

Length-Weight Relationships for Five Cladoceran Species in an Amazonian Lake

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ABSTRACT

This work shows the length-weight regressions established for the five most frequent and abundant cladoceran species (*Bosmina hagmanni*, *Bosminopsis deitersi*, *Ceriodaphnia cornuta*, *Diaphanosoma birgei*, and *Moina minuta*) in two stations at Lake Batata. This lake has received for 10 years very fine bauxite processing tailings, which is responsible for the thick layer over the natural sediment still observed in its western section (impacted station). The individuals were separated into size classes, the dry weight values were determined for each class and were used for establishing weight-length equations. *Bosminopsis deitersi* and *Ceriodaphnia cornuta* were the species showing the smallest size in the two sampled areas (0.152 to 0.322 mm) and *Diaphanosoma birgei* was the largest (0.284 to 0.722 mm). In the natural station, *Moina minuta* and *Bosminopsis deitersi* were the lightest species (0.174 to 0.334 and 0.074 to 0.278 µg, respectively) and in the impacted station, *Bosmina hagmanni* and *Moina minuta* were the lightest (0.248 to 1.555 and 0.210 to 0.566 µg, respectively). In general, individuals from the impacted station exhibited smaller body sizes (0.152- 0.684 mm) and higher weight (0.208 – 1.983 mm), which can be explained by the ingestion of tailing particles. The equations established were shown to be adequate for weight estimates of the analyzed species since the differences found between the observed and estimated weights values were not statistically significant.

Key words: Amazonian lake, zooplankton, cladoceran, length-weight relationships

INTRODUCTION

The basis for construction of quantitative theories about the structure and dynamics of communities are formed by estimates of biomass associated to information on density and productivity (Bird and Prairie, 1985). The zooplanktonic biomass can be measured directly (fresh or dry weight) or estimated from gravimetric and volumetric methods. For Copepoda and Cladocera, the most frequently used technique involves determination of regressions that correlate weight and length;

these regressions became common after the publications of Dumond et al. (1975); Bottrell et al. (1976) and McCauley (*in* Dowing, 1984). Although this information is fundamental for productivity and ecosystem modeling studies, this approach has not been thoroughly explored in tropical regions. In Brazil, few studies have shown biomass results (Rocha and Matsumura-Tundisi, 1984; Matsumura-Tundisi and Tundisi, 1986; Matsumura-Tundisi et al.1989; Okano, 1994; Rocha et al. 1995; Melão,1997) and all of

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them were estimated from length-weight equations previously established in the literature.

Lake Batata, a typical floodplain lake, is distinct from other lakes of the region for the presence of clay material from bauxite processing that has been ejected during 10 years in its west section.

Although there is a substantial amount of information on zooplanktonic community at Lake Batata (Bozelli and Esteves, 1991; Bozelli and Garrido, 1999; Bozelli, 1992, 1994, 1996, 1998a, 1998b), aspects related to productivity of this community have not been explored.

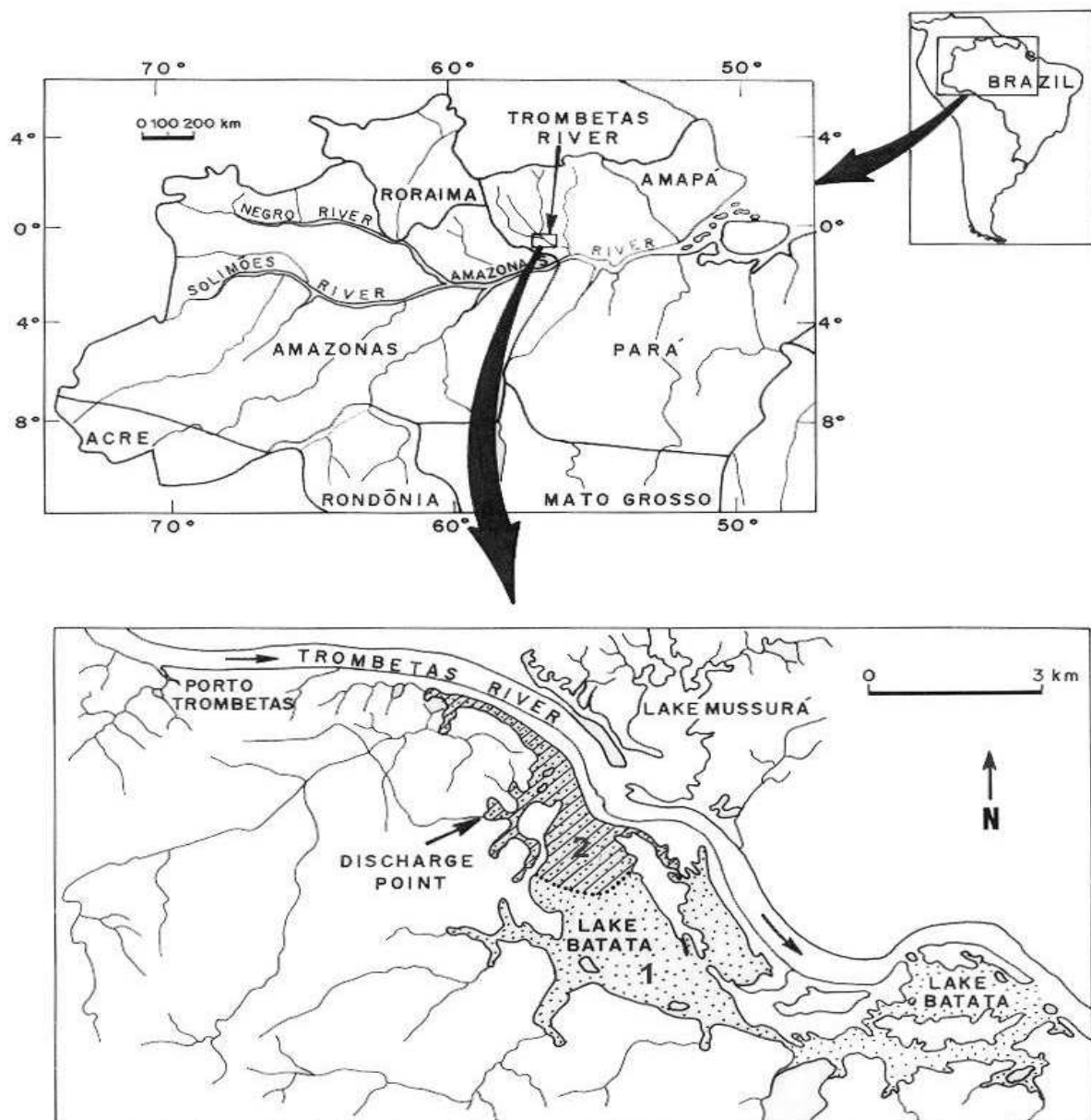


Figure 1 - Map of the study area showing the location of the sampling stations: 1- natural area and 2- impacted area with bauxite tailings

Taking into account the peculiarities exhibited by Lake Batata, this work had as the objective the establishment of length-weight regression for the most representative cladoceran species in the natural and impacted areas. This information will allow the quantification of the zooplanktonic production, to evaluate the role of this community in the trophic structuring and to understand the importance of the bauxite tailings on the productivity of this system.

MATERIAL AND METHODS

Study Area

Lake Batata is situated in the right margin of the Trombetas River (1°25' - 1°35' S; 56°15' - 56°25' W) in Porto Trombetas (Pará State, Brazil). The lake has a dendritic shape and total surface area between 18 and 30 Km² with high fluctuation of the water level. It is a well oxygenated lake showing low values for electric conductivity (c. 8 μS cm⁻¹ in the filling phase and 13 μS cm⁻¹ in the drawdown), pH varying from 6 to 8 and total alkalinity between 40 and 70 μEq l⁻¹ in the dry season (Melo and Huszar, 2000). It is a lateral dam lake that has continuous communication with the Trombetas River. Depending on the intensity of the inundation pulse the river waters can flow over the dike interlinking the two systems.

The lake has received bauxite tailings for 10 years (1979-1989). The liquid effluent is composed of fine solid particles containing 21% aluminum oxide, 47% silicates and 21% iron oxides. According to Lapa and Cardoso (1988) this material, which still covers the natural sediment of the lake forming a thick layer, silts up 30% of the lake area.

Methodology

The specimens used in this study were obtained from samples collected at fixed stations set in natural and impacted areas during the dry phase (October to January). Zooplankton were sampled by vertical hauls using a plankton net (68 μm mesh size) and preserved with neutral formaldehyde (4%) for at least 12 months before analysis. No correction for losses due to preservation was made in this study.

Aluminum weighting boats were dried at 60 °C for 24 h, cooled in a desiccator for at least two hours and weighted with a Mettler microbalance (model UMT2). The specimens were washed in running

tap water, rinsed at least three times in distilled water; eggs and embryos were removed from adult females. Body lengths were measured, excluding shell spines, under a microscope fitted with an eyepiece micrometer. Individuals of different species were separated into size (length) classes, which varied according to the species, and were transferred to the pre-weighted aluminum boats. Each weighting boat containing between three and sixty-three individuals of a known size class were dried at 60°C for 24 h, cooled in a desiccator and re-weighted.

Mean dry weight values determined for each size class were used to derive length-weight regression after natural logarithmic transformation of both length (L) and weight (W) values, which are often assumed to be of the form: $Y = a x^b$ (Winberg, 1971),

$$\begin{aligned} \text{where } Y &= \text{Ln}W \text{ (}\mu\text{g)} \\ x &= \text{Ln}L \text{ (mm)} \\ a &= \text{estimate of intercept} \\ b &= \text{estimate of slope} \end{aligned}$$

The results were compared by ANOVA followed by Mann-Whitney tests using a statistic software (Instat®). The present results were compared with published ones.

RESULTS AND DISCUSSION

The variation range in length and dry weight are shown in Table 1. In general, individuals from the natural station showed higher body size and lower weight (except for *Diaphanosoma birgei* in relation to weight), although the differences were not always considered statistically significant. *Bosminopsis deitersi* and *Ceriodaphnia cornuta* were the species showing the smallest size in the two sampled areas (0.152 to 0.322 mm) and *Diaphanosoma birgei* was the largest (0.284 to 0.722 mm). In the natural station, *Moina minuta* and *Bosminopsis deitersi* were the lightest species (0.174 to 0.334 and 0.074 to 0.278 μg, respectively) and in the impacted station, *Bosmina hagmanni* and *Moina minuta* were the lightest (0.248 to 1.555 and 0.210 to 0.566 μg, respectively). *Diaphanosoma birgei* was the heaviest species (0.419 to 3.121 μg) with higher values in the natural station. All of the species exhibited weight differences between the two areas, although only for *Bosminopsis deitersi* and *Ceriodaphnia cornuta* these differences were

considered significant (Mann-Whitney, $p < 0.007$). A comparison with literature data obtained for the same species or morpho-species showed that at Lake Batata cladocerans were smaller and in the impacted area they showed higher weights. These results could be explained by the ingestion of tailing particles and for the retention of mineral material in the internal part of the valves, which was difficult to remove during the preparation of the specimens for weighting. In the impacted station, most of the individuals analyzed exhibited the digestive tube full of tailings. The ingestion of tailings was also observed in the laboratory in individuals submitted to a solution of bauxite tailing and food. of tropical regions and has been explained by the influence of temperature and food limitation. According to Saint-Jean and Bonu (1994), the permanent high temperature in the tropics.

Smaller body size seemed to be a common characteristic for zooplanktonic species would accelerate metabolic processes (development, reproduction, respiration, and ingestion) creating higher food requirements. Permanent high food requirements are not always accompanied by high ingestion/assimilation. At Lake Batata, three factors would explain the weight and length values observed in this study: persistent higher temperatures ($> 27^{\circ}\text{C}$); periodic water level fluctuations which determined substantial alterations in food offer, and the presence of bauxite tailings in phytoplankton production, could be used as a non-conventional food source due to the bacterial aggregation in the particles (Bozelli, 1994b).

Table 1 - Mean length in different size classes (mm), observed dry weight (O.D.W., μg), estimated dry weight (E.D.W., μg) for five cladoceran species of Lake Batata

Species	Natural Station				Impacted Station			
	Mean length (mm)	O.D.W. (μg)	E.D.W. (μg)	n	Mean length (mm)	O.D.W. (μg)	E.D.W. (μg)	n
<i>Bosmina hagdmani</i>	0.232	0.219	0.239	33	0.217	0.248	0.193	43
	0.281	0.476	0.397	29	0.239	0.208	0.252	63
	0.323	0.536	0.578	14	0.302	0.382	0.475	51
	0.367	0.797	0.813	10	0.361	0.864	0.765	50
					0.418	1.142	1.130	21
					0.465	1.555	1.510	3
<i>Bosminopsis deitersi</i>	0.153	0.074	0.094	27	0.152	0.638	0.573	29
	0.170	0.162	0.119	20	0.170	0.752	0.715	27
	0.186	0.152	0.145	54	0.186	0.686	0.860	28
	0.213	0.175	0.196	54				
	0.232	0.245	0.238	40	0.232	1.226	1.349	19
	0.253	0.278	0.289	31	0.248	1.820	1.545	10
<i>Ceriodaphnia cornuta</i>	0.185	0.188	0.174	51	0.184	0.743	0.652	47
	0.204	0.201	0.210	26				
	0.241	0.270	0.289	60	0.245	0.792	0.991	60
	0.287	0.390	0.400	49	0.287	1.077	1.253	48
	0.322	0.528	0.497	31	0.313	1.826	1.426	23
<i>Diaphanosoma birgei</i>	0.305	0.644	0.662	46	0.284	0.419	0.417	48
	0.394	1.215	1.034	41	0.363	0.580	0.649	51
	0.459	1.243	1.348	49	0.446	1.100	0.944	51
	0.520	1.518	1.675	43	0.530	1.314	1.288	63
	0.578	1.927	2.011	47				
	0.635	2.466	2.373	30	0.623	1.665	1.725	34
	0.722	3.121	2.967	8	0.684	1.983	2.043	18
<i>Moina minuta</i>	0.284	0.174	0.159	47	0.269	0.210	0.204	59
	0.323	0.200	0.193	42	0.310	0.276	0.278	51
	0.374	0.310	0.243	44	0.359	0.358	0.385	62
	0.408	0.334	0.278	26	0.417	0.566	0.538	35

The regression equations of the relationships between the values for body length and dry weight obtained in the present study (Table 2) could be considered adequate for weight estimates of the five cladoceran species since the differences between the observed and estimated weights were not significant (Mann-Whitney, $p \geq 0.8$).

Although the equations obtained could be applied to biomass estimates in other environments it

would be important to stress that the length-weight relationship of zooplankton could vary with temperature, quantity and quality of food, in addition to the physiological state of the animals (Geller and Müller, 1981; Kankaala and Johansson, 1986; Matsumura-Tundisi et al., 1989). Moreover, Giguère et al. (1989) observed 37 to 43% dry weight losses (for the large and small species, respectively) due to chemical preservation, independent of preservation methods.

Table 2 - Relationship between length in millimeters (L) and dry weight in μg (W) in five cladocerans species from Lake Batata (PA, Brazil).

Species	Natural Station		Impacted Station	
<i>Bosmina hagmanni</i>	W= 11.930L	^{2.680} ($r^2 = 0.94$)	W= 11.850L	^{2.690} ($r^2 = 0.95$)
<i>Bosminopsis deitersi</i>	W= 6.098L	^{2.221} ($r^2 = 0.84$)	W= 26.538L	^{2.039} ($r^2 = 0.87$)
<i>Ceriodaphnia cornuta</i>	W= 4.227L	^{1.888} ($r^2 = 0.97$)	W= 7.978L	^{1.481} ($r^2 = 0.70$)
<i>Diaphanosoma birgei</i>	W= 5.222L	^{1.738} ($r^2 = 0.97$)	W= 4.060L	^{1.809} ($r^2 = 0.97$)
<i>Moina minuta</i>	W= 1.161L	^{1.549} ($r^2 = 0.76$)	W= 3.695L	^{2.207} ($r^2 = 0.97$)

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RESUMO

Este trabalho apresenta as regressões peso-comprimento estabelecidas pela primeira vez, para algumas espécies de cladóceros do Brasil, e para as cinco mais frequentes e abundantes de duas estações do lago Batata (*Bosmina hagmanni*, *Bosminopsis deitersi*, *Ceriodaphnia cornuta*, *Diaphanosoma birgei*, *Moina minuta*). Este lago recebeu por 10 anos rejeito de fina granulometria resultante do processamento da bauxita, e que ainda hoje forma uma espessa camada sobre o sedimento natural da porção oeste do lago (estação impactada). Os indivíduos foram separados em classes de tamanho, variáveis de acordo com a espécie, e o peso seco determinado para cada classe, foi usado para o estabelecimento das equações peso-comprimento. *Bosminopsis deitersi* e *Ceriodaphnia cornuta* apresentaram o menor

tamanho nas duas áreas amostradas (0,152 a 0,322 mm) e *Diaphanosoma birgei* o maior (0,284 a 0,722 mm). Na estação natural *Moina minuta* e *B. deitersi* foram as espécies com menor peso (0,174 a 0,334 e 0,074 a 0,278 μg , respectivamente). No geral, indivíduos da estação impactada apresentaram menor tamanho corporal (0,152 - 0,684 mm) e maior peso (0,208 - 1,983 mm), o que pode ser explicado pela ingestão de partículas de rejeito. As equações estabelecidas mostraram-se adequadas para a estimativa de peso das espécies analisadas já que as diferenças entre o peso observado e o estimado não foram estatisticamente significativas.

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