Fecundity and Competitive Success of *Macrobrachium* spp. Coexisting in Reservoir Environments

Fecundidade e Sucesso Competitivo de *Macrobrachium* spp. que Cohabitam em Ambientes de Represamento

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Abstract

The preservation of endemic species is crucial for maintaining balanced ecosystems, especially in unstable environments such as dammed areas. To analyze a possible competitive effect between cohabiting congeners, this study aimed to investigate the fecundity and reproductive investment of both species, using populations from the Lower Tietê in the Promissão Reservoir as a basis. Data were collected over the course of a year along the banks of the Tietê River, with up to 30 breeding females of each species sampled monthly. In addition to measuring cephalothorax length (CC), both females and their eggs were dry weighed. The developmental stage of each female's eggs (initial – IN and final – FI) was also recorded. Fecundity and reproductive investment (IR) data were obtained from females with eggs in the IN stage. Simple linear regression was used to assess the relationship between fecundity and CC, while egg loss between IN and FI stages was analyzed using covariance analysis. Results showed significantly higher fecundity in *M. amazonicum* (717.16 ± 422.8 eggs) compared to *M. jelskii* (46.62 ± 16.44 eggs). However, *M. jelskii* exhibited a greater RI (14.24%) than its congener (12.68%). The higher fecundity of M. amazonicum may explain its competitive success, making it a promising candidate for aquaculture. In contrast, the higher IR of *M. jelskii* may confer an advantage in resource-limited environments, highlighting the importance of monitoring the reproductive dynamics of these species to ensure their viability in competitive, resource-scarce habitats.

Pressures.

Resumo

A preservação de espécies endêmicas é importante para a manutenção de ecossistemas equilibrados, especialmente em ambientes instáveis, como áreas de represamento. Com a finalidade de analisar um possível efeito competitivo entre congêneres que cohabitam, este estudo teve como objetivo investigar a fecundidade e o investimento reprodutivo de ambas as espécies, utilizando como base populações provenientes do Baixo Tietê, no reservatório de Promissão. A coleta de dados ocorreu ao longo de um ano, às margens do Rio Tietê, abrangendo mensalmente até 30 fêmeas embrionadas de cada espécie. Além do comprimento cefalotorácico (CC), fêmeas e respectivos ovos foram pesados a seco. O estágio de desenvolvimento dos ovos de cada fêmea (inicial – IN e final – FI) também foi registrado. Os dados de fecundidade e investimento reprodutivo (IR) foram obtidos utilizando fêmeas com ovos em IN. Uma análise de regressão linear simples foi realizada para relacionar a fecundidade com o CC. A perda de ovos entre IN e IF foi avaliada com análise de covariância. Os resultados indicaram uma fecundidade significativamente maior em *M. amazonicum* (717,16 ± 422,8 ovos) em comparação a *M. jelskii* (46,62 ± 16,44 ovos). No entanto, *M. jelskii* apresentou maior IR (14,24%) em relação ao seu congênere (12,68%). A maior fecundidade de *M. amazonicum* pode justificar seu sucesso competitivo, sendo uma espécie promissora para aquicultura. Em contrapartida, o elevado IR de *M. jelskii* pode fornecer uma vantagem em habitats limitados, destacando a importância de monitorar as dinâmicas reprodutivas dessas espécies para garantir sua viabilidade em ambientes competitivos com recursos escassos.

Palavras-chave: Camarões Dulcícolas. Caridea. Coexistência de Espécies. Estratégias reprodutivas. Pressão Ambiental.

1 Introduction

The study of shrimps from the genus *Macrobrachium* has become increasingly important not only for understanding the ecology of river ecosystems but also for elucidating the remarkable dispersal capacity of these species. *Macrobrachium amazonicum* (Heller, 1862), widely investigated, stands out due to its vast geographic distribution, which may have occurred through both natural means and anthropogenic intervention (Magalhães, 2001; Magalhães *et al*., 2005). Native to the Amazon Basin and endemic to South America, this species is notable for its ecological plasticity, efficiently adapting to a variety of environmental conditions (Anger, 2013; Vergamini; Pileggi; Mantelatto, 2011).

Also endemic to South America, *Macrobrachium jelskii* (Miers, 1887) has been recorded in all Brazilian hydrographic basins, likely due to the same anthropogenic factors that drove the widespread distribution of its congener (Magalhães *et al*., 2005; Vergamini; Pileggi; Mantelatto, 2011). However, studies by Magalhães (2001) revealed that the abbreviated larval development of *M. jelskii* may restrict its dispersal capacity compared to *M. amazonicum*.

Regardless of whether they are exotic or native species, it is crucial to prioritize endemic species in conservation strategies for natural areas and in initiatives for restoring degraded ecosystems. This approach is essential for preserving biodiversity and for a deeper understanding of the biotic and

abiotic interaction processes that sustain ecological balance. The conservation of endemic species not only ensures the continuity of complex ecological interactions but also strengthens ecosystems against invasions by non-native species, which can cause significant imbalances (Tundisi; Straskraba, 1999). In line with this premise, the study by Magalhães *et al.* (2005) demonstrated that the introduction of *M. amazonicum* and *M. jelskii* in northeastern Brazil over 60 years ago has not resulted in observable negative ecological impacts to date. This finding reinforces the need for continuous investigations to assess potential long-term changes and ensure that management and conservation strategies comprehensively and cautiously consider the dynamics between native and exotic species.

Among the central issues regarding the coexistence of these two species, the possible competitive effect stands out, particularly in dammed environments, where there is greater instability in environmental variables. Recent research has analyzed morphological sexual maturity (Silva *et al.*, 2018) and temporal variation in abundance (Lucena *et al.*, 2020) of these species in regions where both were found. These studies revealed not only distinct reproductive strategies but also differences in responses to seasonal variations in abiotic factors. Additionally, Silva *et al.* (2018) identified more pronounced allometric patterns in *M. amazonicum* females compared to *M. jelskii*, suggesting a differential adaptation.

In this context, the hypothesis was raised that *M. amazonicum* has higher fecundity than *M. jelskii*, which could explain its greater success in colonizing new environments and competing for limited resources. Thus, the objective of this study was to investigate the fecundity and reproductive investment of both species, focusing on populations from the Lower Tietê, in the Promissão Reservoir. The research will analyze the number of eggs per female, egg size, and reproductive period to understand the differences in reproductive strategies between these species.

Given this ecological scenario, it is also essential to consider the economic relevance of these species. In Brazil, several *Macrobrachium* species are widely exploited and hold significant economic importance. In the region, *M. amazonicum* stands out as a freshwater shrimp commercially exploited through artisanal fishing, used as live bait (Maciel; Valenti, 2009), and as a commercial resource (Lucena *et al.*, 2020). Furthermore, this exploitation places other species that share the same habitat in a vulnerable situation.

2 Material and Methods

2.1 Characterization of the Study Area

The Lower Tietê River Basin covers an area of approximately 13,655 km², with predominantly sandy soils and some zones of basaltic origin. The primary use of the basin's water resources is hydroelectric power generation, as well as for supply and navigation (Cetesb, 2023). The Promissão Reservoir, officially named Mário Leão Lopes, is located between coordinates 21º18'S and 49º47'W,

downstream of the Nova Avanhandava Reservoir. This reservoir is fed by several tributaries, including the Dourado, Cervo Grande, Ribeirão dos Porcos, and Batalha rivers. The region falls within a subtropical humid climate zone.

Extensive monoculture plantations, such as rice, coffee, soybeans, and corn, surround the reservoir, along with pasture areas and reforested lands. The environment is influenced by anthropogenic activities, leading to modifications in both vegetation and the aquatic ecosystem. However, local pollution is relatively lower compared to upstream reservoirs, as pollutants are partially retained by the upper reservoirs (Cetesb, 2023).

The sampling site is characterized by dense riparian vegetation, including trees, grasses, and aquatic plants, providing abundant refuges for the studied caridean species. Additionally, the region is strongly influenced by fishing activities, which are among the most common practices along this section of the river.

2.2 Biological material

The collections were carried out along the banks of the Tietê River, in the Promissão Reservoir, from November 2017 to October 2018. To capture the specimens, a shrimp-specific sieve was used, with one person applying effort and performing three sweeps in a 180° arc, in addition to using funnel traps. Up to 30 ovigerous females of *M. amazonicum* and *M. jelskii* were collected monthly.

Each female was individually stored in test tubes, placed in ice-filled containers. Once the specimens were immobilized, the water in the tubes was replaced with 70% ethanol.

In the microscopy laboratory at the Universidade Federal do Triângulo Mineiro – Iturama campus, the carapace length (CL) of each female was measured using a digital caliper (precision of 0.01 mm), from the post-orbital margin to the posterior edge of the carapace. Next, the egg development stage was recorded, classified into two stages: stage 1 (initial development – IN), characterized by the absence of eye spots, and stage 2 (final development – FI), with visible eye spots, as described by Reid and Corey (1991).

The eggs were then removed from the pleopods of each female using a pipette with water and 5% sodium hypochlorite and manually counted under a stereomicroscope. Females with eggs in the IN stage were selected for the reproductive investment (RI) study. Both the eggs and the females with IN-stage eggs were weighed separately on a semi-analytical balance with a precision of 0.01 g. The female's weight was recorded after the eggs complete removal from the abdomen.

Dry weight measurements were obtained after drying in an oven at 60 °C for 24 hours. The egg weight was determined as the total egg weight per female. RI was estimated for a single spawning event, with each female's production calculated by dividing the eggs dry weight by the female's dry weight (Zimmermann; Carvalho; Mantelatto, 2015).

2.3 Statistical analysis

For data analysis, homoscedasticity tests (Levene, $\alpha = 0.05$) and normality tests (Shapiro-Wilks, $\alpha = 0.05$) were performed as prerequisites for selecting the statistical test (Sokal; Rohlf, 2009). Whenever necessary, data were log-transformed ($\log(x+1)$) to meet these prerequisites.

For fecundity analysis, only females with IN-stage eggs were selected to avoid egg loss during incubation (Torati; Mantelatto, 2008). A simple linear regression analysis was performed, relating fecundity (dependent variable) to female carapace length (CL – mm) (independent variable). To verify egg loss from IN to FI stages, an analysis of covariance (ANCOVA) was conducted, using carapace length (CL) as a covariate.

A generalized linear model (GLM) with a Poisson distribution (Crawley, 2007), corrected for quasi-Poisson due to overdispersion, was used to compare fecundity across collection months. The pairwise post-hoc Tukey test (Logan, 2011) identified temporal differences. The GLM analyses followed the recommendations of Zuur *et al.* (2009).

Reproductive investment (RI) was estimated by dividing the egg mass dry weight (DWEM) by the female's dry weight (DWF) and multiplying by 100 to obtain percentage values (Hines, 1982). For RI calculation, only the dry weight of females with IN-stage eggs and their egg mass was used, as suggested by Zimmermann, Carvalho and Mantelatto (2015). Subsequently, a linear regression analysis was conducted between RI and CL, also relating DWF to CL.

A significance level of 0.05 was considered for all analyses. Results are presented as mean ± standard deviation. All statistical analyses were performed using the R Development Core Team software (2018) (Fox; Weisberg, 2011) and BioEstat version 5.0.

3 Results and Discussion

3.1 Size and weight of females

In *M. amazonicum*, carapace length (CL) ranged from 8.26 mm to 16.77 mm (mean = 11.77 ± 1.82 mm) in females with IN eggs and from 8.5 mm to 17.92 mm (13.31 ± 2.08 mm) in females with FI eggs. A t-test comparison of CL between the two groups revealed that, in the samples from this study, females with FI eggs were significantly larger than those with IN eggs ($p < 0.001$). To assess reproductive investment, only females with IN eggs were selected. The dry body weight (DBW) ranged from 0.116 g to 1.978 g (0.736 ± 0.472 g). The relationship between DBW and CL was modeled using linear regression, which resulted in a significant association between the variables ($p = 0.0294$, $R^2 = 0.0908$; Figure 1A), although the correlation was weak.

For *M. jelskii*, CL ranged from 7.48 mm to 11.57 mm (9.76 ± 0.75 mm) in females with IN eggs and from 8.27 mm to 11.55 mm (9.81 ± 0.76 mm) in females with FI eggs. DBW ranged from

0.075 g to 0.706 g (0.302 ± 0.192 g). A linear regression analysis of the relationship between DBW and CL did not show significance (p = 0.6106, adjusted R² = -0.008; Figure 1B), indicating no correlation between these variables.

Figure 1 - Relationship between female weight (g) and carapace length (mm) of (A) *Macrobrachium amazonicum* and (B) *Macrobrachium jelskii*; captured along the banks of the Tietê River, Promissão Reservoir, São Paulo, Brazil. In (B), R² is adjusted
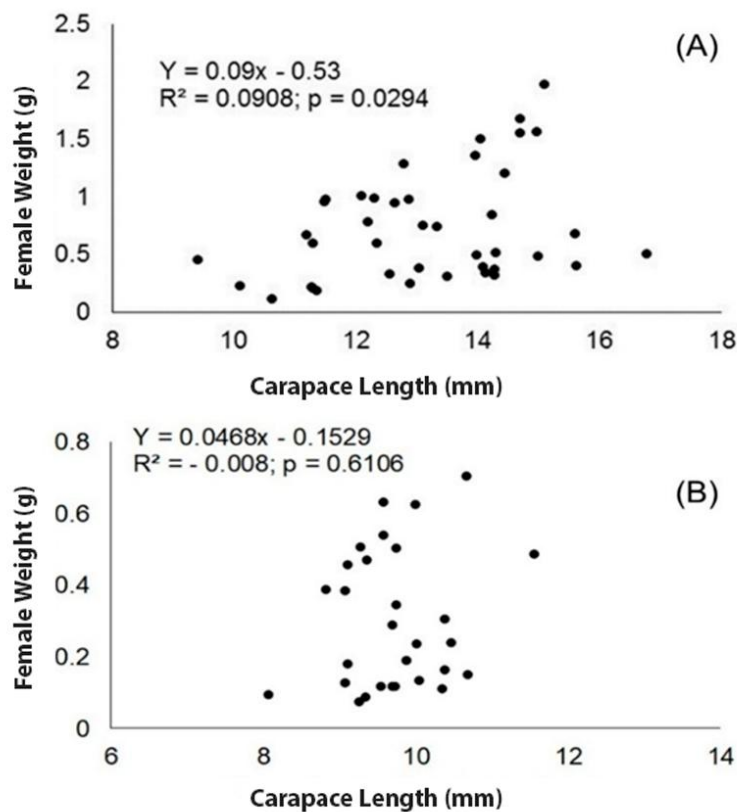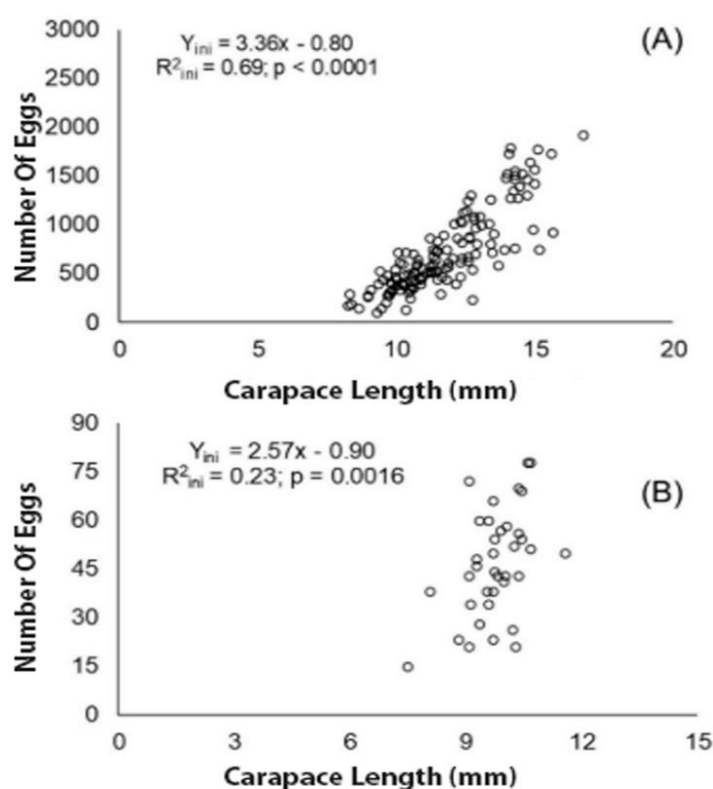

Source: research data.

3.2 Fecundity

Of the 295 *M. amazonicum* females analyzed, 137 carried IN eggs. Linear regression demonstrated that carapace length (CL) is a strong predictor of fecundity ($p < 0.0001$, $R^2 = 0.6933$; Figure 2A). The number of IN eggs ranged from 92 (CL = 9.32 mm) to 1,903 (CL = 16.77 mm), with a mean of 717.16 ± 422.8 eggs. For females with FI eggs, fecundity ranged from 85 (CL = 10.9 mm) to 2,444 eggs (CL = 16.4 mm), with a mean of 1,003.77 ± 550.14 eggs.

Figure 2 - Relationship between the number of eggs at the initial stage (fecundity) and the carapace length (mm) of (A) *Macrobrachium amazonicum* and (B) *Macrobrachium jelskii*, captured along the banks of the Tietê River, Promissão Reservoir, SP, Brazil


$Y_{ini} = 3.36x - 0.80$
$R^2_{ini} = 0.69; p < 0.0001$ (A)

$Y_{ini} = 2.57x - 0.90$
$R^2_{ini} = 0.23; p = 0.0016$ (B)

The analysis of covariance (ANCOVA) showed a strong correlation between fecundity in the two reproductive stages ($p < 0.0001$, $Bw = 3.4855$, $F = 659.6205$; Figure 3A), indicating that the mean number of eggs in females with FI eggs was significantly higher than in females with IN eggs. The *t*-test for CL comparison indicated that FI females were significantly larger than IN females ($p < 0.0001$).

The quasi-Poisson test revealed significant changes in the number of eggs during the sampling period ($F = 18.483$, $p < 0.0001$; Figure 4A), with peaks in fecundity observed in November 2017 and February 2018 (Tukey, $p < 0.05$).

Figure 3 - Analysis of covariance (ANCOVA) between the egg stages (initial and final) of (A) *Macrobrachium amazonicum* and (B) *Macrobrachium jelskii*, captured on the banks of the Tietê River, Promissão Reservoir, São Paulo, Brazil
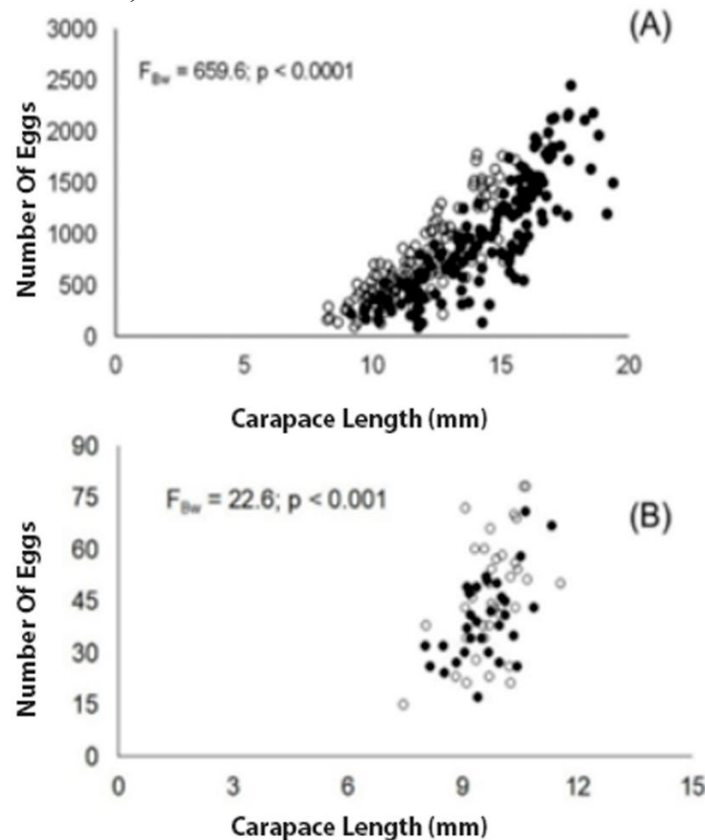
Source: research data.

For *M. jelskii*, out of the 68 females analyzed, 37 carried IN eggs. The linear regression also indicated that CC is a good predictor of fecundity (p = 0.0016, R² = 0.2396; Figure 2B). The number of IN eggs ranged from 15 (CC = 7.48 mm, smallest female) to 78 (CC = 10.67 mm), with an average of 46.62 ± 16.44 eggs. For females with FI eggs, fecundity ranged from 21 (CC = 9.61 mm) to 75 (CC = 10.87 mm), with an average of 44.0 ± 12.40 eggs.

The ANCOVA identified a significant loss of eggs between the IN and FI stages (p < 0.0001, Bw = 2.2668, F = 22.6763; Figure 3B), suggesting a substantial reduction in the number of eggs throughout development. The quasi-Poisson test indicated significant changes in the number of eggs over the months in which the species was observed (F = 4.9931, p = 0.00181; Figure 4B), with higher fecundity observed in January, March, April, and July 2018 (Tukey, p<0.05).

The IR of *M. amazonicum* ranged from 3.78% (CC = 11.36 mm) to 29.3% (CC = 12.57 mm), with an average of 12.68 ± 5.63%. The linear regression between IR and CC showed no significant relationship between these variables (p = 0.6560, R² = -0.0202), indicating that IR is independent of body size in this species.

For *M. jelskii*, IR ranged from 4.37% (CC = 8.83 mm) to 32.0% (CC = 9.27 mm), with an average of 14.24 ± 7.89%. The linear regression analysis also indicated no significant correlation between IR and CC (p = 0.1835; R² = 0.0291), confirming that reproductive investment in this population is independent of female size.

The results confirmed the hypothesis that *M. amazonicum* exhibits higher fecundity than *M. jelskii*, which may be one of the factors explaining its greater success in colonizing new environments and its ability to compete for limited resources. Although the reproductive investment of *M. amazonicum* was slightly lower than that of *M. jelskii,* its higher fecundity may compensate for this difference, ensuring greater offspring production and, consequently, a higher ecological advantage in new habitats.

Figure 4 - Monthly evaluation of the number of eggs of (A) Macrobrachium amazonicum (quasi-Poisson, F = 18.483; p < 0.0001) and (B) Macrobrachium jelskii (F = 4.9931; p = 0.00181); captured along the banks of the Tietê River, Promissão reservoir, São Paulo, Brazil. Bars represent the monthly mean number of eggs
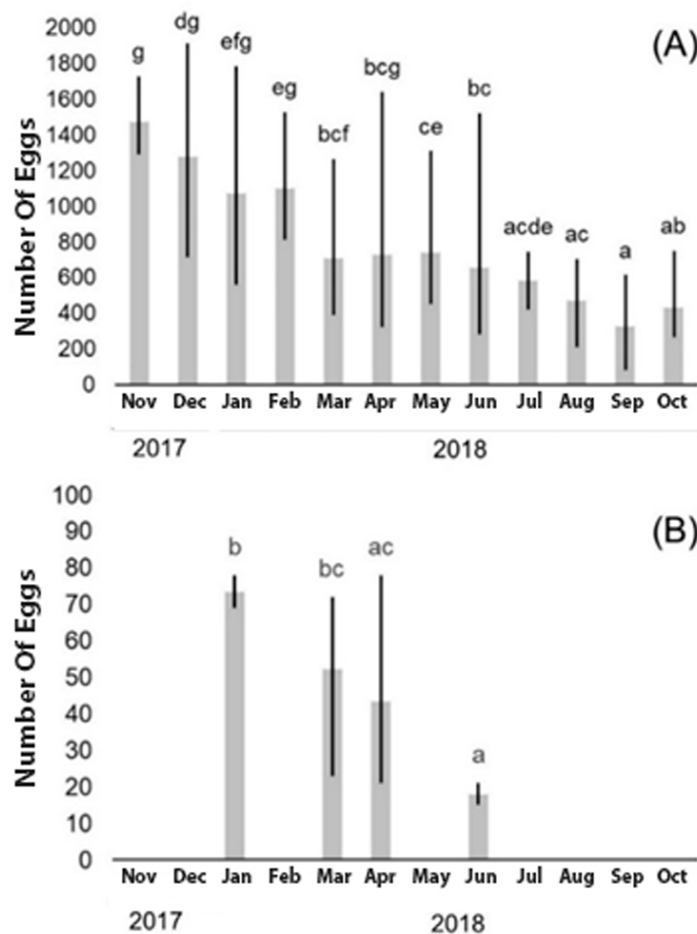
Vertical lines reach the minimum and maximum number of eggs per female. Different letters above the vertical lines indicate significant differences during the sampling period for each species (Tukey, p < 0.05).
Source: research data.

Fecundity and carapace length showed a positive correlation in the populations of M. amazonicum and M. jelskii, as well as in other decapod crustacean species described in the literature (Reid; Corey, 1991; Zimmermann; Carvalho; Mantelatto, 2015). Although this relationship is an important factor in the fecundity of the two species under study, other aspects must be considered, such as environmental variables (temperature, rainfall, latitude, season) and intrinsic species characteristics (Pantaleão *et al*., 2018; Silva *et al*., 2018).

The fecundity of *M. amazonicum* (85 to 2,444 eggs) and *M. jelskii* (15 to 78 eggs) was considerably lower compared to other species of the genus, as reported in the scientific literature. Although the reproductive period of *Macrobrachium rosenbergii* (De Man, 1879) is limited to a few months of the year, the fecundity of this species in a northern region of Brazil ranged from 5,254 to 52,358 eggs per female (Gemaque *et al*., 2021). Meanwhile, Macrobrachium carcinus (Linnaeus, 1758), with a more prolonged reproductive period, exhibited even higher fecundity, ranging from 14,420 to 242,437 eggs per female (Lara; Wehrtmann, 2009). However, high fecundity does not necessarily reflect a more efficient strategy, as numerous other factors determine reproductive success. Aspects such as egg survival, environmental conditions, resource availability, and species adaptability are essential for the reproductive process.

Studies investigating the fecundity of *M. amazonicum* report significant variations in the number of eggs per female, always correlating these values positively with the carapace length of specimens. In the Ibitinga reservoir, located upstream from the dam analyzed in the present study, fecundity was estimated between 104 and 3,136 eggs (mean estimated per season) per female (Pantaleão *et al*., 2018). In another analysis, females captured in the Amazon River, with carapace lengths ranging from 15.38 to 29.6 mm, carried between 1,099 and 7,417 eggs (mean not reported) adhered to the pleopods (Lima et al., 2014). In northeastern Brazil, females captured in the Jaguaribe River had fecundity ranging from 696 to 2,193 eggs (mean not reported) (Silva; Sampaio; Santos, 2004).

In contrast, when comparing the fecundity of *M. jelskii* found in this study with that from other regions, the results were very similar. In another reservoir in the state of São Paulo, females were reported to have between 1 and 56 eggs, with an average fecundity of 23.95 ± 14.8 eggs (Mossolin *et al*., 2013). Populations from six different locations of the Salgado River in Ceará, northeastern Brazil, were studied by two research teams. In three of them, the captured females carried between 8 and 26 eggs (mean not reported) (Macêdo *et al*., 2021), 5 and 20 (13.3 ± 3.34), and 13 to 19 (15.86 ± 2.27) eggs (Nery *et al*., 2015). In the other three regions, where females were larger, fecundity was significantly higher: 4 to 26 (15.0 ± 5.92), 21 to 47 (36.14 ± 6.96), and 20 to 58 (39.14 ± 11.25) eggs (Nery *et al*., 2015). In a dam in central Minas Gerais, in the São Francisco River, females from downstream and upstream were found carrying similar numbers of eggs: from 5 to 69 eggs (35 ± 14)

and from 5 to 78 eggs (37 ± 14), respectively (Soares; Oshiro; Toledo, 2015). The smaller variations in fecundity, compared to those found for *M. amazonicum*, are also due to the smaller variation in female size between sampled locations (Nery *et al.*, 2015; Silva *et al.*, 2018; Macêdo *et al.*, 2021). According to Pantaleão *et al.* (2018), these variations in population parameters are related not only to geographic distribution but also to the specific environmental conditions of each population.

The reduction in the number of *M. jelskii* eggs is justified by several factors, such as the embryos' abbreviated development (Magalhães, 2001), egg loss during incubation (Mossolin *et al.*, 2013), and energy investment performance (Tamburus; Mossolin; Mantelatto, 2012). Furthermore, considering the energy allocation process in producing large eggs in smaller quantities (Sastry, 1983), *M. jelskii* appears to exemplify this premise.

In addition to having higher fecundity, *M. amazonicum* populations also exhibit another important strategy for environmental establishment: continuous reproduction throughout the year. This characteristic has been corroborated by several studies conducted in different regions of Brazil (Lima *et al.*, 2014; Pantaleão *et al.*, 2018; Sampaio *et al.*, 2007; Silva; Souza; Cintra, 2002; Silva; Sampaio; Santos, 2004; Silva et al., 2018). In contrast, the presence of ovigerous *M. jelskii* females was not constant throughout the year, indicating a seasonal reproductive strategy, widely described in the literature (Macêdo *et al.*, 2021; Nery *et al.*, 2015; Silva *et al.*, 2018; Soares; Oshiro; Toledo, 2015). Studies identifying periods of greater reproductive activity suggest that environmental factors, such as temperature and food availability, play a crucial role in this dynamic (Macêdo *et al.*, 2021; Nery *et al.*, 2015; Soares; Oshiro; Toledo, 2015; Silva *et al.*, 2018). This seasonality may represent an adaptive response aimed at maximizing offspring survival under more favorable environmental conditions, contrasting with the continuous reproduction strategy observed in *M. amazonicum*.

When accounting for the number of IN and FI eggs of both species, it was expected that the number of eggs in FI would be lower or, at most, equivalent to that observed in IN. The loss of eggs from the beginning of incubation to the end of embryonic development is common, and several factors can influence this process. One of them is the females' behavior of cleaning and readjusting the eggs among the pleopods, an action that improves the offspring's oxygenation by promoting water circulation (Nazari et al., 2003). Additionally, environments with running waters and rocky substrates can also negatively impact fecundity (Nunes et al., 2022). However, the results of this study revealed that, for *M. amazonicum*, the average number of eggs in FI (1003.77 ± 550.14 eggs, females with 13.31 ± 2.08 mm CL) was higher than in the IN stage (717.16 ± 422.8 eggs, 11.77 ± 1.82 mm CL). This finding suggests that, despite continuous reproduction over certain periods of the year, the higher fecundity observed in FI may be associated with a greater presence of larger ovigerous females, which results in a higher number of externalized eggs.

The higher abundance of ovigerous females in certain seasons is often attributed to more

favorable conditions for larval development (Miranda *et al.*, 2020; Nunes *et al.*, 2022). Additionally, Rodrigues *et al.* (2020) state that such females tend to seek areas with greater availability of microhabitats and food, thus preparing for the reproductive phase (Miranda *et al.*, 2020). Consequently, the number of eggs within the same species may vary depending on resource availability and environmental competition. The greater energetic investment of females during a reproductive peak, for instance, may be related to resource abundance and/or reduced competition (Tamburus; Mossolin; Mantelatto, 2012). In this context, it is plausible that larger females wait for ideal conditions to reproduce, while smaller females ensure their reproduction at any time of the year. This phenomenon may explain the higher average number of FI eggs compared to IN observed in this study. It is also important to highlight that FI females had a greater carapace length (CL) than IN females.

On the other hand, in *M. jelskii*, there was a significant loss of eggs between reproductive stages, something common in palaemonid shrimp. However, some studies report that stricter parental care can minimize this loss, making it negligible and, in some cases, undetectable in statistical analyses. This behavior has been observed in *M. amazonicum* populations (Pantaleão *et al.*, 2018; Nunes *et al.*, 2022) and in *Macrobrachium acanthurus* (Wiegmann, 1836) (Tamburus; Mossolin; Mantelatto, 2012).

The reproductive investment observed in *M. amazonicum* in this study (12.68 ± 5.63%) is consistent with values found in populations of the same species in other locations, such as Costa Rica (RI = 12.0%) (Lara; Wehrtmann, 2009) and in Brazilian states such as Mato Grosso do Sul (RI = 14.5%), Pará (RI = 10.3%) (Meireles; Valenti; Mantelatto, 2013), and Amapá (RI = 11.74%) (Lima *et al.*, 2014). For *M. jelskii*, reproductive investment was higher (14.24 ± 7.89%), which may be explained by the larger volume of this species' eggs. Since *M. jelskii* exhibited a seasonal reproductive strategy, this increase in RI may be related to the concentrated allocation of energy for reproduction during specific periods. The variation in energy allocation for reproduction among *Macrobrachium* species is widely influenced by environmental conditions (Lara; Wehrtmann, 2009; Lima *et al.*, 2014; Meireles; Valenti; Mantelatto, 2013).

Understanding the reproductive strategy of *Macrobrachium* shrimp is essential for analyzing population dynamics and promoting their sustainability. Among these species, *M. amazonicum* stands out for its high fecundity and continuous reproductive cycle throughout the year, demonstrating remarkable environmental adaptability. The presence of ovigerous females in all seasons increases larval survival chances and ensures species establishment in response to environmental variations. In contrast, *M. jelskii* adopts a seasonal reproductive strategy, suggesting an adaptation to maximize offspring survival during environmentally favorable periods. These reproductive differences reflect distinct ecological and adaptive responses, which are crucial for the management and conservation

of aquatic ecosystems.

The preservation of these shrimp species, which play a fundamental role in the aquatic food web, can contribute to the maintenance of other native species, such as fish affected by river damming. By ensuring the health of *Macrobrachium spp.* populations, which serve as prey and influence nutrient cycling, it is possible to promote an ecological balance that benefits the entire trophic chain. This balance is particularly relevant in environments altered by dams, where the loss of native species can compromise biodiversity and habitat sustainability.

4 Conclusion

M. amazonicum shrimp exhibit high fecundity and continuous reproduction throughout the year, leading to greater larval production and facilitating colonization of new environments. In contrast, *M. jelskii* follows a seasonal reproductive strategy, maximizing offspring survival during favorable periods. These differences reflect ecological adaptations that influence population dynamics and should be considered in management and conservation strategies. From this perspective, preserving *Macrobrachium spp.* populations contributes to trophic balance, supports native species affected by river damming, and strengthens the sustainability of aquatic ecosystems impacted by dams.

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