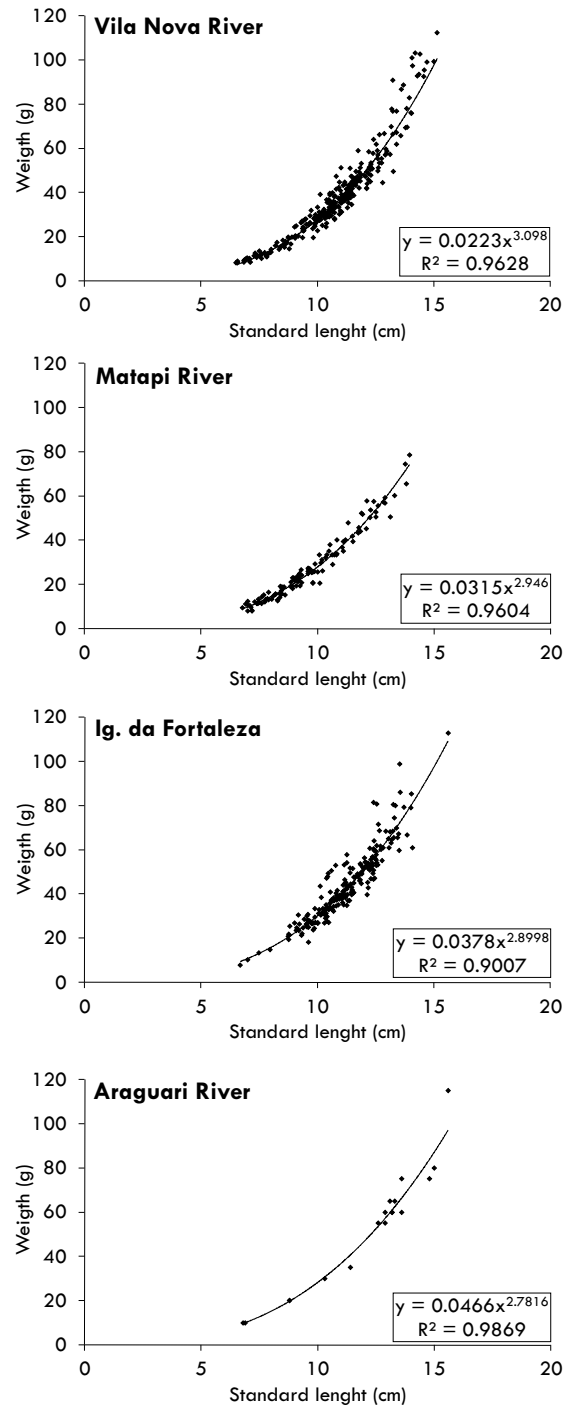
	Fortaleza	Araguari	Matapi	Vila Nova
Fortaleza	1	0.955	0.877	0.907
FG	0.955	1	0.933	0.952
Matapi	0.877	0.933	1	0.978
Vila Nova	0.907	0.952	0.978	1

Figure 2 shows the differences in size among the group of populations examined. We observed that the population of the Matapi River was totally different from that of the igarapé da Fortaleza, whereas a size overlap was observed among the populations of the Matapi, Vila Nova, and Araguari Rivers.



**Figure 2.** Box-plot of the observed values of standard length between populations *Curimata inornata*. / **Figura 2.** Box-plot dos valores observados de comprimento padrão entre as populações *Curimata inornata*.

The length-weight relationship of *Curimata inornata* in the different regions analyzed are shown in Figure 3.



**Figure 3.** Length-weight relationship of individuals of *Curimata inornata* in the Vila Nova River, Matapi River, igarapé da Fortaleza and in the Araguari River and the corresponding equations for all specimens assessed. / **Figura 3.** Relação peso-comprimento de indivíduos de *Curimata inornata* no Rio Vila Nova, Rio Matapi, Igarapé da Fortaleza e no Rio Araguari, e as equações correspondentes para todas as amostras avaliadas.

The  $b$  values, which represent the allometric growth coefficient obtained by the length-weight relationship equation, were compared using the Fisher's exact test ( $\alpha=0,05$ ). These values verified the differences detected by the population parameters analyzed.

The condition factor calculated for each sample point and for the different seasons of the hydrological cycle of the water bodies, winter and summer (=flood and drought), is shown in Table 3.

**Table 3.** Calculated values of the average condition factor for the populations of *Curimata inornata* in the rivers analyzed between the winter and summer seasons. / **Tabela 3.** Os valores médios do fator de condição calculados para as populações de *Curimata inornata* nos rios analisados entre os invernos e verões.

Locality	Average condition factor	
	Summer	Winter
Araguari River	0.039	0.074
Vila Nova River	0.023	0.028
Matapi River	0.033	0.031
Igarapé da Fortaleza	0.044	0.020

To test the independence between the rows and columns of Table 2, (the calculated values of the condition factor of water bodies analyzed suffer interference of the hydrological regime) was used the chi-square test, which showed that the values obtained are independent of hydrological regime of rivers ( $\chi^2=0,967$ ,  $\alpha=0,05$ ).

#### 4. Discussion

Differences in condition factor have been interpreted as measuring various biological features such as, fatness, suitability of environment or gonad development (LE CREN, 1951). Thus, the allometry coefficient is a measure that may reflect resource availability in the environment. A higher level of food availability and its consumption generally results in a larger allometry coefficient (VAZZOLER, 1991 apud ARAUJO and VICENTINI, 2001). The observed values of this coefficient for the different water bodies followed an increasing trend in terms of the conservation degree of the rivers under analysis. The Vila Nova River was the best preserved among all ( $b=3.098$ ), followed by the Matapi River, which experiences heavy traffic involving ferries, as well as some industrial activity on its banks ( $b=2.946$ ). This was followed by the Igarapé da Fortaleza, which is smaller in size, with a high level of activity involving small- and medium-sized boats, as well as several dwellings on the banks ( $b=2.8998$ ), and finally, the Araguari River, which despite its large size, was impacted by the construction of a hydroelectric power plant, besides dwellings and fishing activities on its banks ( $b=2.7816$ ). These figures are a reflection of the different population structure among the environments under study. According to Santos *et al.* (2004), fish populations of larger size and structure usually present lower allometry coefficients compared to populations of smaller size and structure because the latter are more involved in the allocation of energy for growth. The same tendency that was observed for the allometry coefficient values observed for the size of individuals from the population is presented in Figure 2.

The condition factor is a quantitative measure of a fish population's condition (welfare) (LE CREN, 1951), and may provide a possible relation between its body condition and/or physiological state and the environment it inhabits (GOMIERO and BRAGA, 2003); therefore, it is a constant regardless of the growth and size of the fish (GOMIERO and BRAGA, 2003).

Santos *et al.* (2006) commented that it is likely that the condition factor varies according to factors such as food availability and efficient use of food by the individuals each year, without the influence of seasonal variations on the

growth and development of the ovaries in females. The hydrological regime of the water bodies under the study was well defined, with a rainy season (December to June) and a dry season (July to December) described as winter and summer, respectively. Since these conditions determine resource availability for the fish in their environment, one would expect to find a relationship between the condition factor and the analyzed seasons. However, this relationship was not observed, as illustrated in Table 2. The Araguari River and the Vila Nova River presented higher average condition factor values during winter. A large part of the continental species of fish reproduce during winter, thereby generating high condition factor values during summer, when food availability is high and the fish accumulate reserves to utilize during winter. However, this tendency was only observed in the Matapi River and in the Igarapé da Fortaleza River.

#### 5. Conclusion

The length-weight relationship and the condition factor of *Curimata inornata* in the analyzed water bodies proved to be influenced by the degree of preservation of them, while the hydrological regime of the water bodies did not affect the length-weight relationship.

#### 6. Acknowledgements

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