South-Americans freshwater crustaceans and the role as animal-mediated nutrient recyclers: application in integrated multitrophic aquaculture (IMTA)

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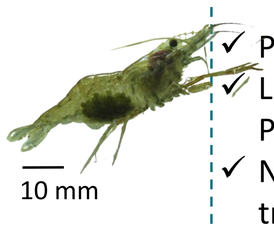
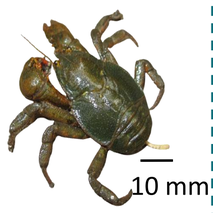
Introduction

Excretion is an immediate process by which animals mineralize nutrients for primary producers and heterotrophic microorganisms. Understanding the complementarity of cultured organisms is a way proposed by IMTA to deal with nutrient waste of intensive feeding. Crustaceans in IMTA could help to efficiently use feed, enhance water quality and increase profit.

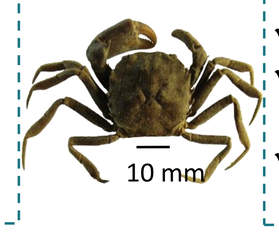
We determined the mass-specific nutrient mineralization/excretion (N, P, N:P) of crustaceans (prawn-*Macrobrachium borellii*, anomuran-*Aegla uruguayana*, crab-*Trichodactylus borellianus*) from South America fed with omnivorous (OF) and detritivorous (DF) fish-feed. We tested across, within and among-taxa the relationship of nutrient mineralization with body mass, body elemental content, and fish-feed to explore the animal-mediated nutrient dynamic and its role in productive systems as a group or individually.



***Macrobrachium borellii* - prawn**
- ✓ Palaemonidae family
- ✓ La Plata Basin of northern Argentina, Paraguay and southern Brazil
- ✓ Natural diet: greater importance of animal trophic resource



***Aegla uruguayana* - anomuran**
- ✓ Aeglidae family
- ✓ Unique genus endemic to southern South America
- ✓ Natural diet: greater importance of vegetal and algae trophic resources

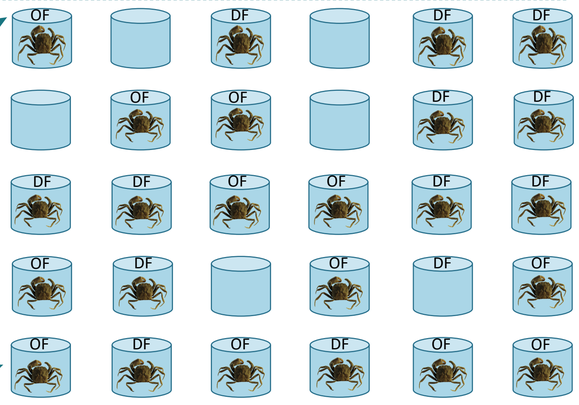


***Trichodactylus borellianus* - crab**
- ✓ Trichodactylidae family
- ✓ Broad distribution in South America (from 0° to 35° S)
- ✓ Natural diet: similar importance of animal and vegetal trophic resources

Material and Methods

1) Wild crustaceans were acclimated to experimental conditions (24±1°C, 250 ± 10 µS, natural photoperiod)

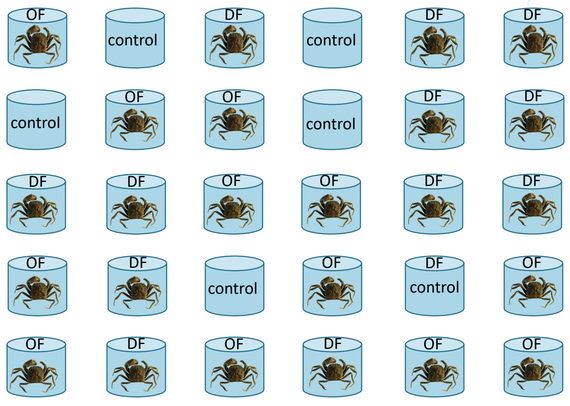
2) Crustaceans of variable sizes were randomly arranged in 1000 ml recipients



3) OF and DF were offered *ad libitum* to each individual during 90 minutes

4) Crustaceans were then washed and transferred to recipients filled with 150 ml of filtered water

5) After 30 minutes, 15 ml of water samples were taken in each recipient



6) Crustaceans were kept without feed for 24 h to eliminate gut content

7) Individuals were oven dried and weighted to determine dry body mass.

8) Dried crustaceans was pulverized, homogenized, and elemental analyzed (C, N and P).

9) Ammonium (N) and phosphorous (P) were determined in water samples.

- ✓ Experiments were repeated to each species
- ✓ Excretion rates were based on the specific dry body mass unit and per unit time.
- ✓ N and P excretion values were corrected by subtracting the average concentration of nutrient excretion of control replicates.

Data analysis

- ✓ Excretion rates→Across and within-taxa: Linear regressions
- ✓ Excretion rates→Among-taxa and diet: two-way ANCOVA analysis. (Covariate: body mass and body content)
- ✓ *Post hoc* Bonferroni adjustment for multiple testing corrections

N excretion P excretion N: P excretion	vs. Body mass	N excretion ~ Body N P excretion ~ Body P N: P excretion ~ Body N:P	taxa and diet

Results

Across-taxa, juveniles excreted more N and P than adults, the N-body content positively affected the mineralization of N, and N:P body content negatively affected mineralized N:P (Fig 1). These relations were similar despite the type of feed.

Within-taxa, juveniles of prawns (slope= -0.5887, R^2= 0.3430, p= 0.0026), anomurans (slope= -0.7518, R^2= 0.8544, p= $4.25x10^{-8}$) and crabs (slope= -0.5628, R^2= 0.2203, p= 0.0426) mineralized more N than adults and only juveniles of anomurans mineralized more P than adults (slope= -0.6783, R^2= 0.6179, p= 0.0005) (Fig. 1). There was no relationship between nutrient mineralization and body content in any species.

Among taxa

The type of feed did not influence nutrient excretions rates (p>0.05).

Body mass as covariate → Individual significant effects body mass and taxa on N (p=$2.79x10^{-12}$), P (p=$4x10^{-4}$), and N:P excretion (p=$8.3x10^{-10}$).

Body content as covariate → Individual significant effect of taxa and body N content on N excretion (p= 0.0014, p= 0.0003). Individual significant effect of taxa on P and N:P excretion (p= 0.0094, p= $1.03x10^{-06}$).

Post hoc → prawns (more N-body content) excreted more N, low P and N:P (p<0.001 in all cases), in comparison with the other species (Fig 2).

Fig. 1 Linear regressions across and within taxa of mass-specific excretion rates for N, P and N:P (µg P mg dry $mass^{-1}$ 0.5 h^{-1}) as a function of invertebrate body mass (a, b, c) and body elemental content (d, e, f). 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).

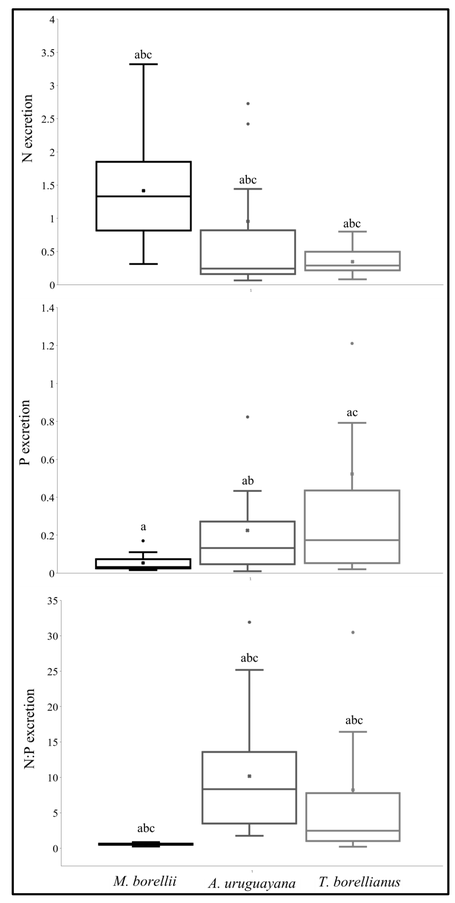


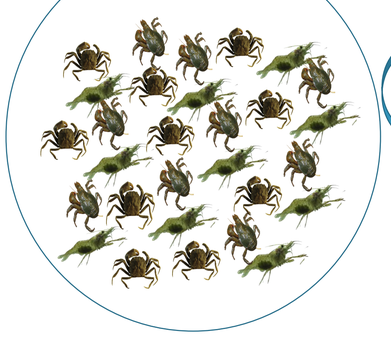
Fig. 2. Box plots of mass-specific excretion rates for NH_4-N, P-PO_4 and NH_4-N: P-PO_4 of each decapod species. Different letters above bars indicate significant differences among taxa ($p < 0.05$).

Discussion

Crustacean-mediate nutrient dynamics was not influenced by the experimental diets → few differences in elemental composition

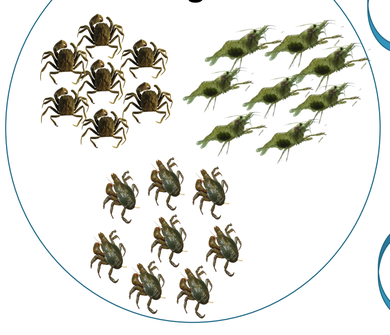
Crustaceans recycle differently N and P at different scales of analyses

Across taxa



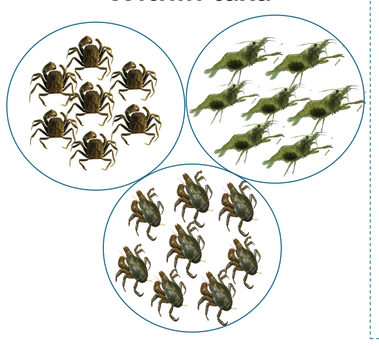
- ✓ Juveniles recycle more nutrients per unity mass than adults, mainly for N
- ✓ At early stages, more N-compounds could be available to grow vegetables in IMTA such as aquaponics systems

Among taxa



- ✓ Prawns had more body N content and mineralize more N than crabs and anomurans,
- ✓ IMTA with prawns could favor more N-availability to grow vegetables
- ✓ Prawns incorporated more P than crabs and anomurans
- ✓ Feeds with more P should be recommended to avoid nutrient limitation to vegetables.

Within taxa



- ✓ Juveniles of all species mineralized more N than adults.
- ✓ Juveniles of anomurans mineralized more P than adults

- ✓ Life stage of each species might be considered in the mass balance of IMTA with growing vegetables.

The role of crustaceans as animal-mediate nutrient recyclers varied with the scale of analysis. Crustaceans are potential species to biomitigate the nutrient excess in fish culture, enhance water quality and diversify the production. If growing vegetables is an aim, it is necessary take into account the type of species (and its body content) and life stage (body mass) to select complementary species that efficiently use feed resources.

Acknowledgments