Among and within-taxa variations of body elemental content of South-American freshwater crustaceans: assessing trophic status and application in integrated multi-trophic aquaculture

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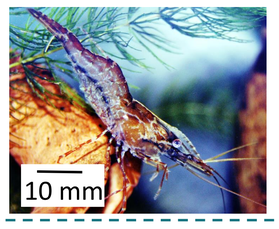
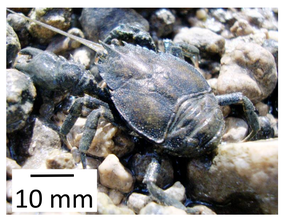
Introduction

The body elemental composition is a useful baseline to establish the nutritional requirements of animals and are related with growth and natural trophic status. Carbon-C, nitrogen-N and phosphorus-P are key elements required for growth, homeostasis of organisms and, therefore, to aquaculture productivity. We measured the body elemental content (C, N, P) of juveniles and adults of three freshwater crustaceans native to South America, infer their nutritional needs (based on natural diet) and the application in integrated multitrophic aquaculture (IMTA).



***Macrobrachium borellii* - prawn**
- ✓ Palaemonidae family
- ✓ La Plata Basin of northern Argentina, Paraguay and southern Brazil
- ✓ Inhabits the aquatic macrophytes of the floodplain littoral zone.
- ✓ Natural diet: greater importance of animal trophic resource



***Aegla uruguayana* - anomuran**
- ✓ Aeglidae family
- ✓ Unique genus endemic to southern South America
- ✓ Inhabits current rivers and streams, typically sheltered in the bottom and under rocks
- ✓ Natural diet: greater importance of vegetal and algae trophic resources

***Trichodactylus borellianus* - crab**
- ✓ Trichodactylidae family
- ✓ Broad distribution in South America (from 0° to 35° S)
- ✓ Inhabits the aquatic macrophytes of the floodplain littoral zone
- ✓ Natural diet: similar importance of animal and vegetal trophic resources

Material and Methods

Specimens of crustaceans of variedGracias body mass were collected from the environment with hand net and kept in starvation for 24 hours to eliminate gut content. To determine the stoichiometric proportion of carbon (C) and nitrogen (N) of crustaceans, each sample were elemental analyzed in a CHN628 Series Elemental Determinators (LECO ®). For total phosphorus (P) analysis, each sample was combusted in a muffle furnace at 550°C, acid-digested and analyzed using the ascorbic-acid method (Muphy & Riley 1962). The C:N, C:P and N:P ratios of crustaceans' bodies were calculated using molar values.

Data Analysis

The body content of elements and ratios (C, N, P, N:P, C:N, C:P) were compared among-taxa through ANCOVA and using body mass (an ontogenetic parameter) as covariate. *Post hoc* Bonferroni adjustment was applied for multiple testing corrections. Body elements and ratios were also analyzed within-taxa as a function of body mass.

Results

Among-taxa, species showed significant differences of body N, P, C, N:P; C:N and C:P ($p= 2x10^{-16}$, $p= 9.56x10^{-13}$, $p= 6.84x10^{-5}$, $p= 3.95x10^{-1}$, $p= 1.05x10^{-14}$, and $p= 3.71x10^{-7}$, respectively) and a significant effect of body mass on body N ($p= 1x10^{-4}$), P ($p=3.54x10^{-6}$) and C:N ($p=5.2x10^{-3}$) (Fig. 1).

Within-taxa, prawns had more C, N and N:P, and less C:N than anomurans and crabs (*post hoc*, $p< 0.001$). Anomurans had less P and intermediate N, C, N:P and C:N (*post hoc*, $p< 0.001$). Crabs had higher P and lower C:P and N:P than anomurans and prawns (*post hoc*, $p< 0.001$). Within-taxa, only crabs exhibited less body-N as they grow (slope= -0.0957, $R^2= 0.3930$, p= 0.0290). Prawns (slope= 0.0576, $R^2= 0.5598$, p= 0.0051) and crabs (slope= 0.0845, $R^2= 0.4889$, p= 0.0114) exhibited a positive relationship between body-C:N and body mass.

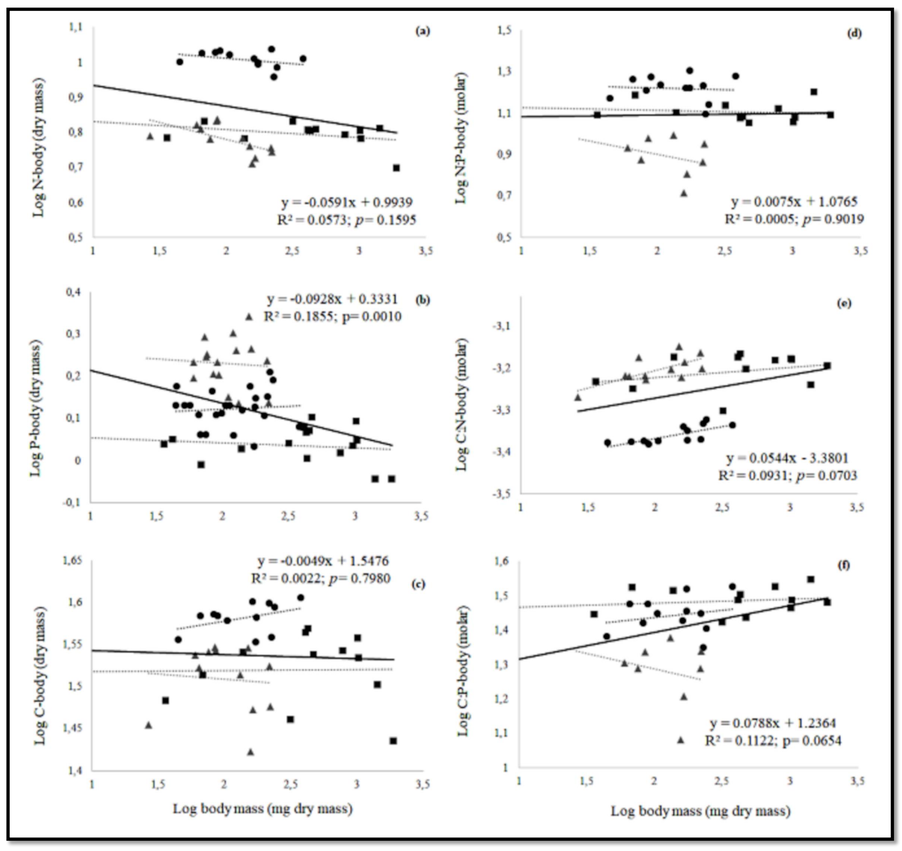


Fig. 1. Linear regressions across and within taxa of body content of N, P, C and N: P, C:N, C:P as a function of invertebrate body mass. The equation, R-squared and p-value belong to the across taxa linear regressions. *Macrobrachium borellii* (black circle), *Aegla uruguayana* (dark gray square), *Trichodactylus borellianus* (light gray triangle)

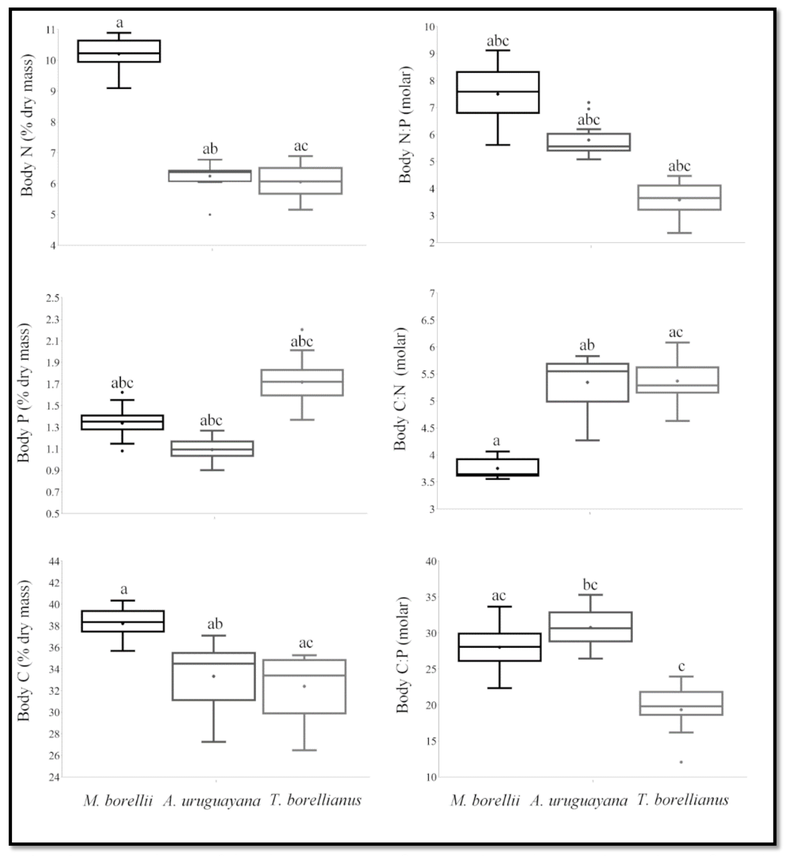
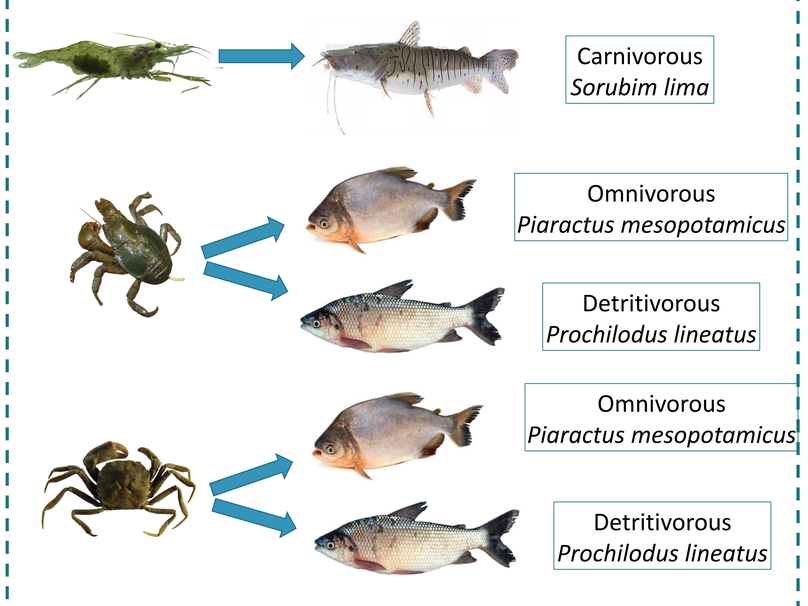


Fig. 2. Box plots of body content of N, P, C and N:P, C:N, C:P of each species. The top, bottom, and line through the middle of the boxes correspond to the 75th, 25th, and 50th (median) percentile, respectively. The whiskers extended from the 10th percentile to the 90th percentile. Crosses indicate the median values. Different letters above bars indicate significant differences among taxa ($p < 0.05$).

Discussion

Results showed higher N-requirements and higher trophic status (lower C:N) of prawns, followed by crabs and anomurans. These findings are in accordance with the natural diet found in the literature, which indicates a more carnivorous trophic habit to *M. borellii* (Collins and Paggi 1997, Collins et al. 2006, Carvalho et al. 2016), an intermediate to *T. borellianus* (Williner and Collins 2013, Carvalho et al. 2016) and a preference of *A. uruguayana* for vegetal remains and algae (Collins et al. 2006, Williner 2010). Moreover, prawns and crabs change the trophic status during ontogeny, requiring lower N in comparison with C at later stages. This information is useful to infer protein requirements of each crustacean and evaluate a feasible integration with fed fish species. Prawns needs around 33-36% of protein in the feed (Carvalho et al. 2020) and might be successfully integrated with fish of higher N-requirements, while crabs and anomurans might exhibit good performance with herbivorous, omnivorous or detritivorous fish. Potential crustaceans-fish pairs must be tested in an IMTA (in tanks together or separately, according to trophic and life habits) to evaluate culture feasibility and yields.

POTENTIAL CRUSTACEAN-FISH PAIRS



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Acknowledgments

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